Transforming Financial Inclusion through Big Data–Driven and AI–Powered Fintech in Indonesia

Sari Asrini , Dwita Sakuntala, Lia Nazliana Nasuiton

Abstract

Financial inclusion in Indonesia still faces significant challenges, despite the national target of 90% by 2024. The rapid development of digital technology, particularly the integration of Big Data and Artificial Intelligence (AI), has become a major driver of financial inclusion through fintech innovation. This study analyses the role of Big Data and AI in promoting financial inclusion in Indonesia by examining the opportunities, challenges, and implications for regulators, industry players, and the public. Using a quantitative approach through panel data regression for the period 2020-2024, this study examines the influence of GDP, education, and internet access on the financial inclusion index. The findings show that Big Data and AI-based technologies can improve the accuracy of risk assessment, expand credit access, and support the recovery of financial inclusion. However, challenges such as digital infrastructure gaps, data privacy issues, and human resource limitations remain major obstacles. This study provides evidence-based recommendations for policymakers and practical strategies for fintech players to build a more inclusive financial ecosystem in Indonesia.

***Keywords**:* Financial Inclusion, Big Data; Artificial Intelligence, Education, Technology, Indonesian Digital Economy.

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Introduction

Digital transformation in the financial sector has brought fundamental changes to the provision of financial services in Indonesia. Technological advances, particularly through the adoption of Big Data and Artificial Intelligence (AI), have driven innovation in the financial technology (fintech) sector, expanding financial inclusion to all levels of society. Indonesia, as the country with the second-largest fintech ecosystem in ASEAN, reflects the surge in economic digitalization through a significant increase in the number of fintech startups, the use of mobile banking, and the growth of digital financial transactions.

Big Data and AI-based fintech not only improve the efficiency and accessibility of services but also enable more accurate risk analysis, product personalization, and automation of the credit verification process for the unbanked and underbanked segments. However, the achievement of national financial inclusion still faces obstacles such as digital infrastructure inequality, high data security risks, and digital literacy gaps, especially in remote areas. Therefore, discussions on the strategic role of Big Data and AI-based technological innovations in promoting financial inclusion in Indonesia have become the center of attention for the government, regulators, industry players, and the wider community.

The level of financial inclusion in Indonesia still faces challenges. Global Findex data (2021) shows that around 29% of Indonesia's adult population does not have an account with a formal financial institution. Bank Indonesia, through its National Survey on Financial Inclusion (2022), has set a financial inclusion target of 90% by 2024, but the achievement in 2022 was only 85.1%. The development of digital technology over the past decade has fundamentally changed the landscape of the financial services industry. According to the 2021 Global Findex Database released by the World Bank, the rate of formal account ownership worldwide increased from 51% in 2011 to 76% in 2021. This surge was significantly driven by the penetration of internet-based and smartphone-based digital financial services, which have made it easier for people to access financial products and services.[1]

Given these conditions, it is essential to understand how modern financial technology can act as a catalyst in expanding inclusive financial access. The development of fintech in Indonesia, particularly that which utilizes Big Data and Artificial Intelligence (AI), offers great potential to reach previously underserved communities. However, to date, academic studies that specifically link the application of Big Data and AI to increased financial inclusion in Indonesia are still relatively limited.

This study aims to identify and analyze the impact of Big Data and AI implementation on the level of financial inclusion in Indonesia. It also examines regulatory challenges, human resource readiness, and collaborative strategies among stakeholders in building an inclusive and sustainable digital financial ecosystem.

Literatur Review

The World Bank (2022) emphasizes that increased financial inclusion contributes positively to inclusive economic growth, poverty reduction, and economic inequality reduction. Countries that adopt cutting-edge financial technologies such as Big Data and Artificial Intelligence (AI) tend to have faster financial service penetration rates, especially in previously underserved segments of society. Based on data from We Are Social (2024), 79.5% of Indonesia's population uses the internet, with 76% accessing the internet via mobile devices. This shows that digital technology penetration in Indonesia is quite high, opening up great opportunities for growth in the fintech sector.[2]

According to McKinsey & Company (2023), the adoption of Big Data in the financial services sector can increase the accuracy of risk assessment by up to 30% and expand credit reach to the unbanked population by 20–40%. Big Data becomes much more effective when combined with AI. Machine learning algorithms in AI are able to identify behavior patterns, predict default risks, and automatically provide relevant financial product recommendations. AI applications in fintech include Non-Traditional Credit Scoring using digital behavioral data to assess creditworthiness, Fraud Detection identifying suspicious activity in real-time, Automated Customer Service Responsive natural language processing-based chatbots, and Personalized Product Recommendations providing offers tailored to users' needs and risk profiles.

A study by Jagtiani & Lemieux (2019) shows that AI can increase the accuracy of creditworthiness assessments by up to 50% compared to traditional methods, especially for customers without a formal credit history. The integration of Big Data and AI has great potential in creating an inclusive and efficient financial services ecosystem. Peer-to-peer lending fintech companies such as Amartha and Modalku have proven the effectiveness of this technology in assessing the creditworthiness of rural communities without formal documentation.[3]

Baijal et al. (2022) project that Indonesia's digital economy will reach USD 146 billion by 2025, with fintech as one of the main driving sectors. This shows that financial inclusion transformation through advanced technology is a strategic direction that is in line with the national digital economy vision. Despite its great potential, several challenges need to be overcome, including Personal Data Protection Compliance with Law No. 27 of 2022, Digital Infrastructure Gap Differences in internet network quality between regions, Human Resource Limitations Lack of experts in data science and AI, System Standardization Lack of interoperability between fintech platforms and financial institutions.[4].

Research Methodology

This study is a quantitative research 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 GDP, 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 5 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 between variables X and Y. Panel data regression analysis 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).[5] Before estimating the model, classical assumptions were tested to ensure that the regression model met the Best Linear Unbiased Estimator (BLUE) criteria. Classical assumption testing included:

1. Autocorrelation test, to detect whether there is a relationship between residuals in different time periods.
2. Multicollinearity test, to ensure that there is no high correlation between independent variables that could affect the stability of the regression coefficient.
3. Heteroscedasticity test, to determine whether the residual variance is homogeneous (constant) across all observations.
4. Normality test, to ensure that the residual distribution is normal so that the estimation results are statistically valid.

Next, inferential statistical testing was conducted, consisting of:

1. T-test, to determine the partial effect of each independent variable on the dependent variable.

2. F test, to test the simultaneous effect of independent variables on the dependent variable.
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.

The selection of the best panel regression model (between the Common Effect Model, Fixed Effect Model, and Random Effect Model) was conducted using the Chow test and the Hausman test. All data processing was performed using EViews 12 statistical software with a significance level of $\alpha = 0.05$ (5%).[6]

Equation:

$$INCLUSION = \alpha 0 + \alpha 1 logPDRB + \alpha 2PDD + \alpha 3INT + \varepsilon t$$

Explanation:

Y1 = Financial inclusion index (INCLUSION)

X1 = Per capita gross domestic product (PDRB)

X2 = Education (PDD)

X3 = Internet (INT)

εt = error term.

Results

4.1 Chow Test

Table. 1. Chow test result
Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	52.122072	(33,133)	0.0000
Cross-section Chi-square	447.818660	33	0.0000

Probability > 0.05 = CEM
Probability < 0.05 = FEM
Probability 0.0000 < 0.05 So the chosen model is FEM.

4.2 Hausman test

Table. 2. Hausman test result
Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	1.164378	3	0.7616

Probability > 0.05 = REM
Probability < 0.05 = FEM
Probability 0.7616 > 0.05 So the chosen model is REM

4.3 Lagrance Multiplier (LM) test

Table 3. LM test result

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis Cross-section	Time	Both
Breusch-Pagan	275.9421 (0.0000)	2.027551 (0.1545)	277.9696 (0.0000)
Honda	16.61150 (0.0000)	-1.423921 (0.9228)	10.73924 (0.0000)
King-Wu	16.61150 (0.0000)	-1.423921 (0.9228)	4.117078 (0.0000)
Standardized Honda	17.57702 (0.0000)	-1.218524 (0.8885)	7.739201 (0.0000)
Standardized King-Wu	17.57702 (0.0000)	-1.218524 (0.8885)	1.834713 (0.0333)
Gourieroux, et al.	--	--	275.9421 (0.0000)

Probability > 0.05 = CEM
Probability < 0.05 = REM
Probability 0.0140 < 0.05
Based on the results of the Chow test, Hausman test and LM test, the selected model is REM. When the selected model is REM or CEM, multicollinearity and heteroscedasticity tests must be carried out (Basuki & Yuliadi: 2014) (Napitupulu et al: 2021: 120).[6]

4.4 Classical Assumption Test

a. Autocorrelation Test – Durbin Watson

Dstat = 1.7835
DL > lower limit of Durbin Watson table = 1.7253 DU > upper limit of Durbin Watson table = 1.77295. D 1.7835 > DU 1.77295, therefore, there is no positive autocorrelation. If (4 – D 1.7835) > DU 1.77295, then there is no negative autocorrelation.

b. Multikolinearitas test

Table 4. Hasil Uji Multikolinearitas

	X1PDRB	X2PDD	X3INT
X1PDRB	1	0.5789731011137816	0.4540417759932282
X2PDD	0.5789731011137816	1	0.3617259567149141
X3INT	0.4540417759932282	0.3617259567149141	1

The correlation coefficient of X1PDRB and X2PDD = 0.5789 < 0.85, X1 and X3INT is 0.3617 < 0.85. Therefore, it can be concluded that there is no multicollinearity or that it passes the multicollinearity test.

c. Heterokedasticity test

Table 5. Hasil Uji Heterokedastisitas

Dependent Variable: ABS(RESID)
Method: Panel Least Squares
Date: 10/19/25 Time: 20:40
Sample: 2020 2024
Periods included: 5
Cross-sections included: 34
Total panel (balanced) observations: 170

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.94821	5.514480	2.166698	0.0317
X1PDRB	-1.082667	0.596531	-1.814937	0.0713
X2PDD	0.117723	0.036321	3.241210	0.0014
X3INT	-0.008939	0.024815	-0.360208	0.7191

Based on the results of the Glejser test for heteroscedasticity, variable X2PDD has a p-value < 0.05, meaning that there are indications of heteroscedasticity caused by this variable. Meanwhile, variables X1PDRB and X3INT have p-values > 0.05, indicating no signs of heteroscedasticity. Since Prob(F-statistic) = 0.016 < 0.05, the model generally indicates the presence of heteroscedasticity. Due to the indication of heteroscedasticity, the recommended corrective measure is to conduct the Breusch Pagan Godfrey test.

Table 6. Hasil Uji Heterokedastisitas Breusch Pagan Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	3.900759	Prob. F(3,166)	0.0100
Obs*R-squared	11.19506	Prob. Chi-Square(3)	0.1107
Scaled explained SS	13.77604	Prob. Chi-Square(3)	0.1032

Test Equation:
Dependent Variable: RESID^2

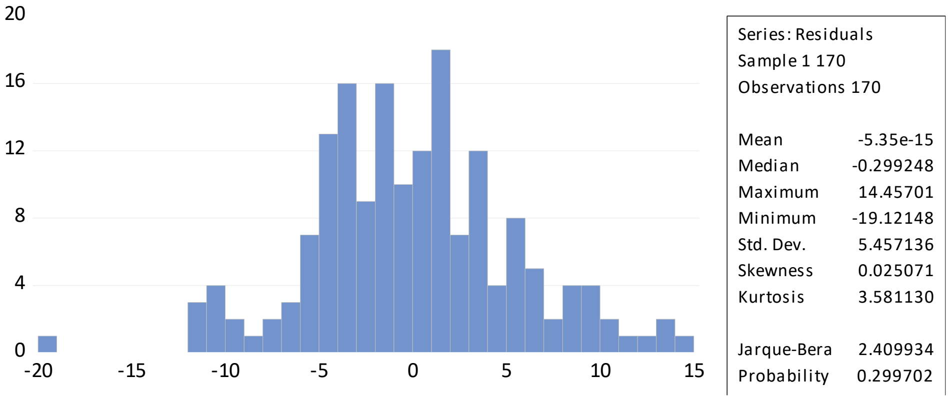
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	120.3220	75.84783	1.586360	0.1146

X1PDRB	- 14.01375	8.204871	-1.707980	0.0895
X2PDD	1.705469	0.499566	3.413899	0.1008
X3INT	- 0.092239	0.341316	-0.270245	0.7873

Probability value Obs*R-squared (0.1107) > 0.05 → indicates no heteroscedasticity. For the probability values of each variable, X1PDRB 0.0895, X2PDD 0.1008 and X3INT 0.7873 > 0.05, it is concluded that there is no heteroscedasticity.

d. Normality test

Figure 1. Jarque–Bera test (JB)



Jarque–Bera = 2.409934
Probability = 0.299702
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) = 0.2997 > 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.

4.5 Hypotesist test

a. T test

Table 7. t test result
Dependent Variable: YINK

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.242144	8.977326	0.138365	0.8901
X1PDRB	2.797378	0.971126	2.880551	0.0045
X2PDD	0.158067	0.059129	2.673287	0.0083
X3INT	0.419559	0.040398	10.38562	0.0000

The t-test result for variable X1PDRB is 2.8805 > t table 1.9741 and sig. is 0.0045, therefore H0 is rejected, meaning that the PDRB variable partially influences the financial inclusion variable significantly. This indicates that the Regional Domestic Product (PDRB) variable has a positive and significant effect on YInklusi Keuangan. This means that an increase in regional economic activity, as reflected in the rise in PDRB, will encourage an increase in financial inclusion among the community.

The t-test result for variable X2PDD is 2.6732 > t table 1.9741 and sig. is 0.0083, so H0 is rejected, meaning that the X2PDD variable partially influences the Inclusion variable significantly. This result shows that the higher the level of education of the community, the greater their ability to understand, access, and utilise formal financial services.

The t-test result for variable X3INT is 10.3856 > t table 1.9741 and sig. is 0.0000, so H0 is rejected, meaning that the INT variable partially influences 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.

b. F test

Table 8. F test result

F-statistic	81.88276	Durbin-Watson stat	0.376701
Prob(F-statistic)	0.000000		

Based on the results of the simultaneous test (F-test), the calculated F-value was 81.8827, which was greater than the table F-value of 19.4897, with a significance value of 0.0000 < 0.05. This indicates that simultaneously, the variables X1PDRB, X2PDD, and X3INT have a significant effect on YFinancial Inclusion. This means that regional economic growth, increased community education levels, and expanded internet access can collectively drive increased financial inclusion.

4.6 Panel Regression Analysis

Panel regression equation results:

Yinklusi=c1+c2logX1PDRB+c3X2PDD+c4X3INT + εt

Yinklusi=1.2421+2.7973X1PDRB+0.1580X2PDD+0.4195X3INT+εt

The above equation can be explained as follows:

1. If all independent variables (GRDP, Education, and Internet) are zero, then the level of financial inclusion is at a base value of 1.2421. This value only serves as a starting point for the model.
2. Each one-unit increase in GRDP (on a log or percentage scale) will increase Financial Inclusion by 2.7973 units. This means that regional economic growth effectively encourages people to participate more actively in the formal financial system, as increased income and economic activity increase demand for financial services.
3. Each unit increase in the education index will increase financial inclusion by 0.1580 units. This means that the higher the level of education of the community, the greater their ability to understand, access, and utilize formal financial products and services. Education contributes to improving the financial literacy and financial awareness of the community.
4. Each one-unit increase in the internet access index will increase Financial Inclusion by 0.4195 units. This confirms that digital connectivity expands the reach of financial services through fintech, mobile banking, and electronic transactions, making it easier for the community to participate in the digital financial system.
5. These results indicate that the three independent variables have a positive effect on financial inclusion. The GRDP coefficient of 2.7973 indicates that increased regional economic activity will significantly drive the growth of financial inclusion. The education level coefficient of 0.1580 shows that improvements in the quality of

public education play a role in expanding financial access and literacy. Meanwhile, the internet access coefficient of 0.4195 illustrates that the wider the internet network and usage, the higher the level of financial inclusion among the community through the adoption of digital financial services. Thus, economic growth, improved education, and expanded internet access are collectively strategic factors in strengthening financial inclusion at the regional level.

4.7 Determination coefficient test

An 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 determination coefficient is 0, the independent variables have no effect on the dependent variable. The adjusted R-Squared value is 0.5894 or 58.94%. This coefficient value explains that independent variables such as GRDP, PDD and INT are able to explain the dependent variable of Inclusion by 58.94 per cent, while the remainder is influenced by other variables not explained in this study.

Discussion

The statistical test results show that the X1PDRB variable has a t-value of 2.8805, which is greater than the t-table value of 1.9741, with a significance value of 0.0045 (< 0.05). This indicates that PDRB has a positive and significant effect on financial inclusion in Indonesia. Empirically, this finding indicates that increased regional economic activity, as reflected in the increase in GRDP, encourages the expansion of public access to formal financial institutions. The increase in GRDP illustrates the increased economic capacity of the community and the productivity of local economic sectors. This growth not only strengthens people's purchasing power but also increases the ability and need of individuals and businesses to utilize financial services such as savings, credit, insurance, and digital financial instruments. In addition, regions with higher GRDP tend to have more developed financial infrastructure, including the number of bank offices, ATMs, and digital-based financial services.

These findings are in line with research (Ain et al., 2020) & (Meila, 2025), which found that regional economic growth contributes significantly to increasing financial inclusion, particularly through increasing the capacity of financial institutions to reach previously underserved communities. Economic growth has a positive impact on expanding formal financial access, both through increasing the community's capacity to use financial services and through the more equitable development of financial institutions in the region. Thus, the higher the GRDP of a region, the higher its level of financial inclusion.[7][8][9]

Furthermore, the analysis results show that the X2PDD variable has a t-value of 2.6732 > 1.9741, with a significance level of 0.0083 (< 0.05), which means that the level of education has a positive and significant effect on financial inclusion. The higher the level of education of the community, the greater their ability to understand, access, and utilize various formal financial products and services. Theoretically, education plays an important role in improving financial literacy, which is the ability of individuals to understand basic financial concepts, manage income, and make wise financial decisions. People with higher levels of education tend to have greater confidence and ability to use banking, insurance, and digital financial platforms. In addition, education also raises public awareness of the importance of saving, investing, and using financial services safely.

These findings are consistent with the results of studies (Grohmann et al., 2018) and (Wardhani, 2019) which show that education and financial literacy are key determinants in expanding financial inclusion. The higher the level of education, the better the financial behavior. In the Indonesian context, the role of education is increasingly important given the existing gap in financial literacy between regions, particularly between urban and rural areas.

Therefore, policies to increase financial inclusion need to be synergized with efforts to improve the quality of education and financial literacy among the public.[10][11]

Furthermore, based on the t-test results, the X3INT variable shows a t-value of 10.3856 > 1.9741, with a significance level of 0.0000 (< 0.05). These results indicate that internet access has a positive and significant effect on financial inclusion. The internet acts as the main enabler of digital financial inclusion through easy access to technology-based financial services such as mobile banking, internet banking, fintech, e-wallets, and peer-to-peer lending platforms. People with internet access utilise this technology to conduct financial transactions more quickly, cheaply, and efficiently without geographical boundaries. In areas that were previously difficult for conventional financial institutions to reach, internet-based digitalization opens up new opportunities for people to join the formal financial system.

These findings reinforce the results of research (Ozili, 2021) and (Elvionita, n.d.) which confirm that the expansion of the internet network is the main driver of digital financial transformation in developing countries, including Indonesia. In addition to accelerating financial access, internet infrastructure also encourages the emergence of technology-based financial innovations (fintech) that make it easier for people to carry out their daily economic activities. Internet access facilitates the public's access to digital financial services, such as mobile banking, internet banking, and e-wallets. It increases the ease of conducting financial transactions without having to visit physical financial institutions. Promoting digital financial inclusion through fintech innovation and electronic payment platforms. Thus, the availability of good internet infrastructure plays a direct role in expanding formal financial access, especially in areas that were previously difficult to reach by conventional financial institutions.[12][13]

Overall, the statistical test results show that the three variables X1PDRB, X2PDD (Education) and X3INT (Internet Access) have a partial positive and significant effect on financial inclusion in Indonesia. This reflects that financial inclusion is multidimensional, influenced by a combination of economic, social and technological factors. Economic growth provides financial capacity, education provides cognitive abilities and confidence in transactions, while the internet facilitates access to various modern financial services. Thus, efforts to increase financial inclusion in Indonesia need to be carried out through a holistic approach that not only strengthens the financial sector but also expands educational opportunities and accelerates the equitable distribution of digital infrastructure throughout Indonesia.

Conclusion and Recomendations

5.1 Conclusions

Economic growth, education, and internet access have been proven to have a positive and significant effect on financial inclusion in Indonesia. Panel regression results show that variables X1PDRB, X2PDD and X3INT partially and simultaneously have a significant effect on the financial inclusion index. This means that increased regional economic activity, improved education quality, and expanded digital infrastructure can collectively expand the reach of formal and digital financial services across all provinces in Indonesia.

The role of digital technology is a major driver of financial inclusion. Fintech innovations based on Big Data and Artificial Intelligence (AI) accelerate the risk assessment process, expand credit access for the unbanked, and support the growth of digital-based financial services such as mobile banking, e-wallets, and peer-to-peer lending. This technology also increases the efficiency of financial institutions and strengthens the national digital economy ecosystem.

The panel regression model used has been proven to be statistically feasible and valid. Classical assumption tests (autocorrelation, multicollinearity, heteroscedasticity, and normality) show that the model meets the BLUE (Best Linear Unbiased Estimator) criteria. An Adjusted R^2 value of 0.5894 means that 58.94% of the variation in financial inclusion can be explained by the variables of GRDP, education, and internet access, while the rest is influenced by other factors such as government policy, financial literacy, and fintech innovation. Indonesia's digital economy has great potential for inclusive finance. With an internet penetration rate of over 79%, the integration of Big Data and AI in the financial sector is a catalyst for realizing national financial inclusion that is equitable, efficient, and sustainable.

5.2 Recommendations

1. The government needs to accelerate the development of internet networks throughout Indonesia, especially in disadvantaged areas, so that digital financial access can reach all levels of society.
2. Financial regulators need to strengthen personal data protection and cybersecurity policies to increase public trust in Big Data and AI-based fintech services.
3. A national education program integrating digital and financial literacy is needed so that the public can use fintech services safely, intelligently, and productively.
4. Financial industry players need to continue developing products and services based on artificial intelligence and big data analytics to expand credit coverage, improve efficiency, and reach the unbanked and underbanked communities.

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