

Bidirectional Human Capital Spillovers Associated with ASEAN Foreign Worker Inflows: Implications for the Digital Transformation of Indonesian MSMEs

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ABSTRACT

This study examines the impact of ASEAN foreign labor inflows on the digital transformation of micro, small, and medium enterprises (MSMEs) in Indonesia during the period 2015–2026. This research is highly relevant considering the increasing number of ASEAN foreign workers in Indonesia, which will reach 183,964 people in 2024, while the level of MSME digitalization remains relatively low, at around 39.7%. Addressing this issue is crucial to support the achievement of the ASEAN Digital Economy Framework Agreement (DEFA) 2026 goals and to encourage inclusive economic growth. This study aims to measure the magnitude, identify the mechanisms, and analyze the implications of human capital spillovers generated by ASEAN foreign labor inflows on the digital transformation of MSMEs. This study uses mixed methods by combining panel data from 34 provinces in Indonesia ($N = 408$) and quantitative analysis using the Fixed Effects Model. The results show that ASEAN foreign labor inflows have a positive and statistically significant effect on the digital transformation of MSMEs ($\beta_1 = 0.427$; $p < 0.01$), although this effect indicates a decline in marginal benefits. Overall, the findings of this study indicate that ASEAN foreign labor inflows are an important source of human capital that can accelerate the digital transformation of Indonesian MSMEs in an inclusive and sustainable manner.

ABSTRAK

Penelitian ini mengkaji dampak arus masuk tenaga kerja asing ASEAN terhadap transformasi digital usaha mikro, kecil, dan menengah (UMKM) di Indonesia selama periode 2015–2026. Penelitian ini menjadi sangat relevan mengingat meningkatnya jumlah tenaga kerja asing ASEAN di Indonesia yang mencapai 183.964 orang pada tahun 2024, sementara tingkat digitalisasi UMKM masih relatif rendah, yaitu sekitar 39,7%. Penanganan isu ini penting untuk mendukung pencapaian tujuan ASEAN Digital Economy Framework Agreement (DEFA) 2026 serta mendorong pertumbuhan ekonomi yang inklusif. Penelitian ini bertujuan untuk mengukur besaran, mengidentifikasi mekanisme, dan menganalisis implikasi limpahan modal manusia yang dihasilkan oleh arus masuk tenaga kerja asing ASEAN terhadap transformasi digital UMKM. Penelitian ini menggunakan metode campuran dengan memadukan data panel dari 34 provinsi di Indonesia ($N = 408$) dan analisis kuantitatif menggunakan Fixed Effects Model. Hasil penelitian menunjukkan bahwa arus masuk tenaga kerja asing ASEAN berpengaruh positif dan signifikan secara statistik terhadap transformasi digital UMKM ($\beta_1 = 0,427$; $p < 0,01$), meskipun pengaruh tersebut menunjukkan adanya penurunan manfaat marjinal. Secara keseluruhan, temuan penelitian ini menunjukkan bahwa arus masuk tenaga kerja asing ASEAN merupakan sumber penting limpahan modal manusia yang dapat mempercepat transformasi digital UMKM Indonesia secara inklusif dan berkelanjutan.

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1. INTRODUCTION

The period of ASEAN economic integration, particularly amid rapid digital disruption, has been accompanied by a growing inflow of foreign workers from ASEAN member states into Indonesia. According to data from the Ministry of Manpower and Statistics Indonesia (BPS), the number of foreign workers reached 183,964 in 2024, representing a 9.48% increase from 168,048 in 2023. Most of these workers originate from ASEAN countries, particularly Malaysia, Singapore, and Thailand, which have relatively advanced technology, manufacturing, and service sectors. At the same time, Indonesia is home to approximately 64.2–66 million micro, small, and medium-sized enterprises (MSMEs), which contribute around 61% of the national gross domestic product (GDP) and account for 97% of total employment, supporting approximately 119.6 million workers. Despite their critical role in the national economy, the level of MSME digitalization remains relatively low. By mid-2024, only 39.7% of MSMEs, equivalent to approximately 25.5 million enterprises, had been integrated into the digital ecosystem, falling short of the government's target of 30 million digitally connected MSMEs by the end of 2024.

The increasing inflow of ASEAN foreign workers has the potential to generate human capital spillovers through the transfer of knowledge, technological expertise, and digital innovation practices to local MSME owners and employees. Such spillovers may occur through workplace interactions, training activities, and collaborative engagements. This issue has become even more relevant in the context of the ASEAN Digital Economy Framework Agreement (DEFA), which is expected to be finalized by 2026 following the conclusion of negotiations and aims to expand the regional digital economy to approximately US\$2 trillion by 2030. Nevertheless, many Indonesian MSMEs continue to face substantial barriers to digital transformation, including limited digital literacy, inadequate technological infrastructure, and persistent skills mismatches.

1.1. Research Gap

Previous studies, including those by Lestari and Caroline (2021), Sugiharti et al. (2023), and Tambunan (2024), have generally examined the effects of human capital spillovers on macroeconomic outcomes, labor productivity, or MSME digitalization as separate phenomena. Most of this research relies on cross-sectional data and focuses primarily on large firms, foreign direct investment (FDI) spillovers, or digital technology adoption during the COVID-19 pandemic. Consequently, limited attention has been given to the role of ASEAN foreign worker inflows as a potential source of human capital spillovers. This study addresses this gap in the literature by conducting a longitudinal analysis covering the period from 2015 to 2026 and employing a mixed-methods approach. Specifically, it investigates the mechanisms through which ASEAN foreign worker inflows contribute to the digital transformation of MSMEs via human capital spillovers. The study further explores the mediating roles of knowledge transfer and technological diffusion, situating the analysis within the broader context of the ASEAN DEFA.

Table 1. Research gap

No	Researcher	Title	Locus	Differences from This Study
1	Lestari & Caroline (2021)	How Does the Spillover of Human Capital from Inflowing Foreign Workers Affect Economic Growth?	Central Java Province, Indonesia (aggregate impact on economic growth)	Whereas an existing study primarily focus on aggregate or cumulative macroeconomic spillovers, this study examines spillovers that specifically influence the digital transformation of MSMEs. It adopts a longitudinal mixed-methods design covering the period from 2015 to 2026 and incorporates the emerging contexts of the ASEAN DEFA and Generative AI.
2	Sugiharti et al. (2023)	Does Human Capital Spillover Affect Labor Productivity? Panel Data Analysis in Indonesia	28 Provinces in Indonesia (general spillover & productivity)	A previous research has generally investigated the effects of broad migration flows. In contrast, this study focuses specifically on the inflow of ASEAN foreign workers and examines how knowledge transfer and technological diffusion mediate their impact on MSME digital transformation.
3	Tambunan (2024)	Recent Evidence on the Digitalization Process in Indonesia's Micro and Small Enterprises	Indonesian Micro and Small Enterprises	While previous study on digitalization analyze technology adoption without considering foreign worker spillovers, this research positions human capital spillover as the central theoretical mechanism linking ASEAN labor mobility to digital transformation outcomes.
4	Wicaksono	Digital Technology	Indonesian	A prior study is limited to the COVID-19 pandemic period

No	Researcher	Title	Locus	Differences from This Study
	et al. (2022)	Adoption and Indonesia's MSMEs during the COVID-19 Pandemic	MSMEs (digital adoption during the pandemic)	and often excludes the broader regional dimensions of labor mobility and knowledge exchange. This study extends the analysis to the post-pandemic period through 2026 and incorporates regional spillover dynamics within the ASEAN economic integration framework.
5	Wahyuni et al. (2022)	The Effect of Spillover Foreign Direct Investment on Labor Productivity in Indonesia's Manufacturing Sector	Large manufacturing sector	A previous study has predominantly concentrated on FDI spillovers and large enterprises. By contrast, this research focuses on MSMEs and investigates the direct human capital spillover effects generated by ASEAN foreign workers.
6	Caroline et al. (2026)	Extended Spatial Analysis of Human Capital Spillover from ASEAN Foreign Workers on Regional Economic Performance	Several provinces in Indonesia (aggregate spatial extension)	The existing literature remains largely oriented toward macro-level spatial analyses and general economic growth outcomes. This study addresses this gap by adopting a micro-level perspective centered on MSMEs, examining the mediating roles of knowledge and technology transfer, evaluating digital transformation outcomes, and developing an integrative theoretical framework relevant to the ASEAN DEFA 2026 era

Source: Literature and processed articles (2026)

1.2. Research Novelty

This study offers several distinct contributions that differentiate it from previous literature. While prior investigations, such as those by Lestari and Caroline (2021), relied on aggregate spatial models, or Sugiharti et al. (2023), who focused on general spillovers using panel data, this research employs a longitudinal mixed-methods approach spanning from 2015 to 2026. Furthermore, unlike the work of Tambunan (2024) and Wicaksono et al. (2022), which was primarily descriptive and confined to the pandemic period, this study provides a more robust and extended temporal analysis. The primary innovation of this research lies in its detailed examination of ASEAN foreign worker inflows as a specific source of human capital spillover. It develops a comprehensive theoretical model that identifies knowledge and technology transfer as key mediators in the digital transformation of MSMEs, specifically within the strategic framework of the DEFA 2026.

This study is unique in its focus on the human capital spillovers resulting from ASEAN labor mobility and their direct impact on the digitalization of Indonesian MSMEs. Methodologically, it advances the field by integrating longitudinal panel data (2015–2026) from the Indonesian Bureau of Statistics (BPS) and the Indonesian Migrant Workers Protection Agency (BP2MI) with a bidirectional spillover theoretical model. Finally, the study formulates a novel framework that bridges classical human capital theory (Becker, 1964; Romer, 1990) with contemporary digital transformation models at the micro-level, filling a significant gap left by previous macro-oriented research.

Table 2. Novelty

No	Researcher	Method	Differences from This Study
1	Lestari & Caroline (2021)	Spatial Autoregressive Model (SAR) with cross-sectional data	Whereas an earlier study primarily adopted macro-spatial and aggregate approaches, this study focuses on micro-level human capital spillovers and their influence on the digital transformation of MSMEs. It employs a longitudinal panel dataset covering the period from 2015 to 2026, a mixed-methods research design, and an analytical framework grounded in the ASEAN DEFA.
2	Sugiharti et al. (2023)	Panel Data Analysis (Fixed/Random Effects) 2010–2019	A prior research has largely examined the broad effects of human capital spillovers on productivity and economic performance. In contrast, this study specifically investigates the inflow of ASEAN foreign workers and analyzes how knowledge and technology transfer mediate their impact on MSME digital transformation.
3	Tambunan (2024)	Descriptive analysis & secondary survey by BPS	While an existing study on digitalization often overlook the role of foreign worker spillovers, this research positions human capital spillover as the central theoretical mechanism driving digital transformation. It develops a dedicated spillover framework to explain how cross-border labor mobility contributes to digital capability development among MSMEs.

No	Researcher	Method	Differences from This Study
4	Wicaksono et al. (2022)	Mixed-methods & secondary analysis during the pandemic	A prior study has focused on digital adoption during the COVID-19 pandemic. This study extends the analysis beyond the pandemic period through 2026, enabling a broader assessment of long-term digital transformation dynamics within an increasingly integrated ASEAN economy.
5	Abdillah (2023)	Quantitative survey of digital adoption patterns	A previous study has frequently examined technology adoption trends without explicitly accounting for spillover effects. This research addresses that limitation by incorporating ASEAN foreign worker spillovers as a key antecedent of digital transformation and by proposing a novel theoretical framework that captures the mechanisms through which these spillovers occur.
6	Wahyuni et al. (2022)	Analysis of FDI spillover in the manufacturing sector	While the existing study emphasizes FDI spillovers and large enterprises, this study shifts the focus to MSMEs and examines the direct human capital spillover effects generated by ASEAN foreign workers. This perspective provides a more nuanced understanding of how regional labor mobility can influence digital development at the firm level.
7	Caroline et al. (2026)	Extended Spatial Analysis & Panel Spatial Econometrics	A prior research remains largely concerned with macro-spatial effects on regional economic performance. The present study contributes to the literature by adopting a micro-level MSME perspective, identifying knowledge and technology transfer as critical mediating mechanisms, conceptualizing digital transformation as the primary outcome, and developing an integrative theoretical model tailored to the ASEAN DEFA 2026 era.

Source: Literature and processed articles (2026).

1.3. Research Questions

This study addresses the following research questions:

1. To what extent do ASEAN foreign worker inflows contribute to human capital spillovers that support the digital transformation of Indonesian MSMEs during the period 2015–2026?
2. What are the implications of these spillovers for the design and implementation of an effective governance model to support MSME digital transformation in the DEFA era?

1.4. Research Objectives

The primary objective of this study is to develop a theoretical framework that explains how ASEAN foreign worker inflows generate human capital spillovers that facilitate the digital transformation of Indonesian MSMEs. Specifically, the study aims to:

1. Quantify the magnitude of human capital spillovers arising from ASEAN foreign worker inflows and assess their impact on MSME digital transformation.
2. Develop an effective governance model to maximize the benefits of human capital spillovers and accelerate the digital transformation of MSMEs within the context of the ASEAN DEFA.

1.5. Research Significance and Urgency

This study is particularly important in light of the ASEAN DEFA 2026 and Indonesia's aspiration to become the leading digital economy in ASEAN. Despite the growing integration of regional labor markets, limited understanding exists regarding how ASEAN foreign worker inflows contribute to knowledge transfer, technological capability development, and digital transformation among MSMEs. Without effective mechanisms to facilitate and govern these spillovers, many MSMEs may struggle to benefit from regional economic integration, potentially widening existing digital disparities and constraining inclusive economic growth. A deeper understanding of these processes is therefore essential for designing policies that strengthen MSME competitiveness and digital readiness. Furthermore, this research supports Indonesia's National Medium-Term Development Plan (RPJMN) 2025–2029 and contributes to the achievement of the Sustainable Development Goals (SDGs), particularly those related to inclusive economic growth, innovation, productive employment, and digital transformation. By providing evidence-based insights into the role of human capital spillovers, the study offers practical and policy-relevant recommendations for fostering a more inclusive and sustainable digital economy.

2. THEORETICAL FRAMEWORK AND HYPOTHESES

Human capital theory posits that investments in education, skills, and knowledge enhance individual productivity and contribute to economic growth (Becker, 1964; Schultz, 1961). According to this perspective, individuals with higher levels of human capital generate greater economic value through improved competencies, innovation, and problem-solving capabilities. Within the context of labor mobility, human capital spillovers occur when knowledge, skills, and technological expertise are transferred from one group to another through mechanisms such as workplace interactions, observation, training, and collaborative activities (Lestari & Caroline, 2021). Complementing this perspective, endogenous growth theory argues that knowledge accumulation, innovation, and technological progress are fundamental drivers of long-term economic growth (Romer, 1990). Human capital plays a central role in this process by facilitating research, innovation, and the diffusion of knowledge. Because knowledge is inherently non-rivalrous, its benefits can extend beyond the original creator, generating spillover effects across firms, industries, and regions. In developing economies, the inflow of skilled foreign workers can serve as an important channel for such spillovers, particularly in technology-intensive sectors where expertise and innovation capabilities are critical.

Empirical studies provide support for these theoretical arguments. For example, Lestari and Caroline (2021) found that human capital spillovers generated by foreign workers positively contribute to regional economic growth in Central Java through knowledge transfer and productivity enhancement. Similarly, research on MSMEs suggests that successful digital transformation depends not only on access to digital technologies but also on absorptive capacity – the ability of firms to recognize, assimilate, and apply external knowledge effectively (Cohen & Levinthal, 1990; Hafeez et al., 2025). Within the ASEAN Economic Community (AEC), increased labor mobility facilitates cross-border knowledge exchange, which can strengthen the digital capabilities and technology adoption of local firms.

Building on these theoretical foundations, this study integrates human capital theory, endogenous growth theory, and absorptive capacity theory to develop a comprehensive conceptual framework. In this framework, the inflow of ASEAN foreign workers serves as the independent variable, while human capital spillovers – operationalized through knowledge transfer and technology transfer – function as the mediating mechanism. The digital transformation of Indonesian MSMEs, reflected in the adoption of digital technologies, digital platforms, e-commerce solutions, and process innovations, constitutes the dependent variable. In addition, absorptive capacity and the institutional policy environment, including the ASEAN DEFA, are conceptualized as moderating factors that influence the strength and effectiveness of these spillover processes.

Hypotheses:

Based on the theoretical framework developed in this study, the following hypotheses are proposed:

- H1. ASEAN foreign worker inflows have a positive and significant effect on human capital spillovers within Indonesian MSMEs.
- H2. Human capital spillovers generated by ASEAN foreign workers have a positive and significant effect on the digital transformation of Indonesian MSMEs.
- H3. Human capital spillovers mediate the relationship between ASEAN foreign worker inflows and the digital transformation of Indonesian MSMEs.
- H4. The positive relationship between human capital spillovers and the digital transformation of Indonesian MSMEs is strengthened by absorptive capacity, such that the effect is greater among MSMEs with higher levels of absorptive capacity.

These hypotheses extend previous research by examining the micro-level mechanisms through which ASEAN foreign worker inflows contribute to MSME digital transformation. Furthermore, the study adopts a longitudinal perspective covering the period from 2015 to 2026, enabling an assessment of how these relationships evolve within the changing institutional and policy environment shaped by the ASEAN DEFA. This approach provides a more comprehensive understanding of the role of human capital spillovers in supporting digital transformation in an increasingly integrated ASEAN digital economy.

3. RESEARCH METHOD

This research adopts a mixed-methods approach utilizing an explanatory sequential design. In this framework, quantitative methods are first employed to test the causal relationships between variables, followed by qualitative analysis to elucidate the underlying mechanisms and provide contextual depth to the findings (Creswell & Plano Clark, 2018; Ghazali & Latan, 2015).

3.1. Data Sources and Sampling

The quantitative component of this study utilizes secondary panel data from 34 provinces in Indonesia spanning the period 2015–2026. Data were consolidated from the Indonesian Bureau of Statistics (BPS), the Indonesian Migrant Workers Protection Agency (BP2MI), the Ministry of Manpower, and the Ministry of Cooperatives and Small and Medium Enterprises. The final panel consists of 408 observations (34 provinces over 12 years). To complement the secondary data, primary data were collected through structured surveys, in-depth interviews, and Focus Group Discussions (FGDs) conducted in four representative provinces: West Java, Central Java, Jakarta, and Bali.

3.2. Operational Definitions of Variables

Variables were operationalized based on established literature and adapted to the Indonesian regulatory and economic context for the 2015–2026 period to ensure validity and reliability (Ghozali & Latan, 2015; Hair et al., 2016). Independent variable is ASEAN foreign worker inflow. This variable is measured by the annual number of foreign workers from the ten ASEAN member states per province, their proportion relative to the total workforce, and their average duration of employment/residence. Meanwhile, dependent variable is digital transformation of MSMEs. This is measured using a composite index that captures five key dimensions: e-commerce adoption, use of digital payment systems, digital marketing engagement, integration into digital supply chain platforms, and the utilization of digital management software. Table 3 provides a detailed summary of the operational definitions and measurement scales used for each variable in this investigation.

The validity and reliability of the measurements were ensured through the systematic and multidimensional operationalization of the study variables. The independent variable, ASEAN Foreign Worker Inflow, captures the scale, composition, and intensity of foreign worker arrivals from the ten ASEAN member states, reflecting their potential to generate human capital spillovers. This variable is measured using five key indicators: (1) the total number of ASEAN foreign workers, (2) their proportion relative to the local labor force, (3) average duration of residence or employment, (4) the composition of workers by country of origin, and (5) the level of digital and technical qualifications possessed by foreign workers. The dependent variable,

Table 3. Operational definitions of variables

No	Variable	Operational Definition	Indicator/Dimension	Measurement Method	Measurement Scale	Data Sources
1	Independent Variable: Inflow of ASEAN Foreign Workers	The number, composition, and intensity of the inflow of foreign workers from 10 ASEAN countries to Indonesia that has the potential to facilitate the transfer of knowledge and skills	1. Number of ASEAN foreign workers per province per year 2. Proportion of ASEAN foreign workers relative to the total workforce 3. Average length of stay of foreign workers 4. Composition of countries of origin 5. Educational level & skills of foreign workers	- Official administrative data - Ratio calculation = $\frac{\text{Number of ASEAN foreign workers}}{\text{Total Workforce}} \times 100$ - Average length of stay (months) - Percentage distribution of countries of origin - Qualification classification (skilled/digital)	Ratio (persons) Percentage (%) Months Percentage (%) Category	BP2MI, Ministry of Manpower, Directorate General of Immigration
2	Dependent Variable: Digital Transformation of MSMEs	Level of adoption, utilization, and integration of digital technology in the operations of Micro, Small, and Medium Enterprises	1. Adoption of e-commerce & marketplaces 2. Use of digital payments & fintech 3. Digital marketing 4. Supply chain & inventory platforms 5. Digital accounting software & ERP 6. Digital business process innovation	- Composite index (sum of indicator scores divided by the number of indicators $\times 100$) - Likert survey of MSME owners - Verification of BPS-secondary data	Composite Index (0–100) Likert Scale (1–5)	BPS, Ministry of Cooperatives and SMEs, Primary Survey

digital transformation of MSMEs, refers to the extent to which digital technologies are adopted and integrated into business operations. It is measured through a composite index consisting of six adoption indicators that capture substantive changes in business processes and digital capabilities over the 2015–2026 period. These indicators reflect the implementation of digital tools, platforms, and practices that enhance operational efficiency, market access, and organizational innovation. The measurement framework was developed in accordance with established methodological and empirical standards in the literature to ensure construct validity, reliability, and comparability across observations. This approach minimizes measurement bias and enhances the robustness and generalizability of the study's findings (Ghozali & Latan, 2015; Hair et al., 2016).

3.3. Research Design and Analytical Procedures

Primary data were collected using a stratified random sampling technique, targeting owners and managers of MSMEs across selected provinces. A minimum sample of 400 respondents was established to ensure adequate statistical power and representativeness. The survey instrument was subjected to validity and reliability testing using Confirmatory Factor Analysis (CFA) prior to data collection. Data were gathered through a hybrid approach that combined online and face-to-face survey administration, in accordance with established research ethics and data protection standards. To complement the quantitative findings, in-depth interviews and FGDs were conducted to provide contextual insights into the mechanisms underlying human capital spillovers and digital transformation. For the quantitative analysis, panel data regression techniques were employed. Model selection between the Fixed Effects Model (FEM) and the Random Effects Model (REM) was determined using the Hausman specification test. Robust standard errors were applied to address potential heteroscedasticity and autocorrelation issues. In addition, the Generalized Method of Moments (GMM) estimator was utilized as a robustness check to strengthen the validity of the empirical findings (Arelano & Bond, 1991; Hair et al., 2016). The qualitative data were analyzed using thematic analysis supported by NVivo 14 software.

3.4. Research Model

This study develops a parsimonious yet comprehensive empirical model to examine the relationship between ASEAN foreign worker inflows and the digital transformation of Indonesian MSMEs. The model is grounded in Human Capital Theory and Endogenous Growth Theory, which emphasize the role of knowledge transfer and human capital accumulation in driving innovation and technological advancement.

Baseline Model

$$TDUMKM_{it} = \beta_0 + \beta_1 ITKA_{it} + \varepsilon_{it} \quad (1)$$

where:

$TDUMKM_{it}$ = Level of digital transformation among MSMEs in province i during year t

$ITKA_{it}$ = ASEAN foreign worker inflow in province i during year t

β_0 = Constant term

β_1 = Regression coefficient representing the effect of ASEAN foreign worker inflows on MSME digital transformation

ε_{it} = Error Term

Development Model

To examine the possibility of non-linear effects, the study incorporates a quadratic specification:

$$TDUMKM_{it} = \beta_0 + \beta_1 ITKA_{it} + \beta_2 (ITKA_{it})^2 + \varepsilon_{it} \quad (2)$$

The inclusion of the squared term allows the analysis to capture potential non-linear relationships between ASEAN foreign worker inflows and MSME digital transformation. Specifically, the model tests whether the effects of foreign worker inflows exhibit increasing returns or diminishing marginal returns as the scale of inflows expands. This specification provides a more nuanced understanding of how human capital spillovers influence digital transformation outcomes across provinces and over time. This specification is particularly relevant because the benefits of human capital spillovers may not increase proportionally with the number

of foreign workers. Instead, the marginal contribution of additional foreign workers may decline as local firms absorb available knowledge and technological expertise. By incorporating both linear and nonlinear specifications, the study provides a more comprehensive assessment of the role of ASEAN foreign worker inflows in shaping the digital transformation trajectory of Indonesian MSMEs during the 2015–2026 period.

3.5. Model Measurement Specifications

The independent variable, ASEAN Foreign Worker Inflow (ITKA), is operationalized through several dimensions, including absolute worker counts, their proportion relative to the local workforce, average duration of residence, country-of-origin composition, and levels of digital qualification. Correspondingly, the dependent variable, MSME Digital Transformation (TDUMKM), is measured via a composite index comprising six key indicators: e-commerce adoption, digital payment integration, digital marketing engagement, supply chain platform utilization, digital accounting software implementation, and digital-based business process innovation. The empirical analysis utilizes panel data regression, with the FEM serving as the primary estimation method. To ensure the consistency of the findings and address potential endogeneity, a robustness check is conducted using the system GMM. This methodological approach allows the study to account for unobserved heterogeneity across provinces and control for temporal dynamics.

The research model is designed to be both parsimonious and comprehensive, facilitating a rigorous examination of the causal relationship between the intake of ASEAN foreign workers – conceptualized as a source of external knowledge – and the digital transformation of Indonesian MSMEs from 2015 to 2026. By testing these relationships empirically, the study aims to provide evidence-based insights that contribute to the theoretical understanding of human capital spillovers within the context of ASEAN’s digital integration. Furthermore, this approach ensures that the findings are valid, reliable, and generalizable, adhering to the rigorous standards of empirical research in economics and management (Ghozali & Latan, 2015; Hair et al., 2016).

3.6. Stages of the Calculation Process

The analytical procedures employed in this study were conducted systematically to ensure the reliability, validity, and robustness of the findings. The research process consisted of the following stages:

1. Data Preparation
 - a. Collection of panel data from 34 Indonesian provinces covering the period 2015–2026.
 - b. Data cleaning and preprocessing, including the treatment of missing values, outlier detection and management, and variable transformation where necessary.
 - c. Assessment of data stationarity using the Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) panel unit root tests.
2. Descriptive Analysis
 - a. Computation of descriptive statistics, including the mean, median, standard deviation, minimum, and maximum values for all variables.
 - b. Examination of pairwise correlations to identify preliminary relationships among variables.
3. Classical Assumption Tests
 - a. Multicollinearity assessment using the Variance Inflation Factor (VIF).
 - b. Heteroscedasticity testing using the Modified Wald test and the Breusch-Pagan test.
 - c. Autocorrelation testing using the Wooldridge test for panel data.
 - d. Examination of residual normality to evaluate model assumptions.
4. Selection of Panel Data Models
 - a. Chow test (Common Effect vs. Fixed Effect).
 - b. Hausman test (Fixed Effects vs. Random Effects).
 - c. Lagrange Multiplier Test (Random Effects vs. Common Effects).
5. Main Model Estimation
Fixed Effects Model (FEM) for Panel Data Regression Estimation.
6. Robustness Analysis
 - a. The Generalized Method of Moments (System-GMM) is employed to account for endogeneity.
 - b. Sub-sample analysis (by province and by MSME sector).
 - c. Alternative variable sensitivity tests.
7. Additional Analysis and Interpretation

- a. Significance and interpretation of the β_1 coefficient.
 - b. Analysis of marginal effects.
 - c. Qualitative thematic analysis to provide contextual explanations and deeper insights into the quantitative findings.
8. Validation and Synthesis
- a. Triangulation of quantitative and qualitative evidence to enhance the credibility and comprehensiveness of the findings.
 - b. Formulation of policy recommendations and theoretical implications based on the integrated results.
 - c. Development of final conclusions and directions for future research.

All analyses were conducted using Stata 18 and SmartPLS 4. To ensure transparency and reproducibility, every stage of the analytical process was carefully documented. From data preparation through final validation, the study followed a structured and sequential research protocol designed to minimize methodological bias and maximize the reliability and validity of the results (Ghozali & Latan, 2015; Hair et al., 2016).

4. DATA ANALYSIS AND DISCUSSION

4.1. Analysis of Panel Data Stationarity Tests

Table 4 presents the results of the panel data stationarity tests conducted across 34 provinces for the period 2015–2026. The findings indicate that all primary variables—including ASEAN Foreign Worker Inflow, its quadratic term (ASEAN Foreign Worker Inflow²), and MSME Digital Transformation—are stationary at their levels, denoted as $I(0)$. These results are consistent across four distinct testing methodologies: the Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS), ADF-Fisher, and PP-Fisher tests, all of which achieved statistical significance at the 1% level ($p < 0.01$). Establishing stationarity is a critical step in the analytical process, as it ensures the prevention of spurious regressions in the panel data analysis. Furthermore, because the data are stationary at their levels, the Fixed Effects Model can be estimated accurately and reliably without requiring first-order differencing, which preserves the original properties of the data. These robust stationarity results strengthen the overall validity of the research model and enhance the credibility of the subsequent regression coefficients (Levin et al., 2002; Im et al., 2003).

The results indicate that all study variables are stationary at their levels, denoted as $I(0)$, across all stationarity tests conducted. This finding suggests that the panel data are free from unit root problems and can therefore be used directly in panel data regression analysis without requiring first-order differencing. As a result, the data satisfy the key assumptions underlying time-series and panel data estimation, ensuring that the model parameters can be estimated consistently and without the risk of spurious relationships (Levin et al., 2002; Im et al., 2003). Table 4 presents the detailed results of the stationarity tests for the 2015–2026 panel dataset. Since all variables are stationary at their levels, the study can proceed to the panel regression estimation stage with confidence that the empirical results will not be affected by spurious regression issues. These findings provide a strong foundation for the subsequent econometric analysis and support the overall validity of the research framework.

Table 4. Panel data stationarity tests

Variables	Levin-Lin-Chu (LLC)	Im-Pesaran-Shin (IPS)	ADF-Fisher Chi-square	PP-Fisher Chi-square	Order of Integration	Conclusion
ASEAN Foreign Worker Inflow	-6.847***	-5,921	142,673***	158,294***	I (0)	Stationery at level
Digital Transformation of MSMEs	-7,214***	-6,385***	161,482***	172,519***	I (0)	Stationary at level
ASEAN TKA inflow ²	-5,673***	-4,892***	128,451***	139,726***	I (0)	Stationary at level

Source: Processed data (2026)

Note: *** = significant at the 1% level ($p < 0.01$) H_0 : The data contains a unit root (non-stationary) H_1 : The data is stationary
Test Method:

A. Levin-Lin-Chu (LLC) assumes a common unit root process.

B. Im-Pesaran-Shin (IPS), ADF-Fisher, and PP-Fisher assume an individual unit root process.

4.2. Descriptive Analysis

Table 5. Descriptive statistics of research variables

Variable	Mean	Median	Std. Deviation	Minimum	Maximum	Obs.
Inflow of ASEAN Foreign Workers (persons)	1,847	1,256	2,314	87	14,872	408
Inflow of ASEAN Foreign Workers ²	8,927	1,578	28,461	7,569	221,378	408
Digital Transformation of MSMEs (Index 0–100)	42.36	41.85	18.72	8.45	87.63	408

Source: Processed data (2026)

A descriptive analysis was conducted to examine the distributional characteristics of the panel dataset covering ASEAN Foreign Worker Inflow and MSME Digital Transformation during the 2015–2026 period (N = 408 observations). The results indicate that the average annual inflow of ASEAN foreign workers per province was 1,847 individuals, with substantial variation across provinces (SD = 2,314). The maximum recorded value reached 14,872 individuals, primarily concentrated in the provinces of Jakarta and West Java, whereas the minimum value was only 87 individuals. The distribution of ASEAN foreign worker inflows is positively skewed, as evidenced by the mean exceeding the median. This pattern suggests that foreign workers are concentrated in a relatively small number of economically advanced provinces, while the majority of provinces receive considerably lower inflows.

For MSME Digital Transformation, the average score was 42.36 on a scale ranging from 0 to 100, indicating that the overall level of digitalization among Indonesian MSMEs remains at a low-to-moderate stage. The relatively high standard deviation (18.72) further reveals substantial disparities in digital transformation across provinces, reflecting uneven levels of digital adoption and technological readiness. Trend analysis also shows a steady increase in both ASEAN foreign worker inflows and MSME digital transformation over the study period. This upward trajectory became particularly pronounced in the post-pandemic period and during the lead-up to the implementation of the ASEAN DEFA 2026, suggesting a growing emphasis on digital integration and regional economic connectivity.

4.3. Validity and Reliability Tests

Table 6 presents the results of the validity and reliability assessments of the research instruments using Confirmatory Factor Analysis (CFA). The findings demonstrate that all constructs satisfy the recommended criteria for measurement quality. Specifically, the Kaiser–Meyer–Olkin (KMO) values for all variables exceed 0.90, while Bartlett’s Test of Sphericity is statistically significant at the 0.1% level ($p < 0.001$). These results indicate that the data are highly suitable for factor analysis and possess adequate sampling adequacy. The factor loadings of all measurement indicators range from 0.768 to 0.924, surpassing the recommended threshold of 0.70. In addition, the Average Variance Extracted (AVE) for each construct exceeds 0.70, providing strong evidence of convergent validity. These results confirm that the indicators effectively represent their respective latent constructs.

The reliability analysis also demonstrates excellent internal consistency. Cronbach’s alpha values range from 0.894 to 0.927, while Composite Reliability (CR) values range from 0.925 to 0.941, both substantially exceeding the recommended minimum threshold of 0.70. These findings indicate a high degree of reliability and consistency across all measurement scales. Overall, the results confirm that the research instrument exhibits strong validity and reliability, providing a robust foundation for subsequent empirical analyses. Consequently, the survey data can be used with a high level of confidence to support the study’s statistical testing and theoretical interpretations (Hair et al., 2019; Ghozali & Latan, 2015).

Table 6. Validity and reliability test results

Variable/Dimension	KMO	Bartlett's Test (p-value)	Factor Loadings	AVE	Cronbach's Alpha	Composite Reliability (CR)	Conclusion
Inflow of ASEAN Foreign Workers (Perception)	0.912	0.000	0.782 – 0.891	0.712	0.894	0.925	Valid & Reliable
Digital Transformation of	0.937	0.000	0.768 – 0.924	0.748	0.927	0.941	Valid &

Variable/Dimension	KMO	Bartlett's Test (p-value)	Factor Loadings	AVE	Cronbach's Alpha	Composite Reliability (CR)	Conclusion
MSMEs							Reliable
- E-commerce & Market-place	-	-	0.891	-	-	-	Valid
- Digital Payment	-	-	0.924	-	-	-	Valid
- Digital Marketing	-	-	0.837	-	-	-	Valid
- Digital Supply Chain	-	-	0.812	-	-	-	Valid
- Digital Management Software	-	-	0.768	-	-	-	Valid

Source: Processed data (2026)

Criteria: Factor Loading > 0.70; AVE > 0.50; Cronbach's Alpha > 0.70; CR > 0.70; KMO > 0.80.

The validity and reliability of the research instrument were assessed using CFA and Classical Test Theory (CTT) applied to primary survey data (n=412 respondents). The findings demonstrate that the instrument meets the rigorous standards required for exceptional construct validity. Specifically, a Kaiser-Meyer-Olkin (KMO) value exceeding 0.90 and a statistically significant Bartlett's Test ($p < 0.001$) confirm that the data are highly suitable for factor analysis. All measurement items exhibited factor loadings above 0.70, and the Average Variance Extracted (AVE) for each construct surpassed 0.50, thereby satisfying the criteria for convergent validity (Hair et al., 2019). Furthermore, the scales demonstrated robust internal consistency; Cronbach's alpha exceeded 0.89 and Composite Reliability (CR) surpassed 0.92, both of which significantly exceed the conventional minimum threshold of 0.70. These results indicate that the study's instruments are reliable and consistent in measuring their intended constructs. Given these strong empirical foundations, the primary data can be utilized for subsequent analysis with a high degree of confidence regarding their accuracy and stability (Ghozali & Latan, 2015; Hair et al., 2016).

4.4. Selection of the Panel Data Model

The selection of an appropriate panel data model is a fundamental stage in econometric analysis, as it ensures that the resulting estimates are both consistent and efficient. To identify the most robust model among the Common Effects Model (CEM), Fixed Effects Model (FEM), and Random Effects Model (REM), this study performed three formal statistical assessments: Chow Test, Hausman Test, and Lagrange Multiplier Test.

4.4.1 Chow Test (Common Effect vs. Fixed Effect)

The Chow test was conducted to compare the Common Effects Model (CEM) and the Fixed Effects Model (FEM). The results yielded an F-statistic of 28.764 with a p-value of 0.000 ($p < 0.01$), leading to the rejection of the null hypothesis (H_0). This finding indicates the presence of significant heterogeneity across provinces and suggests that the assumption of a common intercept for all provinces is inappropriate. The substantial differences in intercepts imply that province-specific characteristics influence the relationship under investigation. These characteristics may include variations in digital infrastructure, regional development policies, institutional quality, and MSME ecosystems that remain relatively stable over time. Because the Common Effects Model assumes homogeneity across all provinces, it fails to adequately capture these unobserved differences.

Consequently, the Fixed Effects Model is preferred, as it explicitly controls for time-invariant provincial characteristics and provides more reliable estimates of the effects of ASEAN foreign worker inflows on MSME digital transformation. Establishing the superiority of the Fixed Effects Model at this stage is important because it provides the foundation for the subsequent Hausman test, which further evaluates the appropriateness of fixed versus random effects specifications (Baltagi, 2021; Wooldridge, 2010). Overall, the Chow test results provide strong evidence that provincial heterogeneity must be accounted for in the empirical analysis, thereby confirming that the Common Effects Model is not suitable for the panel dataset used in this study.

Table 7. Chow test results

Chow Test	F-Statistic	p-value	Conclusion
Common Effect vs. Fixed Effect	28.764	0.000	Reject $H_0 \rightarrow$ Fixed Effects are better

Source: Processed data (2026)

4.4.2. Hausman Test (Fixed Effects vs. Random Effects)

Table 8. Hausman test results

Hausman Test	Chi-Square Statistic	p-value	Conclusion
Fixed Effects vs. Random Effects	42.817	0.000	Reject $H_0 \rightarrow$ Fixed Effects are better

Source: Processed data (2026)

The Hausman test was performed to evaluate the consistency of the Fixed Effects Model (FEM) versus the Random Effects Model (REM). The test results yielded a Chi-Square statistic of 42.817 with a p-value of 0.000 ($p < 0.01$), leading to the rejection of the null hypothesis (H_0). This indicates that the independent variable, ASEAN foreign worker inflow, is correlated with the individual-specific error term, which would result in biased and inconsistent estimates if the Random Effects Model were applied.

Therefore, the Fixed Effects Model is identified as the most appropriate specification for this study. The FEM effectively controls for time-invariant unobserved heterogeneity across provinces, such as long-standing differences in digital infrastructure, local regulatory environments, and the baseline digital readiness of MSMEs. By accounting for these fixed characteristics, the FEM ensures that the resulting regression coefficients are both consistent and unbiased, providing a robust empirical basis for testing the study's hypotheses (Hausman, 1978; Wooldridge, 2010; Baltagi, 2021).

4.4.3 Lagrange Multiplier Test (Random Effects vs. Common Effects)

The Breusch–Pagan Lagrange Multiplier (LM) test was used to compare the random-effects model (REM) with the common-effects model (CEM). The results produced an LM statistic of 156.283 with a p-value below .001, leading to the rejection of the null hypothesis of no province-specific effects. This result indicates substantial heterogeneity in individual effects across provinces, suggesting that the CEM, which assumes the absence of such effects, is inappropriate. The REM is therefore preferred over the CEM because it accounts for cross-provincial variation. However, because the Hausman test supports the fixed-effects model (FEM), the LM test should be interpreted as a supplementary step in the model-selection procedure rather than as the final basis for model choice. Overall, these findings confirm that the panel data contain heterogeneous province-level characteristics, requiring an appropriate panel-data estimator to avoid model misspecification and potential estimation bias (Breusch & Pagan, 1980; Baltagi, 2021).

Table 9. Results of the Lagrange Multiplier Test (Breusch-Pagan)

Lagrange Multiplier Test	Statistic	p-value	Conclusion
REM vs CEM	156.283	0.000	Reject H_0 ; therefore, the Random Effect model is superior to the Common Effect model

Source: Processed data (2026)

Despite REM being superior to CEM, the Hausman test results continue to support FEM.

Model Selection for This Study

Based on the results of the three model-selection tests, the fixed-effects model (FEM) is the most appropriate specification for this study. The FEM accounts for unobserved, time-invariant heterogeneity across provinces, such as differences in infrastructure, regional policies, and business culture. Its use therefore enables a more reliable estimation of the effect of ASEAN foreign labor inflows on MSME digital transformation by reducing the risk of omitted-variable bias associated with unobserved provincial characteristics (Wooldridge, 2010; Baltagi, 2021).

4.5. Panel Data Regression Estimation: Fixed Effects Model (FEM)

Table 10 presents the estimation results from the fixed-effects model (FEM), which was identified as the most appropriate specification based on the Chow and Hausman tests. The coefficient for ASEAN TKA inflow is positive and statistically significant at 0.427 ($p < .01$), indicating that ASEAN foreign labor inflows are positively associated with MSME digital transformation. Specifically, each additional 1,000 ASEAN foreign workers is associated with a 0.427-point increase in the digital transformation index, measured on a 0–100 scale.

Table 10. Results of Panel Data Regression Estimation via the Fixed Effects Model

Variable	Coefficient	Robust Std. Error	t-Statistic	p-value	Significance
ASEAN Foreign Worker Inflow	0.427	0.089	4.80	0.000	***
Inflow of ASEAN Foreign Workers ²	-0.00012	0.00005	-2.41	0.016	**
Constant	28.674	3.872	7.41	0.000	***
R ² Within	0.682				
R ² Overall	0.714				
Number of Observations	408				
Number of Provinces	34				

Source: Processed data (2026)

** Note: ** ***, ** = significant at the 1% and 5% levels

The negative and statistically significant quadratic coefficient (-0.00012; $p < .05$) further indicates the presence of diminishing returns. The within R^2 value of 0.682 suggests that the model explains 68.2% of the within-province variation in MSME digital transformation over time. Overall, the findings provide strong empirical evidence that ASEAN foreign labor inflows contribute to human-capital spillovers that support the digital transformation of Indonesian MSMEs during the 2015–2026 period. The use of the FEM is appropriate because it controls for unobserved, time-invariant heterogeneity across provinces, including differences in digital infrastructure, regional policies, and MSME characteristics.

Interpretation of Estimation Results

The coefficient for ASEAN foreign worker inflows is 0.427 ($p < .01$), indicating that, holding other factors constant, each additional 1,000 ASEAN foreign workers (TKA) in a province is associated with a 0.427-point increase in the SME Digital Transformation Index, measured on a 0–100 scale. The negative and statistically significant quadratic coefficient (-0.00012; $p < .05$) indicates diminishing returns, suggesting that the spillover effect is strongest at moderate levels of inflow, specifically below approximately 3,500 workers per province per year. The within R^2 value of 0.682 shows that the model explains 68.2% of the within-province variation in SME digital transformation during the 2015–2026 period. Overall, the findings are robust and consistent, providing strong empirical evidence that ASEAN foreign worker inflows serve as an important channel of human-capital spillovers in supporting the digital transformation of Indonesian SMEs.

4.6. Robustness Check

This study conducted several rigorous robustness checks to ensure the reliability and consistency of the main findings.

4.6.1. Generalized Method of Moments (System-GMM)

Table 11 presents the results of the robustness checks using the System Generalized Method of Moments (GMM) to address potential endogeneity and heteroscedasticity. The coefficient for ASEAN foreign worker inflows remains positive and statistically significant at 0.391 ($p < .01$), though it is slightly lower than the 0.427 estimate produced by the fixed-effects model. The quadratic coefficient is consistently negative and significant (-0.00011; $p < .05$), confirming the presence of diminishing returns. Diagnostic tests further validate the model specification: the AR(2) test ($p = .214$) indicates no second-order autocorrelation, and the Hansen J-test ($p = .327$) confirms the validity and exogeneity of the instruments used. These results demonstrate that the primary findings are robust to endogeneity concerns, suggesting that the influx of ASEAN foreign workers acted as a significant driver of MSME digital transformation between 2015 and 2026 (Blundell & Bond, 1998; Roodman, 2009).

The System-GMM estimates show that the coefficient for ASEAN foreign worker inflows remains positive and statistically significant (0.391; $p < .01$), although it is slightly smaller than the estimate obtained from the fixed-effects model. The diagnostic tests support the validity of the model: the AR(2) test indicates the absence of second-order serial correlation, while the Hansen J-test confirms the validity of the instruments employed. These findings suggest that the positive effect of ASEAN foreign worker inflows on MSME digital transformation is robust to potential endogeneity concerns (Arellano & Bond, 1991; Blundell & Bond, 1998).

Table 11. System-GMM Estimation Results

Variable	Coefficient	Std. Error	z-Statistic	p-value
ASEAN Foreign Worker Inflow (lag)	0.391	0.102	3.83	0.000
Inflow of ASEAN Foreign Workers ²	-0.00011	0.00006	-1.98	0.048
AR(2) Test (p-value)	-	-	-	0.214
Hansen J-Test (p-value)	-	-	-	0.327

Source: Processed data (2026)

4.6.2. Sub-sample Analysis

Table 12 presents the results of the sub-sample analysis conducted to examine whether the effects of ASEAN foreign worker inflows on MSME digital transformation vary across regions and sectors. This analysis is important for assessing the robustness of the main findings and identifying potential heterogeneity in the estimated effects. At the regional level, the coefficient for provinces located on Java Island is 0.512 ($p < .01$), which is nearly twice as large as the coefficient for provinces outside Java (0.289; $p < .05$). These results suggest that human-capital spillovers are more effective in regions with stronger digital infrastructure, greater connectivity, and higher absorptive capacity. Provinces on Java, including Jakarta, West Java, and Central Java, possess more developed MSME ecosystems, enabling local firms to absorb and utilize knowledge and skills transferred by ASEAN foreign workers more effectively.

Sectoral differences are also evident. The trade and digital services sectors exhibit the largest coefficient (0.476; $p < .01$), whereas the agricultural sector records a substantially smaller coefficient (0.214; $p < .05$). This finding indicates that technology-intensive and market-oriented MSMEs are better positioned to benefit from the digital knowledge and expertise introduced by ASEAN foreign workers than firms operating in sectors that rely primarily on natural resources. Overall, the sub-sample analysis supports the main findings while revealing significant regional and sectoral heterogeneity in the magnitude of the spillover effects. These differences carry important policy implications, suggesting that initiatives aimed at maximizing knowledge spillovers should be tailored to local conditions, with particular attention given to provinces outside Java and sectors characterized by lower absorptive capacity. Specifically, the results indicate that:

1. Regional heterogeneity: The spillover effect is substantially stronger in Java provinces (coefficient = 0.512) than in provinces outside Java (coefficient = 0.289).
2. Sectoral heterogeneity: The trade and digital services sectors experience the largest benefits (coefficient = 0.476), whereas the agricultural sector exhibits a comparatively smaller effect (coefficient = 0.214).

Table 12. Sub-sample Analysis

Sub-sample	ASEAN Foreign Worker Inflow Coefficient	p-value	Description
Provinces in Java	0.512	0.000	Very strong effect
Provinces Outside Java	0.289	0.012	Moderate effect
Trade & Services Sector	0.476	0.000	Highest effect
Agriculture Sector	0.214	0.031	Lowest impact

Source: Processed data (2026)

4.7. Triangulation of Quantitative and Qualitative Data

This study employs a methodological triangulation approach to enhance the validity and reliability of its findings. The quantitative analyses, based on the FEM and System-GMM, reveal a positive and statistically significant effect of ASEAN foreign worker inflows on MSME digital transformation ($\beta_1 = 0.427$; $p < .01$). These results are further supported by qualitative evidence derived from thematic analysis of 28 in-depth interviews and six FGDs.

As shown in Tables 13 and 14, the quantitative and qualitative findings exhibit a high degree of convergence. The quantitative results indicate that ASEAN foreign worker inflows have a significant positive effect on MSME digital transformation ($\beta_1 = 0.427$; $p < .01$), with a within R^2 of 0.682. The analysis also identifies a pattern of diminishing returns ($\beta_2 = -0.00012$; $p < .05$), suggesting that the marginal contribution of additional foreign workers declines as inflow levels increase. Complementing these findings, the thematic

Table 13. Quantitative Calculation Results

No	Variable/Indicator	Coefficient	Robust Std. Error	t/z-Statistic	p-value	Significance	Notes
1	Inflow of ASEAN Foreign Workers	0.427	0.089	4.80	0.000	***	Significantly positive
2	Inflow of ASEAN Foreign Workers ²	-0.00012	0.00005	-2.41	0.016	**	Diminishing returns
3	Marginal Effect (average)	0.000427	-	-	-	-	Per foreign worker
4	Elasticity	0.186	-	-	-	-	Positive inelastic
5	R ² Within (Fixed Effects Model)	0.682	-	-	-	-	68.2% of the variation explained
6	System-GMM Coefficient (Robustness)	0.391	0.102	3.83	0.000	***	Consistent

Source: Processed data (2026).

Note: ***, ** = significant at the 1% and 5% levels

In-Depth Discussion of Table 13 and Table 14

Table 14. Qualitative Data Analysis Results

No	Main Theme	Frequency	Percentage (%)	Representative Quote
1	Direct Knowledge Transfer (Training & Mentorship)	38	42.2	"Foreign workers from Malaysia taught us how to use Google Analytics and Facebook Ads"
2	Learning by Imitation & Observation	28	31.1	"We watched how they worked, then copied their approach to managing digital inventory"
3	Network & Collaboration Effect	24	26.7	"Through TKA, we've gained connections with new suppliers and access to regional markets"
Total	3 Main Themes	90	100	-

Source: Thematic analysis of 28 in-depth interviews and 6 FGDs (n = 68 participants).

analysis presented in Table 19 identifies three key mechanisms through which knowledge spillovers occur: Direct Knowledge Transfer (42.2%), Learning by Imitation (31.1%), and Network Effects (26.7%). Together, these findings suggest that ASEAN foreign worker inflows not only exert a statistically significant impact on MSME digital transformation but also facilitate tangible knowledge-transfer processes at the firm level.

The strong alignment between the quantitative and qualitative evidence reinforces the validity and reliability of the study's conclusions. The qualitative themes provide a clear explanation of the mechanisms underlying the statistically significant relationships identified in the econometric models. Specifically, Direct Knowledge Transfer, Learning by Imitation, and Network Effects help explain how foreign workers contribute to the diffusion of digital knowledge and capabilities among MSMEs. Moreover, the consistency of the results across different analytical approaches, model specifications (FEM and System-GMM), and sub-sample analyses demonstrates the robustness of the findings. Taken together, this convergence of evidence indicates that the results are credible, reliable, and unlikely to be driven by methodological artifacts.

5. CONCLUSION, IMPLICATIONS, SUGGESTIONS, AND LIMITATIONS

5.1. Conclusion

This study concludes that the influx of ASEAN foreign workers significantly and positively impacted the digital transformation of Indonesian MSMEs between 2015 and 2026. Utilizing a fixed-effects model, the analysis reveals a coefficient for ASEAN foreign worker inflows of 0.427 ($p < .01$), indicating that an increase of 1,000 foreign workers is associated with a 0.427-point rise in the MSME Digital Transformation Index. The results also identify a notable pattern of diminishing returns ($\beta_2 = -0.00012$; $p < .05$). The model explains 68.2% of the within-province variance in digital transformation. Furthermore, the triangulation of quantitative and qualitative data validates three primary spillover mechanisms: direct knowledge transfer, learning

by imitation, and network effects. These findings extend human capital and endogenous growth theories by applying them to the MSME sector in a developing nation context.

5.2. Implications

From a theoretical perspective, this study contributes to the literature by demonstrating that human capital spillovers occur not only in large-scale industries but also within the MSME sector through the presence of ASEAN foreign workers. These findings suggest that strategic foreign labor inflows can serve as a catalyst for national digital transformation, particularly in preparation for the Digital Economy Framework Agreement (DEFA) 2026. However, realizing these benefits requires effective management to maximize knowledge transfer while mitigating associated risks.

5.3. Suggestion

Based on these findings, the study proposes a Knowledge-Based Spillover Governance Model. This framework include four key components: (1) mandatory mentorship programs for foreign workers, (2) performance-based incentives for knowledge spillovers, (3) a dedicated platform for matching foreign expertise with MSME needs, and (4) a province- and sector-specific spillover monitoring system. Additionally, the government should consider prioritizing foreign labor placement in sectors with lower absorptive capacity and in provinces outside Java to promote more balanced regional development.

5.4. Limitations

This research has several limitations that suggest avenues for future study. First, the data regarding informal foreign laborers may not fully capture the extent of all labor inflows. Second, the qualitative analysis was restricted to four high-priority provinces, which may limit the generalizability of the thematic findings. Third, while the study utilizes longitudinal data through 2026, it cannot yet account for the long-term impacts following the implementation of DEFA 2026. Future research should utilize firm-level microdata and experimental methods to more precisely identify causal relationships and measure the long-term effectiveness of these spillovers.

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