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Impact analysis of financial inclusion on profitability and stability of bank using rolling-window autoregressive lag modeling

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Abstract

This research examines the influence of financial inclusion on the profitability and stability of commercial banks using the bank observations of Japan from 2004–2018. The composite index of financial inclusion was created by utilizing principal component analysis after identifying the significant financial inclusion indicators. The bank performance or profitability variables namely return on equity (ROA), return on assets (ROE), net interest margin (NIM), and bank stability variable (z-score) are used in this analysis. Then, to analyze the long-run relationship existing between financial inclusion and bank's performance and stability, this research used the rolling-window autoregressive distributed lag model (RARDLM) testing strategy of co-integration, a new technique. This approach can potentially assess the relationship between variables when details regarding the underlying variables are not known with certainty. Financial inclusion has a favorable influence on bank stability, according to the findings. Financial inclusion indicators such as the number of bank branches, deposit accounts, depositors, and borrowers have a considerable positive influence on bank performance, whilst the number of loan accounts and ATMs has no effect. The findings imply that banks should work to improve the efficiency of financial technology, which would boost financial inclusion while also enhancing bank profitability and stability.

***Keywords*:** Financial Inclusion (FI); Bank Profitability; Bank Stability; Principal Component Analysis (PCA); Rolling-Window Autoregressive Distributed Lag Modeling (RARDLM)

1. Introduction

Financial inclusion (FI) refers to all adults in a community having access to and utilizing a range of products and services provided by the finance sector at a cost that is reasonable even to the poorest and lowest-income groups. People's financial security and the economy's prosperity are both enhanced when services of the banking system such as insurance, loans, savings, and payment systems are available to all sectors of society. People and organizations may save for retirement, invest in education and business prospects as well as protect themselves from risk by using life insurance plans (Dadej, 2025). As a result, financial services become more accessible, efficient, and cost-effective. Increasing the amount, quality, and efficiency of financial system services is what is meant by the term "financial inclusion." This improves people's lives, opens up new possibilities, and strengthens economies. FI encourages local savings, which leads to more productive investments in local firms (Le et al. 2019). According to the endogenous growth theory, financial development has garnered a lot of attention as a vital and inextricable aspect of the economic process. FI has gained a lot of momentum among newly presented ideas, particularly after the financial crisis occurred globally in 2008.

Figure 1: Factors influencing financial inclusion

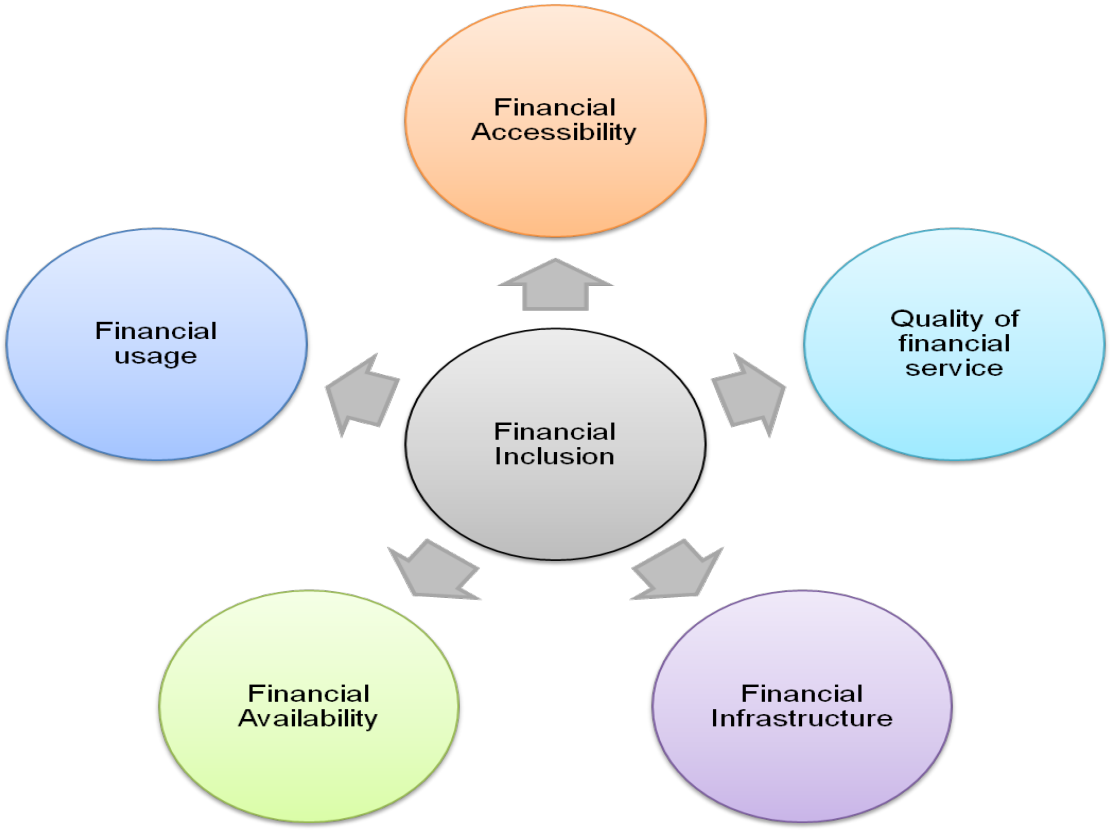


Figure 1 shows the factors that influence FI. That crisis pushed financial organizations to create novel techniques to offer the broadest possible range of banking services and ensure financial stability (ElDeeb et al. 2021). Bank profitability (BP) and bank stability (BS) are significant indicators for the efficiency of banking organizations. In many developing nations, there is a growing realization that financial inclusion may improve bank profitability and performance (Issaka Jajah et al. 2020). The influence of FI on bank profitability and stability has only been studied in a few types of research. Economic progress requires a prosperous and stable banking industry. Banks help the economy expand by investing in profitable ventures. BP and BS have been demonstrated to be influenced by a variety of bank-specific criteria, including size, liquidity, efficiency, capital, non-performing loans, and cost management. However, the effect of FI on BP and BS is still unclear. There is lesser research done in this field. This motivated us to analyze the relation between FI, BP, and BS. In this paper, we investigated the effect of FI on profitability and stability of banks using RARDL. Significant FI variables for the study are selected using PCA. The further proceedings of the paper are organized as shown. Section II shows the related literature and the problem statement. Section III provides the materials and methods. Performance evaluation is given in section IV. Finally, section V gives the conclusion of the proposed paper.

2. Literature Review

Iqbal et al. 2017 wanted to look at the influence of FI on the growth of economy over seven years. Secondary data was employed, which was examined using a multiple regression model as the primary statistical method. Ramzan et al. 2021 studied the influence of corporate social responsibility (CSR) on the FI, BS, and BP utilizing yearly data of twenty commercial banks of Pakistan from 2008 to 2017. FI and financial stability are both harmed by high levels of leverage, and FI is also linked to asset tangibility. The aim of Banna et al. 2021 is to investigate if digital FI is a key factor in BS maintenance in ASEAN countries and whether this relationship has consequences for the pandemic era of Covid-19. They concluded that one of the most essential methods to guarantee BS in ASEAN countries is to accelerate digital finance, which contributes to financial and economic resilience even in the crisis phase (Ozili, 2025). The influence of bank concentration and FI on the performance of enterprises in emerging and developing nations was studied by Chauvet et al. in 2017. They found that FI across enterprises has a beneficial influence on company growth using firm-level data from 55,596 firms in 79 countries. Bhattacharya et al. 2021 studied the relationship between CSR spending, FI, and BP in the years after the legislation's implementation. Utilizing the stock market and accounting indicators of performance, they investigated whether mandatory CSR spending and/or FI policies are connected with higher financial success for Indian banks from 2015 to 2017. The influence of financial regulation on FI in Sub-Saharan Africa was studied by Anarfo et al. in 2020, taking into account the moderating

function of financial stability. Lee et al. 2020 looked at the influence of FI on the growth of firm sales in developing countries, as well as how this effect varies based on different subsamples.

Vo et al. 2021 used a dataset of 3071 Asian banks from 2008 to 2017 to investigate the association between FI and the stability of financial markets. A generalized method of moments (GMM) technique is employed in their study. For the years 2011 and 2014, Datta et al. 2019 sought to assess the FI situation in numerous developed and developing nations throughout the globe. The goal of the research is to create a FI index and investigate its relationship with the human development index. An Ordinary Least Square (OLS) with a clustered standard error regression estimator was utilized to provide insights into the factors influencing FI globally. Van et al. 2021 presented a thorough examination of the relationship between FI and developing country's economic development. To begin, a multidimensional index is created to assess the extent of FI on a global scale. Second, the panel econometric approach is used to quantify the influence of FI on economic growth using this newly established index. Depending on data collected from 120 countries between 2011 and 2014, Bozkurt et al. 2018 explored the causes behind variations in FI levels. They used the local and Global Moran parameters of spatial association analysis to uncover evidence of the existence of geographical dependencies after computing the FI index across nations. Then, to account for geographical dependency, we use spatial regression and spatial panel data models.

Banna et al. 2022 investigated the influence of FinFI (Financial technology-dependent FI) on the "risk-taking activity" of microfinance organizations in Sub-Saharan Africa. As a result, they built an index to gauge FinFI and experimentally evaluate its effect in lowering the risk-taking of firms. The impact of FI on financial stability was studied by Feghali et al. 2021. They proposed that financial stability is neutral or positive when people have access to savings and payment accounts, but that financial stability is weakened when people have access to credit. Before and during the current financial crisis, Bouzgarrou et al. (2018) looked at the performance of local and international banks. One hundred and seventy commercial banks that functioned in the French market from 2000 to 2012 are included in their sample. The findings were confirmed using the robustness check procedure. In the Gulf Cooperation Council countries, Belkhaoui et al. 2020 developed a conceptual model that comprises several financial factors, effectiveness, and performance of Islamic banks. Their research adds to the body of knowledge on the parameters that influence the bank's performance. To evaluate the model, this study used a route analysis technique known as the second-generation approach. Chuc et al. 2022 used a dataset of sixty countries with low and middle income from 1996 to 2017 to look at the combined influence of FI and foreign remittance inflows on economic development. The results suggest that FI might boost remittances' growth-enhancing impact. **N'dri & Kakinaka (2020)** employ matching techniques to analyze the impact of FI and mobile money usage on the nonmonetary wellbeing of individuals in Burkina Faso. The results support the importance of FI in reducing poverty. Chen et al. 2018

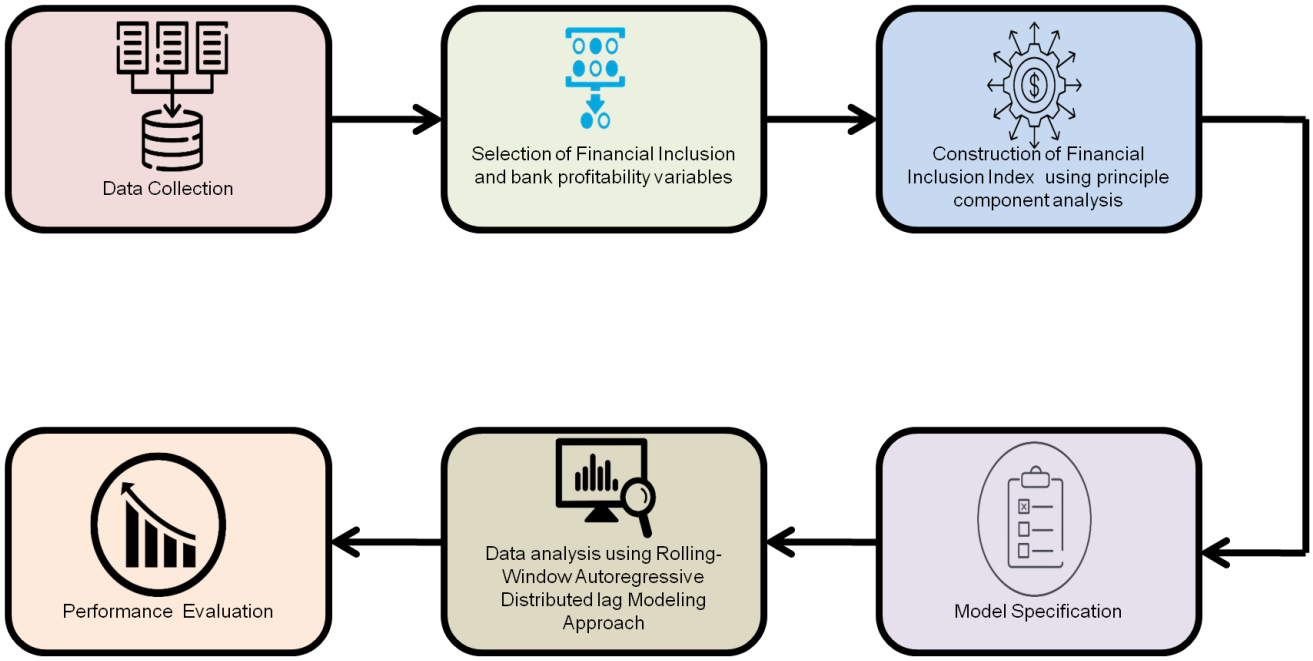
examine probable geographical connections between FI and non-performing loans of the bank by building a model of panel data utilizing the observations from thirty-one provinces in China during 2005 to 2016. They employed the fixed-effect approach for their empirical investigations. Mia et al. 2019 analyzed the association between the outreach and efficiency of financial firms in Bangladesh using a two-stage strategy. The efficiency of the firm from 2009 to 2014 is measured using a dynamic data envelopment technique in the first step. The problems that arise from the endogenous character of outreach initiatives can be reduced by the double bootstrapping process. Malik et al. 2019 looked at the existing state of FI in India, analyzed the existing gaps, and proposed a strategy for closing them. The situation-actor-process plus learning-action-performance model is used to give a holistic perspective of FI in India in this research. The research identifies the areas where stakeholders should concentrate their efforts to improve people's access to financial services. Using the GMM approach, Le et al. 2020 studied the drivers of BP in twenty-three countries from 2002 to 2016. The findings show that expanding the amount of bank cards issued, point of sale (POS) terminals, and automated teller machines (ATMs) may boost BP. Almaqtari et al. 2019 looked at the factors that influence commercial BP in India. The study spans a ten-year period during which the Indian banking system has seen several changes, including demonetization, concerns with banking sector sustainability, and banking sector scams. This research employs a stationary test, as well as a fixed and random effect, pooling models, and panel correction standard error.

Today, financial institutions are the ones that largely contribute to the economic growth, progress, and development of the nation. FI is rapidly being acknowledged as a critical component of many nations' efforts to achieve the long-term growth of these institutions. Extending formal financial services to prohibited individuals and businesses is the main goal of the government in many countries. Fewer studies have examined the influence of FI on BP and BS, which is the primary source of formal financing. Determining whether the FI variables are steady or not over a longer period is a difficult task. Wrong assumptions of these variables will lead us to wrong conclusions. Hence, an efficient statistical analysis tool must be used. In this paper, we evaluated the long-run relationship between FI and BP plus BS using RARDL, an efficient data analysis technique.

3. Methodology

The framework of the suggested approach is given in Figure 2. Initially, the bank data was collected. The important financial inclusion factors were selected using PCA and the statistical description of the variables is provided. Then the composite index of FI was constructed. Then the impact of FI on BP and BS was analyzed using the RARDLM technique.

Figure 2: Flow of the suggested approach



3.1 Data Collection and selection of variables

For this research, the panel dataset includes observations from 122 Japanese banks from 2004 to 2018 (Kumar et al. 2021). The data was gathered from a variety of sources including the Bank-Scope database which provides income statements and balance sheets of banks and Financial Access Survey database of the International Monetary Fund and the World Bank database which provides insights into the macroeconomic indicators on infrastructure and development of banks. The FI variables namely "number of bank branches per one lakh adults", "number of ATMs per one lakh adults", "number of deposit accounts with the bank per thousand adults", "number of depositors with the bank per 1000 adults", "number of loan accounts with the bank per thousand adults", and "number of borrowers from the bank per thousand adults", are used in this study. These variables are represented as V1, V2, V3, V4, V5, and V6 correspondingly. FI variables are defined as the independent variables. The financial performance of banks is referred to as bank profitability. ROA, ROE, and NIM are the indicators used to determine the level of BP. These factors are calculated by equations 1, 2, and 3.

$$ROA = \frac{Total\ Income\ obtained}{Total\ Assets} \quad (1)$$

$$ROE = \frac{Total\ Income\ obtained}{Shareholder's\ Equity} \quad (2)$$

$$NIM = \frac{Total\ Interest\ Income}{Total\ Assets} \quad (3)$$

One of the main indicators of measuring bank stability (BS) is the bank's Z-score. It is calculated by equation 4. BP and BS variables are the dependent variables. The statistical description of independent and dependent variables is provided in table 1.

$$Z - score = \frac{ROA + \left(\frac{Equity}{Assets}\right)}{Standard\ deviation\ of ROA} \quad (4)$$

Table 1: Statistical description of different variables

Variables		Mean	Standard deviation	Minimum	Maximum
Independent variables					
Availability dimension	V1	127	2.22	123.9	132.8
	V2	34	0.21	33.8	34.6
Accessibility dimension	V3	265	15.2	195	360
	V4	300	20.1	205	419
Usage dimension	V5	187.7	12.6	170.5	210.6
	V6	210	13	160.5	230
Dependent variables					
Bank Profitability	Return on Assets	0.31	0.8	-16	6.03
	Return on Equity	6.29	7.66	-21	29.6

	Net Interest Margin	7.35	3.79	0.032	39.2
Bank Stability	Z-score	16.14	10.1	2.58	60.89

3.2 Construction of composite index for financial inclusion

Before investigating the importance of FI with BP and BS variables, the study's preliminary and main goal is to build a FI index. To verify the amount of FI across countries, standardize the FI measure for the emerging economies, assess the progress towards national FI objectives, and conduct cross-country comparisons, such a comprehensive measure of FI is required. This research looks at several financial sector outreach metrics in the context of three key elements of an inclusive financial organization: bank accessibility, availability, and utilization. To determine which indicators, have the strongest individual influence on this score, principal component analysis (PCA) is used.

3.2.1 Availability dimension of banks

This represents the extent to which financial services are available in a certain geography or demographic through financial institution outlets such as branches, offices, and ATMs. Two metrics are used to show the availability of financial services. They are the number of branches and ATMs corresponding to the bank per one lakh people.

3.2.2 Accessibility dimension of banks

This is the total number of people who have logged into the official financial system. The number of deposit accounts and depositors with the bank per thousand adults is used to measure financial service accessibility. Deposit accounts are a crucial metric for determining the size of the banked population. Depositors with accounts in the financial system may be active or inactive in the financial system. So, the accessibility of the financial system is one of the most important indicators of FI.

3.2.3 Usage dimension of banks

This metric assesses how often and effectively consumers utilize the services of financial systems in different forms, like borrowing, savings, payments, remittances, and transfers. This dimension shows the financial system's efficiency. The utilization dimension includes two variables, the number of loan accounts and borrowers relative to the bank per thousand people.

The financial index is computed using PCA. In all domains of research, PCA is the most widely utilized approach for data exploration and analysis. The first step in calculating the FI index is to use equation 5 to calculate the indices of each variable in each FI dimension.

$$h_{i,d} = \frac{x_i - b_i}{B_i - b_i} \quad (5)$$

Where x_i means the actual value of the indicator, b_i and B_i define the minimum and maximum values of the indicator 'i' of dimension 'd', and $h_{i,d}$ defines the standardized value of the variable. We estimated the eigenvalues of each FI variable using the PCA approach. The component with the greatest eigenvalue maintains the most standardized variance among the others, and an eigenvalue larger than one is included in the analysis. As a result, the independent variables with higher eigenvalue are selected for constructing FI_I. Then in the second step, the weight corresponding to the selected variables is determined using PCA. Finally, FI_I was constructed using the selected variables of each dimension and their relative weights according to equation 6.

$$FI_I = (g_1 * X_i^a) + \left(g_2 * X_i^b\right) + (g_2 * X_i^c) + u_i \quad (6)$$

Where g_1, g_2, and g_3 are the relative weights of each dimension, X_i^a means the availability dimension of bank 'i', X_i^b means the accessibility dimension of bank 'i', X_i^c means the usage dimension of bank 'i', u_i means the variation that occurs due to the error.

3.3 Model specification

Four models respective to ROA, ROE, NIM, and Z-score were specified in equations 7, 8, 9, and 10.

$$ROA_{i,s} = \delta_0 + (\delta_1 * V1_s) + (\delta_2 * V2_s) + (\delta_3 * V3_s) + (\delta_4 * V4_s) + (\delta_5 * V5_s) + (\delta_6 * V6_s) + e_{i,s} \quad (7)$$

$$ROE_{i,s} = \delta_0 + (\delta_1 * V1_s) + (\delta_2 * V2_s) + (\delta_3 * V3_s) + (\delta_4 * V4_s) + (\delta_5 * V5_s) + (\delta_6 * V6_s) + e_{i,s} \quad (8)$$

$$NIM_{i,s} = \delta_0 + (\delta_1 * V1_s) + (\delta_2 * V2_s) + (\delta_3 * V3_s) + (\delta_4 * V4_s) + (\delta_5 * V5_s) + (\delta_6 * V6_s) + e_{i,s} \quad (9)$$

$$Z - score_{i,s} = \delta_0 + (\delta_1 * V1_s) + (\delta_2 * V2_s) + (\delta_3 * V3_s) + (\delta_4 * V4_s) + (\delta_5 * V5_s) + (\delta_6 * V6_s) + e_{i,s} \quad (10)$$

Where δ_0, δ_1, δ_2, δ_3, δ_4, δ_5, and δ_6 are the relative weights of each variable, V1, V2, V3, V4, V5, and V6 define the independent variables. Also 'i' denotes the bank, s means the time period, and $e_{i,s}$ is the error.

3.4 Rolling window autoregressive distributed lag modelling approach

We utilized the RARDLM technique to assess the association between FI and BP plus FI and BS in this article. The RARDL technique, also known as the rolling bound testing strategy, is a variation of the ARDL methodology. The quantity of data available to estimate the stationary distribution may not always be sufficient to provide statistically reliable market parameter

estimates. Rolling analysis, also known as RARDL, may be used to solve this issue. The goal of RARDL is to create 'new' observations from samples of previous data. Consider a set of data from which you want to estimate an aggregated return over some time S. The sample may then be taken or divided into S/ΔS non-overlapping, equally sized sub-samples from which aggregated statistical measures of the stationary distribution can be derived. The problem with this approach is that if S isn't big enough, the number of S aggregated observations isn't large enough to generate good statistics estimations. By sliding the window forward one observation at a time instead of separating the sample into non-overlapping subsets, RARDL is a superior technique for calculating aggregated returns.

Assume the size of the rolling window as T_S for the sample size of 'S',. In this paper, we set the rolling window size of 2 years. The following steps are used to perform the RARDLM bounds test. The RARDLM test is applied on the first T_K observations of each independent variable X_S and dependent variable Y_S, where s = 1, 2, ..., T_S. F − statistics, and p-value are recorded. Then, by removing the first observations and incorporating one more that is $(T_S+ 1)^{th}$ of X_S and Y_S, a RARDLM limits test is performed. The RARDLM bounds test is estimated for s =2, 3, ..., T_S+1 records of X_S and Y_S. F − statistic, and p-value are again recorded. Step 2 is done until all of the remaining observations have been accounted for. As a result, there will be (S – T_S+ 1) RARDLM cointegration tests and their corresponding statistics.

4. Results and Discussion

This section is focused on analyzing whether the relationships existing between FI and BP as well as between FI and BS are significant or not using a novel method RARDL technique. We used ROA, ROE, and NIM as a measure of profitability and Z-score as an indicator of BS. The results of PCA and RARDL and their discussions are given in this section.

4.1 Results of PCA

The financial index was constructed using PCA. The results of the PCA method are given in figure 3. The variables with an eigenvalue greater than 1 are significant variables for this study. The independent variables namely the number of ATMs, bank branches, loan accounts, and deposit accounts are having eigenvalues higher than 1. As a result, these variables are significant parameters. This result is evident from table1. FI_I is constructed using these four independent variables. This measure is most influenced by the selected indicators. Other variables such as the number of borrowers, and depositors are having eigenvalues less than 1 and hence these variables are not considered for FI_I construction.

Figure 3: Eigenvalues of different financial inclusion variables

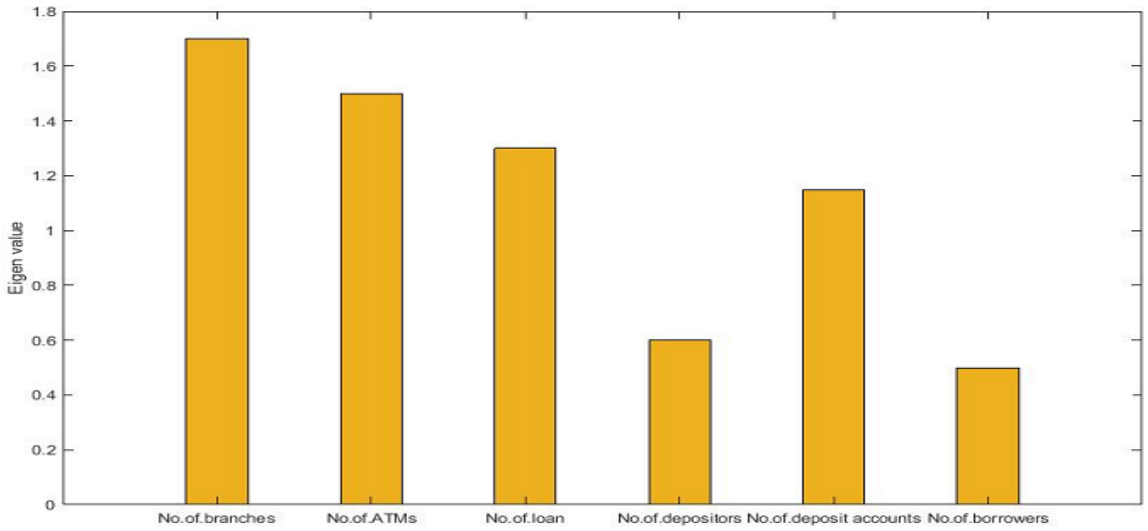


Table 2: PCA estimates of FI variables

Variable	Eigenvalue	Difference	Proportion	Cumulative
Number of bank branches (V1)	1.7	0.2	0.53	0.53
Number of ATMs (V2)	1.5		0.47	1.00
Number of deposit accounts (V3)	1.15	0.55	0.57	0.57
Number of depositors (V4)	0.6		0.43	1.00
Number of loan accounts (V5)	1.3	0.8	0.62	0.62
Number of borrowers (V6)	0.5		0.38	1.00

4.2 Results of RARDLM

RARDLM is employed to examine the impact of FI variables on BP parameters like ROE, ROA, NIM, and bank stability (Z-score). P-values for the relations existing between different independent and dependent variables are provided in table 3. P-values lesser than 0.05 are termed as significant. In table 3, p-values with the star in the superscript are significant. The relations for which p-values are lesser than 0.05

Table 3: P-values obtained by RARDL approach

Independent variables	**Dependent variables**			
	Bank Profitability			**Bank Stability**
	R_A	R_E	NIM	Z-score
V1	0.0282*	0.0287*	0.035*	0.029*
V2	0.258	0.335	0.378	0.03*
V3	0.022*	0.035*	0.039*	0.029*
V4	0.02*	0.04*	0.049*	0.024*
V5	0.3	0.56	0.48	0.03
V6	0.01*	0.05*	0.029*	0.023*

F-statistic values for the impact of FI variables on BP and BS are provided in table 4. Lower and upper bound values are obtained at a 1% significance level. The association is positive if the F-statistic value exceeds the upper limit. The connection is negative if the F-value is lower than the upper limit. The relations between independent and dependent variables are categorized into positive and negative based on F-value. From Tables 1 and 2, it is evident that the impact of bank branches, deposit accounts, depositors, and borrowers on ROA, ROE, and NIM has a p-value lower than 0.05 and F-statistic value greater than the upper limit. This result indicated that there is a strong confirmation of a “positive relationship between these independent variables and BP” in Japan. One reason for this result is that as the number of branches grows, so does the number of clients, which leads to a rise in deposits and loan portfolios. This suggests that branch networks are vital for improving bank income. The influence of loan accounts and ATMs on ROA, ROE, and NIM has a p-value greater than 0.05 and an F-value lower than the upper limit, as shown in

tables 1 and 2. This finding suggested that a negative association exists between these independent variables (number of ATMs and loan accounts) and bank profitability in Japan. An increase in ATMs and loan accounts does not account for the rise in the performance of the bank. The rise in the number of loan accounts does not always imply a rise in bank profitability since transaction overheads and costs may balance the higher revenue from new loan accounts, among other factors. In addition, the influence of all considered FI variables on Z-score has a p-value lower than 0.05 and an F-value greater than upper critical values at a 1% level of significance. The stability of Japanese banks has been greatly improved as a consequence of FI.

Table 4: F-statistic results of RARDLM approach at 1% significance level

Independent variable	Dependent variable	Lower Bound value	Upper Bound value	F-Statistic value	Effect
V1	Bank Profitability (R_A, R_E, and NIM)	3.24	5.8	7.29	Positive
V2		2.97	6.3	4.89	Negative
V3		3.12	5.6	8.34	Positive
V4		2.9	5.9	7.34	Positive
V5		3.54	7.9	5.24	Negative
V6		2.45	5.28	8.45	Positive
V1	Bank stability (Z-score)	2.36	5.13	9.23	Positive
V2		3.12	5.66	8.32	Positive
V3		2.13	4.8	10.13	Positive
V4		3.23	5.7	7.64	Positive
V5		2.16	4.77	8.35	Positive
V6		3.24	5.185	9.43	Positive

The significant variables selected using PCA are the number of ATMs, bank branches, loan accounts, and deposit accounts. The effect of these parameters on BP and BS was further analyzed graphically. In this study, we considered 2 years as the size of the rolling window. The p-values of the effect of the number of bank branches on ROA, ROE, and NIM throughout 2004 to 2018

for the rolling window size of 2 years are depicted in figure 4. The p-values of the effect of the number of deposit accounts on ROA, ROE, and NIM throughout 2004 to 2018 for the rolling window size of 2 years are depicted in figure 5. In figures 4 and 5, p-values were less than 0.05. From 2004 to 2018, there is substantial evidence of a long-term association between the number of bank branches and BP, as well as the number of deposit accounts and BP, as shown in figures 4 and 5.

Figure 4: Relationship between bank branches and bank performance

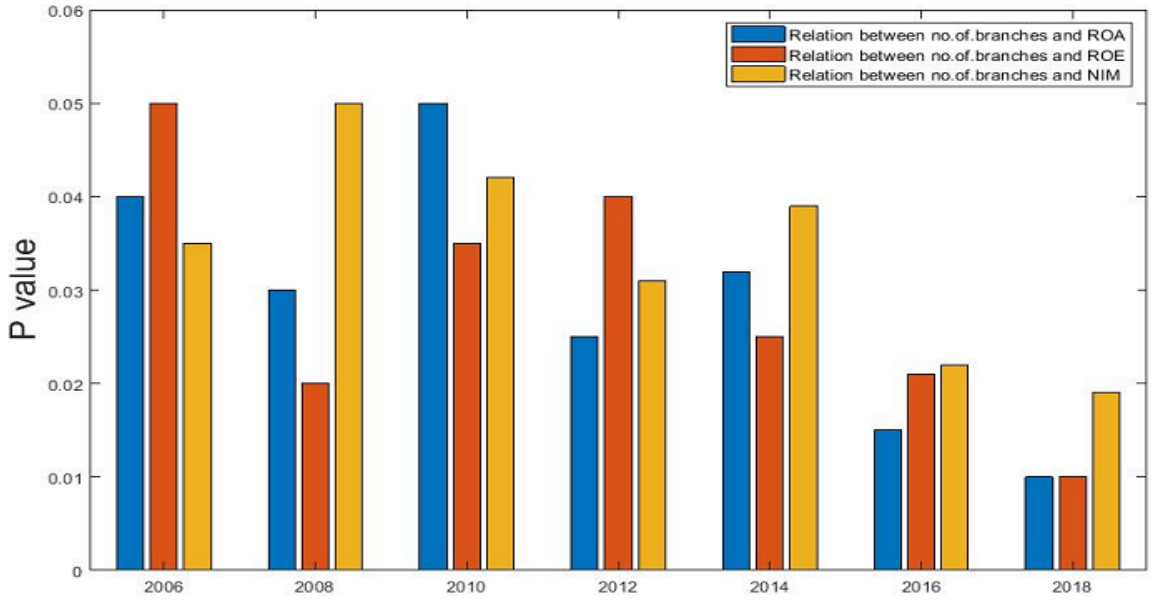


Figure 5: Relationship between deposit accounts and bank performance

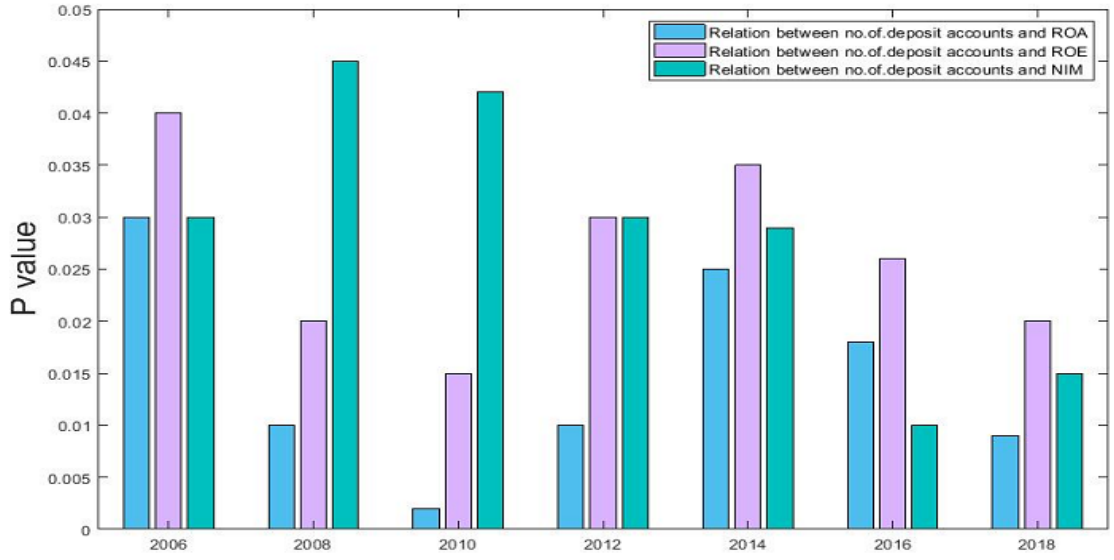


Figure 6 depicts the p-values of the influence of the ATMs on ROA, ROE, and NIM from 2004 to 2018 for a rolling window size of two years. Figure 7 shows the p-values of the influence of the loan accounts on ROA, ROE, and NIM from 2004 to 2018 for a rolling window size of two years. From Figures 6 and 7, it is clear that no long-run relationship exists between the number of ATMs and bank performance as well as between the number of loan accounts and bank performance.

Figure 6: Relationship between ATMs and bank performance

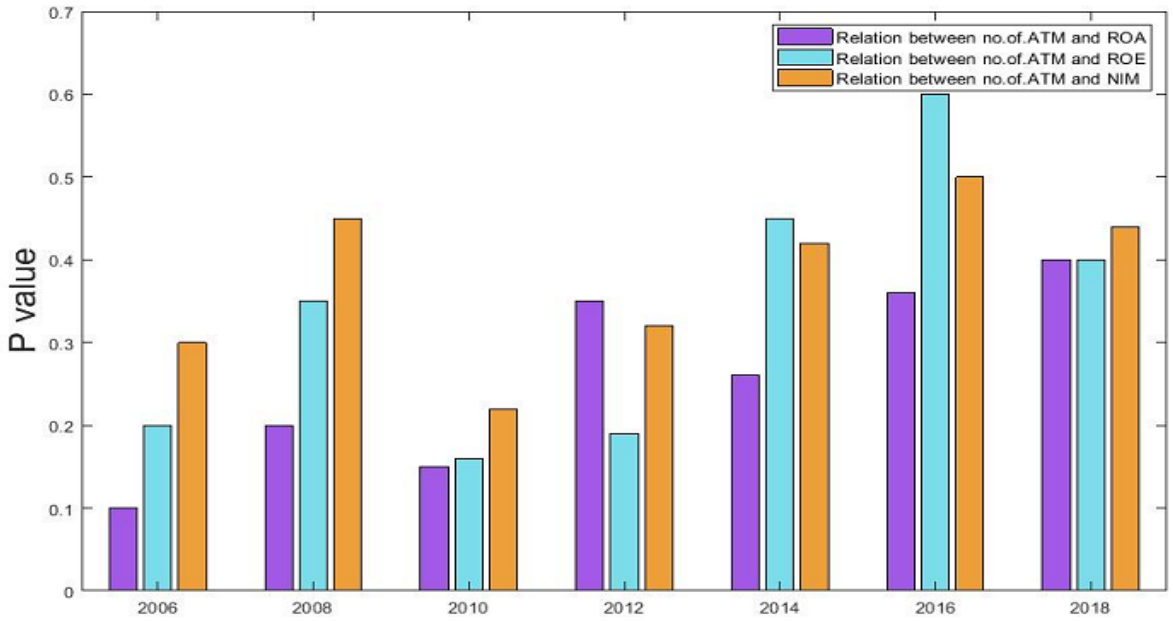


Figure 7: Relationship between loan accounts and bank performance

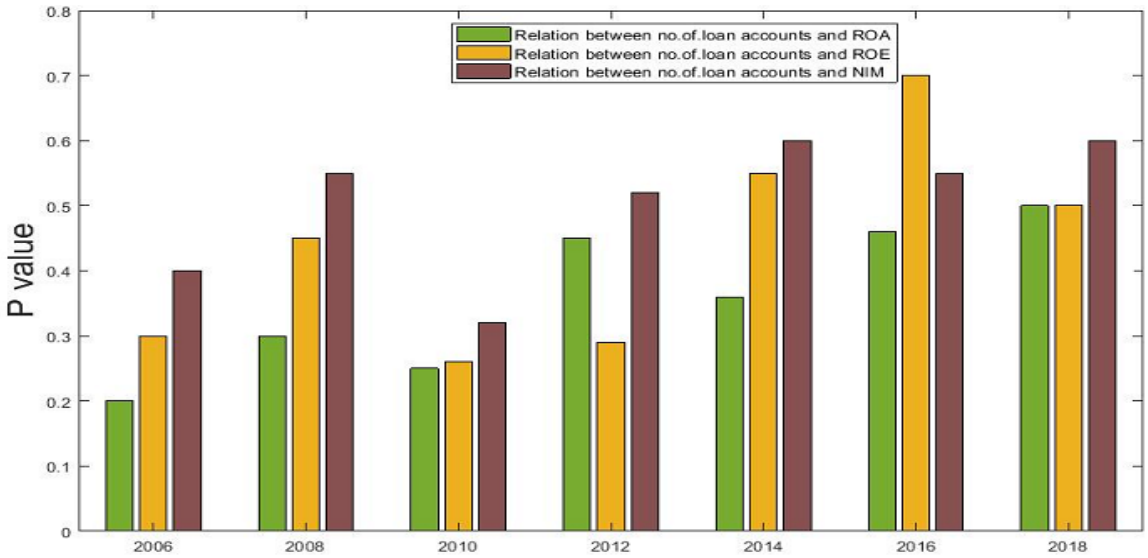
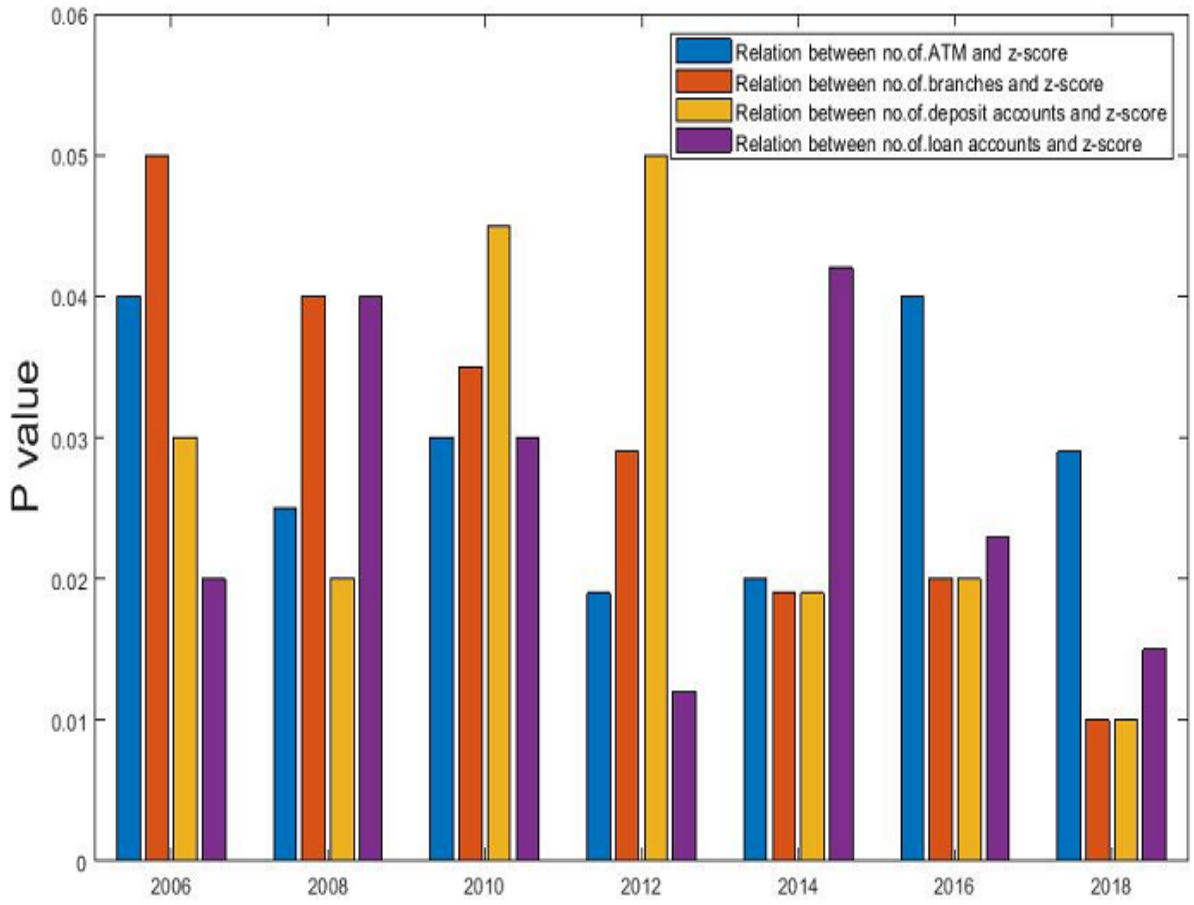


Figure 8 depicts the p-values for the impact of bank branches, ATMs, loan accounts, and deposit accounts on bank stability indicator, z-score during a two-year rolling window from 2004 to 2018. The p-values were less than 0.05, which means that FI has a beneficial influence on BS. Figure 8 shows that in Japan, FI plays a crucial role in maintaining the stability of banks. There is evidence that the stability of banks may be improved by boosting their FI.

Figure 8: Relation between significant financial inclusion variables and bank stability



4.3 Additional analysis

We performed an additional analysis that focused on assessing the relationship between the constructed multiple composite financial inclusion index and the bank's profitability plus stability. Table 5 shows the F-statistic and p-values for the impact of the FI index on BP and BS. FI's influence on BP/BS has a lower p-value than 0.05 and a higher F-statistic than the upper limit. This implied that the FI index has a positive effect on BP and BS.

Table 5: Effect of FI index on BP and BS

Independent variable	Dependent variable	Lower Limit value	Upper Limit value	F-Statistic value	P-value	Effect
Financial Inclusion index	Bank Profitability (R_A, R_E, and NIM)	3.24	5.45	7.43	0.02	Positive
Financial Inclusion index	Bank stability (Z-score)	2.43	5.24	8.41	0.032	Positive

Figure 9 showed the comparative analysis of the efficiency of the RARDLM technique with conventional techniques. Figures 10 depicted the prediction error of the RARDLM technique and other existing techniques.

Figure 9: Efficiency of different statistical techniques

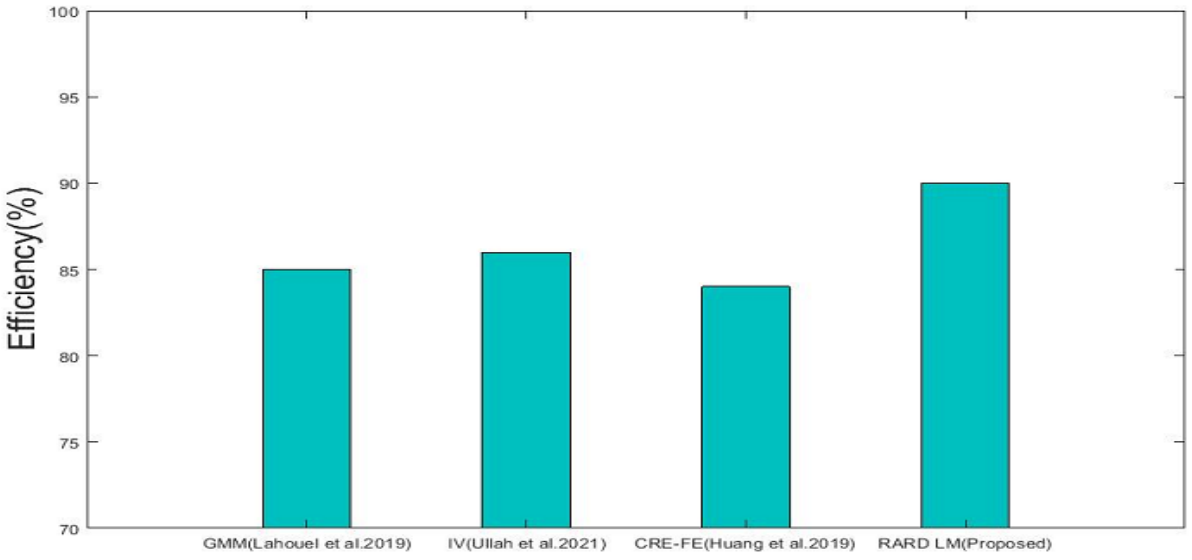
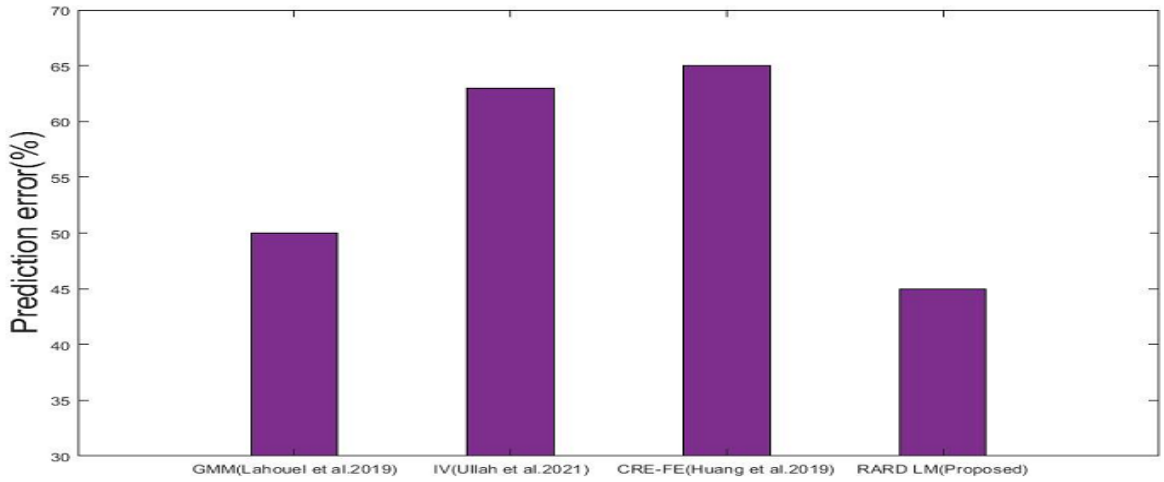


Figure 10: Prediction error of various statistical approaches



4.4 Discussion

The benefits of financial inclusion in the banking sector are clearly understood from the above section. The appropriateness behind the use of the RARDLM estimator and its benefits over the other approaches like GMM (Generalized method of moments), IV (Instrumental variable), and combined random effect-fixed effect model (CRE-FE) are discussed in this section. Endogeneity often endangers the validity of a particular model. Endogeneity refers to the difficulty of an explanatory variable being associated with the error term in regression modeling. From figure 9, the efficiency of RARDLM in estimating the relationship between independent and dependent variables was higher when compared to the existing models such as GMM, IV, and CRE-FE. Because of RARDLM's use of suitable lag selection, it is more efficient than other regression methods, allowing for more accurate estimations by adequately addressing the issues of the variables' serial correlation, heteroskedasticity, or endogeneity. The results of RARDLM account for endogeneity which leads to appropriate estimations, valid interpretations, and theoretical propositions about the dynamic nature of FI-BP and FI-BS relationships. RARDLM addressed the endogeneity problem more efficiently compared to GMM, IV, and CRE-FE approaches. RARDLM may also be used on samples of a smaller size. But other conventional methods are not efficient in empirical research of investigating smaller samples. When comparing CRE-FE, GMM, and IV, the error in predicting a long-term link between the variables is lower using the RARDLM, as shown in figure 10. This result ensured that interpretations made using RARDLM are effective when compared to other models. In addition, RARDLM can assess the relationship between variables efficiently even though the details regarding the underlying variables are not known with certainty compared to existing statistical techniques.

5. Conclusion

This paper is focused on analyzing the long-run relationship existing between FI and BP as well as between FI and BS using a new technique called RARDLM. This research helps us to uncover the reliable association between FI and BP plus BS. The significant FI variables namely the number of ATMs, bank branches, deposit accounts, and loan accounts were chosen using PCA for constructing a composite FI index. F-statistic and P values obtained using RARDLM were applied for assessing the long-run relationships between independent and dependent variables. The number of bank branches, deposit accounts, depositors, and borrowers has a significant impact on BP. But the number of ATMs and loan accounts does not have a significant effect on BP. In addition, FI has a positive impact on bank stability. Japan's policymakers should concentrate on increasing FI by adopting regulations that encourage financing to small and medium-sized firms and startups. It is ensured that RARDLM is a robust statistical tool compared to GMM, I, and CRE-FE. Further, the effect of FI on poverty reduction and economic growth of Japan through commercial banks must be analyzed using RARDLM.

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