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ANALYSIS OF BIG DATA-BASED FINANCIAL TECHNOLOGY AND AI ON FINANCIAL INCLUSION IN INDONESIA

Sari Asrini[1], Dwita Sakuntala[2], Lia Nazliana Nasution[3]
Universitas Pembangunan Panca Budi[123]
E-mail: [1]sariasrini52@gmail.com, [2]sakuntaladwita@gmail.com, [3]lianazlina@dosen.pancabudi.ac.id

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Abstract

the effect of implementing Big Data and Artificial Intelligence (AI)-based financial technology on increasing financial inclusion in Indonesia during the period 2019–2024. The background of this study is based on the rapid increase in digital transformation in the financial sector triggered by the adoption of fintech, but there is still a gap in financial access, especially among low-income groups and disadvantaged regions. This study uses a quantitative approach with a panel data model, involving independent variables of Gross Regional Domestic Product (GRDP), education level, average internet access, fintech loan recipient entities, and the number of mobile banking users on the dependent variable of the Financial Inclusion Index. The data was obtained from official publications of the Financial Services Authority (OJK), Bank Indonesia (BI), and the Central Statistics Agency (BPS). The results of the analysis show that Big Data and AI have a positive and significant contribution to expanding financial inclusion through increased credit distribution efficiency, expanded access to digital services, and personalized financial products. However, their influence is still limited by gaps in digital literacy, infrastructure, and trust in data security. The findings of this study are expected to provide strategic input for regulators, fintech industry players, and academics in formulating technology-based inclusive policies to achieve sustainable national financial inclusion targets.

Keywords: *Big Data, Artificial Intelligence, Fintech, Financial Inclusion, panel model*

INTRODUCTION

Financial inclusion is one of the main pillars of national economic development because it plays an important role in expanding public access to formal financial services such as savings, credit, insurance, and investment (Zulkifli & Wasesa, 2024). Inclusive financial access enables individuals and micro, small, and medium enterprises (MSMEs) to improve their welfare, productivity, and economic resilience ("Glob. State Financ. Incl. Consum. Prot. 2022," 2023). In Indonesia, efforts to increase financial inclusion have become a national priority through the National Strategy for Financial Inclusion (SNKI), which emphasizes cross-sectoral synergy to achieve a fair and sustainable financial system (OJK, 2021). Although the national financial inclusion index increased from 67.8% in 2016 to 85.1% in 2022 (OJK, 2023), there is still a gap between the level of inclusion and financial literacy, which has only reached 49.68% (Henry Wasosa, 2025). This condition shows that some people have access to financial services but do not fully understand how to use them optimally. This challenge is exacerbated by geographical and digital disparities, especially in disadvantaged, frontier, and outermost (3T) areas (Maryana et al., 2025).

The development of digital technology, particularly Big Data Analytics and Artificial Intelligence (AI), has revolutionized the financial services sector. These two technologies enable financial institutions to analyze customer behavior in real-time, assess creditworthiness based on non-traditional data, and reduce risk through predictive models (Gomber et al., 2018). Fintech that adopts AI and Big Data can accelerate the microcredit process, expand digital financial access, and personalize services for people who were previously unreachable by formal financial institutions (Sarah Lutfiyah Nugraha & Ika Yunia Fauzia, 2021; Bakar et al., 2025). However, the use of this technology poses new dilemmas, such as the digital divide, data security risks, and low digital literacy among some segments of society. Although Indonesia's fintech ecosystem is growing rapidly and is the second largest in ASEAN, not all financial institutions are optimally utilizing the potential of AI and Big Data to expand national financial inclusion (Sutrisno, 2018; Venia & Shochrul Rohmatul Ajija, 2024). A gap in the literature is also evident. Most previous studies have focused only on aspects of fintech, financial literacy, or payment digitization, without examining the empirical relationship between the application of Big Data and AI-based technology and

improvements in the financial inclusion index (Sutrisno, 2018; Sari & Utami, 2022; Caseba, 2024). Therefore, this study aims to fill this gap by analyzing the influence of macroeconomic variables and technology indicators—namely GRDP, education level, internet access, fintech loan recipients, and mobile banking users—on the financial inclusion index in Indonesia during the period 2019–2024. The results of this study are expected to enrich the empirical literature on the role of financial technology in expanding financial access and provide strategic recommendations for regulators and industry players to accelerate the achievement of sustainable national financial inclusion targets. The Technology Acceptance Model (TAM) theory proposed by Davis (1989) explains that user acceptance of technology is influenced by two main factors, namely perceived usefulness and perceived ease of use. In the context of Big Data and Artificial Intelligence (AI)-based financial technology, TAM helps explain how people, especially those who are financially underserved, are willing to adopt digital services as a means of financial inclusion (Wilson, 1914; Darmajaya, 2011).

Furthermore, the Monetary Transmission Mechanism theory highlights how monetary policies such as interest rate changes can have a more effective impact in an inclusive financial system, as public participation in financial institutions increases. In line with this, the Quantity Theory of Money (Irving Fisher) asserts that the greater the amount of money circulating through the formal system, the more stable the national economic circulation will be. Meanwhile, the Financial Intermediation Theory positions financial institutions as important intermediaries between savers and borrowers, where increased financial inclusion strengthens this intermediary function. In the Keynesian Liquidity Preference Theory, financial inclusion enables the public to manage money for transaction, precautionary, and speculative needs, thereby contributing to monetary stability. Meanwhile, Financial Deepening Theory emphasizes that the deeper a country's financial system, the higher the efficiency and effectiveness of economic resource allocation (Rihani et al., 2025).

According to the World Bank Group (2020), financial inclusion is the availability of equitable and affordable access to formal financial services for all levels of society. The success of financial inclusion is measured through indicators such as the number of accounts, the volume of digital transactions, and the level of use of digital financial services. Indonesia's national target is to achieve a 90% inclusion rate by 2024. In the context of digital transformation, Big Data and Artificial Intelligence (AI) play a central role in expanding financial access and improving the efficiency of fintech services. Big Data enables in-depth analysis of the behavior of people who do not yet have access to formal finance, while AI supports non-traditional data-based credit scoring, product personalization, and predictive fraud detection (Caseba, 2024; Maryana et al., 2025). The application of these two technologies also supports financial process automation, real-time reporting, and high-accuracy regulatory compliance (Putri, 2024; Serang et al., 2025; Nazari & Mukhtaruddin, 2025). However, challenges such as data security, digital literacy, and infrastructure readiness still need to be addressed in order for the use of this technology to run optimally (Zulkifli et al., 2025).

Fintech has also changed the behavior of the younger generation, who are increasingly accustomed to digital financial services. Generation Z and millennials prefer application-based platforms because of their convenience, speed, and personalized services (Njonge, 2023; Bermeo-Giraldo et al., 2023). This shift in behavior has led to an increase in digital transactions, micro-investments, and awareness of data security. This phenomenon shows that fintech plays an important role not only as a provider of financial services but also as an agent of financial education that shapes the consumptive and productive behavior of the digital generation (Nugraha & Fauzia, 2021).

From the perspective of supporting research variables, economic growth is measured through GRDP, which, according to the Finance-Growth Nexus theory (King & Levine, 1993) and Endogenous Growth Theory (Romer, 1986), is positively related to increased public access to finance. The education variable is explained by Human Capital Theory (Becker, 1964) and Knowledge-Based Economy (Lucas, 1988), which emphasize that higher education encourages financial literacy and participation. Meanwhile, household internet access is related to the Technology Diffusion Theory (Rogers, 1962) and Network Effect Theory (Katz & Shapiro, 1985), which show that digital penetration accelerates the adoption of technology-based financial services. The fintech loan recipient variable is supported by Financial Innovation Theory (Merton, 1995) and Peer-to-Peer Lending Theory (Chernoff & Jagtiani, 2024), which affirm the role of fintech in reaching the unbanked through alternative credit models. Finally, the mobile banking user variable is explained by Diffusion of Innovations Theory (Rogers, 2003), which describes the spread of digital financial innovations in modern society. Overall, these theories form the conceptual basis of this study, which examines the relationship between economic factors, education, digital access, and technological innovation on increasing national financial inclusion in the digital era.

METHOD

This study is a quantitative study with a descriptive approach. A quantitative approach was used because this study aims to examine the relationship between variables based on numerical data and perform statistical analysis. This study is also explanatory in nature because it explains the influence of independent variables (X), namely GRDP, education level (PDD), and households with internet access (INT), on the dependent variable (Y), namely the Financial Inclusion Index in Indonesia. The population uses all banking statistics data in Indonesia published by the OJK, Bank Indonesia, and other financial institutions. The sample was taken from annual data in Indonesia for a period of 6 years (2020–2025) in 34 provinces in Indonesia.

This study uses a panel data equation model, which is a combination of time series and cross-sectional data, to test the significance of the relationship between variables X and Y. The model used in this study is a panel data regression analysis, which is a statistical method used to examine the effect of several predictor variables on one response variable with a panel data structure (Salsabila et al., 2022). The selection of the best panel regression model (between Common Effect Model, Fixed Effect Model, and Random Effect Model) was conducted using Chow and Hausman tests. All data processing was performed using EViews 12 statistical software with a significance level of $\alpha = 0.05$ (5%). The research equation is :

$$INCLUSION = \alpha 0 + \alpha 1 lnPDRB + \alpha 2 PDD + \alpha 3 INT + \alpha 4 lnFINT + \alpha 5 MB + \varepsilon$$

explanation:

INCLUSION = Financial inclusion index
X1 = PDRB (PDRB)
X2 = PDD (Education level)
X3 = INT (RT Internet access)
X4 = FINT (Number of fintech loan recipient accounts)
X5 = MB (Number of Mobile Banking users)
ln = logaritm natural
ε = error term

Next, classical assumption testing was conducted to ensure that the regression model met the Best Linear Unbiased Estimator (BLUE) criteria. Classical assumption testing included:

1. Autocorrelation test, to detect the presence or absence of relationships between residuals in different time periods (Baltagi, B. H. (2021).
2. Multicollinearity test, to ensure that there is no high correlation between independent variables that could affect the stability of the regression coefficients (Handema et al., 2024).
3. The heteroscedasticity test, to determine whether the residual variance is homogeneous (constant) across all observations (Salsabila et al., 2022).
4. The normality test, to ensure that the residual distribution is normal, so that the estimation results are statistically valid (Nugraha & Fauzia, 2021).

Next, inferential statistical testing was carried out, consisting of:

1. The t-test, to determine the partial effect of each independent variable on the dependent variable (Nugraha & Fauzia, 2021).
2. F test, to test the simultaneous effect of independent variables on the dependent variable, Baltagi, B. H. (2021).
3. Coefficient of determination (R^2), to measure the extent to which the variation in the dependent variable can be explained by the independent variables in the model (Zulkifli et al., 2025).

RESULTS AND DISCUSSION

A. Chow Test

Table 1. Chow Test Results

Cross-section Chi-square	6.595.442	5	**0.2525**

Source: EViews test results, 2025

Probability 0.2525 > 0.05. Therefore, the selected model is the CEM.

After the Chow test selects the Common Effect Model (CEM), the first test that must be performed is the overall F test to test the significance of the regression parameters simultaneously. This verifies whether the CEM model as a whole has a significant effect on the dependent variable. (Baltagi, B. H. (2021). Econometric Analysis of Panel Data. Springer) (Handema et al., 2024).

B. F-test

Table 2 F-Test Results

F-statistic	3.858.051
Prob(F-statistic)	0.000000

Source: EViews test results, 2025
F table = 2.678667
F calculated = 38.58051
If the calculated F value > F table and if the probability (significance) is less than 0.05 (α), then H0 is rejected, meaning that the independent variables simultaneously affect the dependent variable significantly.
Calculated F 38.58501 > Table F 2.678667 and probability sig 0.0000 means that the independent variables, namely X1 (PDRB), X2 (PDD), X3 (INT), X4 (FINT), and X5 (MB), simultaneously or together significantly affect the dependent variable Y (INK).

C. Classic Assumption Test
Next, perform standard classical assumption tests such as multicollinearity, heteroscedasticity, and autocorrelation to ensure the validity of the model.
1. Autocorrelation Test

Table 3 Durbin Watson Test Results

Durbin-Watson stat	2.086.984

Source: EViews test results, 2025
Dstat = 2.086984
DL is the lower limit of the Durbin Watson table = 1.17545. DU is the upper limit of the Durbin Watson table = 1.79873.
Where D 2.086984 > DU 1.79873, there is no positive autocorrelation.
If (4 – D 2.086984) > DU 1.79873, then there is no negative autocorrelation.

2. Multicollinearity Test

Table 4 Multicollinearity Test Results

X1	X2	X3	X4	X5
1	**0.1995771883954067**	0.4436892066107548	0.0842814167303410 8	0.2632823224126942
0.1995771883954067	1	**0.6098934012451148**	0.5309426067315235	0.3402315614521593
0.4436892066107548	0.6098934012451148	1	0.3732339461340287	0.2662770360436906
0.0842814167303410 8	0.5309426067315235	0.3732339461340287	1	0.6323118171717958
0.2632823224126942	0.3402315614521593	0.2662770360436906	0.6323118171717958	1

Source: EViews test results, 2025
The correlation coefficient for X1PDRB = 0.19957 < 0.85, X2 = 0.6098 < 0.85. X3 = 0.37323 < 0.85, X4 = 0.263282 and X5 = 0.6323 < 0.85. Therefore, it can be concluded that there is no multicollinearity or that the multicollinearity test has been passed.

3. Heteroscedasticity Test

Table 5 Heteroscedasticity Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.029.333	7.121.257	1.127.516	0.2685
X1	-1.39E-06	8.00E-06	-0.173879	**0.8631**
X2	0.114197	0.069686	1.638.749	**0.1117**
X3	-0.083573	0.055030	-1.518.686	**0.1393**
X4	-0.237771	0.720565	-0.329978	**0.7437**
X5	-0.575010	0.405066	-1.419.547	**0.1660**

Source: EViews test results, 2025

Based on the results of the Glejser test for heteroscedasticity, variables X1, X2, X3, X4, and X5 have p-values > 0.05, meaning that there is no indication of heteroscedasticity caused by these variables.

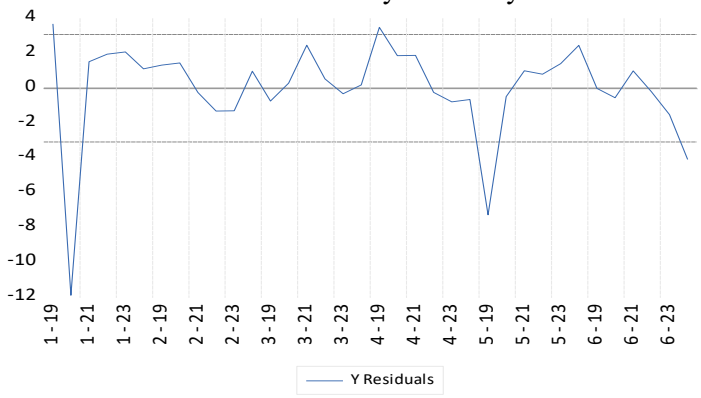

Figure 1. Heteroscedasticity Test Results Graph

D. Normality Test

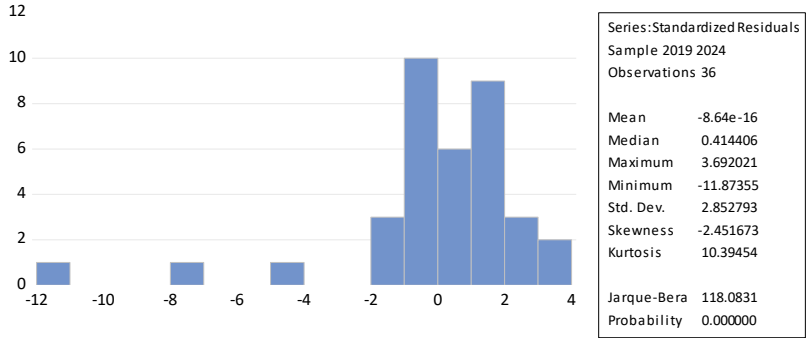

Figure 2. JB test results chart

Source: EViews test results, 2025

Jarque–Bera = 118.0831

Probability = 0.0000

H_0: Residuals are normally distributed.

H_1: Residuals are not normally distributed.

Decision criteria:

If Prob (JB) > 0.05, then fail to reject H_0 → residuals are normally distributed.

If Prob (JB) < 0.05, then reject H_0 → residuals are not normally distributed.

Since the value of Prob (JB) = 118.0831 > 0.05, the residuals in this model are normally distributed. Based on the results of the normality test, the JB probability value > 0.05 indicates that there is no violation of the normality

assumption. This means that the panel regression model used has fulfilled one of the classical assumptions, namely the assumption of residual normality.

E. t-test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.814.162	1.025.304	-0.567067	0.5749
X1	5.22E-05	1.15E-05	4.527.103	0.0001
X2	-0.069946	0.100332	-0.697143	0.4911
X3	0.471785	0.079230	5.954.606	0.0000
X4	3.002.116	1.037.455	2.893.732	0.0070
X5	0.745235	0.583206	1.277.825	0.2111

Source: EViews test results, 2025

The t-test result for variable X1 is 4.527103 > t table 2.032245, and the significance. is 0.0001, so H0 is rejected, meaning that variable X1 partially affects the financial inclusion variable significantly. This shows that the Regional Gross Domestic Product (GDP) variable has a positive and significant effect on Financial Inclusion. This means that an increase in regional economic activity, as reflected in the rise in GRDP, will encourage an increase in community financial inclusion.

The t-test result for variable X2 is -0.697143 < t table 2.032245, and sig. is 0.4911, so H0 is accepted, meaning that variable X2PDD does not partially influence the Inclusion variable significantly. This result shows that a higher level of education does not necessarily guarantee a greater ability to understand, access, and utilize formal financial services such as Fintech applications and mobile banking.

The t-test result for variable X3INT is 5.9546 > t table 2.032245 and sig. is 0.0000, so H0 is rejected, meaning that the INT variable partially affects the Inclusion variable significantly. This finding shows that the wider the community's internet access, the higher the level of financial inclusion in a region.

The t-test result for variable X4FINT is 2.8937 > t table 2.032245 and sig. is 0.0070, so H0 is rejected, meaning that the FINT variable partially influences the Inclusion variable significantly. This finding shows that the wider the community's internet access, the higher the community's access to formal finance, such as online loans/paylater, and thus the level of financial inclusion in a region also increases.

The t-test result for variable X5MB is 1.27785 < t table 2.032245 and sig. is 0.2111, so H0 is rejected, meaning that the MB variable does not significantly affect the Inclusion variable. The results of this study indicate that the use of mobile banking by the public is not an indicator of an increase in the financial inclusion index in each province because not all groups understand how to use mobile banking, even if they are highly educated.

F. Panel Regression Analysis

Panel regression equation results:

Yinklusi=c1+c2logX1PDRB-c3X2PDD+c4X3INT+c5logFINT + c6MB

Yinklusi= 5.81416 + 5.21701*X1 - 0.06994*X2 + 0.47178*X3 + 3.00211*X4 + 0.74523*X5

The above equation can be explained as follows:

1. Interpretation of the Constant (Intercept). The constant value of 5.81416 indicates that if all independent variables (X_1–X_5) are considered to be zero, then the level of financial inclusion (Yinklusi) is at 5.81416 units. Although this condition is hypothetical because in empirical practice it is difficult to find an absolute zero value for economic variables, this constant is still important to show the baseline level of financial inclusion that may be generated by factors outside the model, such as basic financial regulations, government initiatives, or community behavior towards formal financial services.
2. A coefficient of 5.21701 indicates that every 1 unit increase in PDR will increase the level of financial inclusion by 5.21701 units, assuming other variables remain constant. This finding illustrates that regional economic growth has a positive and substantial contribution to increasing financial inclusion. The higher the PDRB, the greater the economic capacity of the community to access and utilize formal financial services.
3. The coefficient of the education variable of –0.06994 shows a negative relationship, albeit relatively small. This means that every 1-unit increase in the education variable is associated with a 0.06994-unit decrease in the level of financial inclusion, ceteris paribus. This finding can be interpreted in two ways: formal education has not

been fully followed by practical financial literacy, or highly educated individuals may have preferences for forms of investment or financial transactions that are not recorded in the conventional inclusion system. These results show that the three independent variables have a positive effect on financial inclusion.

4. The coefficient of the financial technology (FINT) variable of 3.00211 shows a positive and significant effect on the level of financial inclusion. This means that every one-unit increase in the use and penetration of fintech services such as online lending (P2P lending) and paylater services will drive an increase in financial inclusion of 3.00211 units, assuming other variables remain constant. This relatively high coefficient value indicates that the development of the fintech sector is a major determinant in expanding public access to formal financial services in the digital era. These results illustrate that the existence of fintech platforms is able to reach segments of society that were previously unserved (unbanked) and underserved (underbanked) by conventional financial institutions. Through more flexible mechanisms, digital applications, and without the need for physical infrastructure such as bank branches, fintech provides alternative financial solutions for low-income communities, MSME players, and the younger generation who prefer fast and practical services.
5. The mobile banking (MB) variable coefficient of 0.74523 shows a positive and significant effect on the level of financial inclusion. This indicates that every one-unit increase in the intensity or penetration of mobile banking service usage will increase the financial inclusion index by 0.74523 units, assuming other variables remain constant. Empirically, these findings reinforce the view that the transformation of banking services towards digitalization through mobile applications has become a major driver of the expansion of formal financial access, especially in areas with limited physical banking infrastructure.

G. Test the coefficient of determination

The Adjusted R-Square value is considered good if it is > 0.5 because the value of Adjusted R2 is close to 1, meaning that most of the independent variables explain the dependent variable, whereas if the coefficient of determination is 0, the independent variables have no effect on the dependent variable. The adjusted R-Squared value is 0.8654 or 86.54%. This coefficient value explains that independent variables such as PDRB, PDD, INT, FINT, and MB are able to explain the dependent variable of Inclusion by 86.54 percent, while the remainder is influenced by other variables not explained in this study.

CONCLUSION

Based on the empirical research results described in the discussion section, it can be concluded that all variables in this research model have a significant effect on the level of financial inclusion in Indonesia. The regression estimation results show that economic and digital factors play a complementary role in encouraging public participation in the formal financial system.

First, economic growth (GRDP) has a positive and significant effect on financial inclusion. This shows that the higher the national economic activity, the greater the community's ability to participate in formal financial services, whether through savings, credit, or investment. Thus, stable economic growth is an important prerequisite for strengthening community access to finance.

Second, education levels show a positive but not yet optimal relationship with financial inclusion. These results indicate that improvements in formal education are not always followed by improvements in financial literacy. This condition illustrates the need to strengthen financial education and digital literacy programs so that education can make a real contribution to increasing public financial participation.

Third, internet access has a positive influence on financial inclusion. The wider the internet network coverage, especially in semi-urban and rural areas, the greater the opportunity for the community to utilize digital banking services, fintech, and non-cash transactions. The internet serves as the basic infrastructure that strengthens the transformation of the financial sector towards a more efficient and inclusive digital model.

Fourth, financial technology (fintech) is the variable with the most dominant influence on financial inclusion. Innovations such as peer-to-peer lending, digital payments, and paylater have expanded the reach of financial services to groups of people who were previously not served by formal financial institutions. Fintech acts as an instrument of financial democratization that accelerates national financial inclusion, although strict supervision is still needed so that these innovations do not pose social or financial risks.

Fifth, mobile banking has also proven to have a positive and significant effect on financial inclusion. The digitization of banking services allows people to conduct transactions quickly, safely, and affordably without geographical barriers. Mobile banking bridges the gap between the formal financial sector and the wider community, especially in connecting informal economic activities with the formal financial system.

Overall, this study confirms that the digital ecosystem and the development of financial technology have been key factors in accelerating the achievement of national financial inclusion targets as mandated in the National Strategy for Inclusive Finance (SNKI). The synergy between economic growth, education, and digital infrastructure is the main foundation for an inclusive, sustainable, and socially just financial system. The results of this study have important implications for the formulation of public policy in the areas of finance and national economic development. The government, together with the Financial Services Authority (OJK), Bank Indonesia (BI), and the Ministry of Education, needs to strengthen digital financial literacy through integrated programs in formal and non-formal education. Education on the use of mobile banking, fintech, and other digital financial services must be expanded so that the public understands both the benefits and risks. In addition, accelerating the development of digital infrastructure, especially in disadvantaged, frontier, and outermost (3T) areas, is a priority in order to reduce the internet access gap and ensure that the benefits of the digital economy are felt evenly. This step is in line with the implementation of the Indonesian National Financial Literacy Strategy (SNLKI) and the National Digital Economy and Finance Strategy (SNEKD) 2021-2025.

Furthermore, supervision of the fintech sector needs to be strengthened through a Regulatory Technology (RegTech) and Supervisory Technology (SupTech) approach so that digital financial innovation continues to run in a healthy and safe corridor. Bank Indonesia also needs to optimize the 2025 Indonesian Payment System Blueprint (BSPI) by emphasizing the interoperability of digital payments, such as QRIS, and expanding mobile banking services for MSMEs and informal workers. The integration of fiscal, monetary, and financial inclusion policies is key to driving inclusive economic growth. For further research, it is recommended that the focus be directed towards spatial analysis or machine learning approaches to map financial inclusion disparities between regions and identify the effectiveness of digital policy interventions in greater depth.

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