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**Financial sector development and credit risk: an insight of BRICS countries using continuously updated fully modified and continuously updated bias corrected methods**

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## **Financial sector development and credit risk: an insight of BRICS countries using continuously updated fully modified and continuously updated bias corrected methods**

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**Abstract:** The impact of financial sector development on non-performing loans (NPLs) among emerging countries is inconclusive. For this purpose, the study investigates the relationship between financial sector development and NPLs among BRICS countries, covering the period from 1995–2018. The study has used a novel continuously-updated fully-modified (CUP-FM), and continuously-updated bias-corrected model (CUP-BC) for long-run estimation, together with CIPS, CADF second-generation unit root test, and Westerlund cointegration analysis. The findings infer that financial intermediation in terms of banks' deposits to GDP ratio and private credit to GDP ratio negatively impact NPLs in the long run. Furthermore, financial sector efficiency, financial sector stability, and regulatory capital help in reducing NPLs in the long run in BRICS countries. However, the study highlights that financial sector liberalisation in terms of foreign banks' presence has an insignificant relationship with NPLs in BRICS countries in the long run. This study offers useful policy implications.

**Keywords:** financial sector development; credit risk; CUP-FM; CUP-BC; BRICS; non-performing loans; NPLs.

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## 1 Introduction

Financial sector development is crucial for the economic growth of a country. The rapid development of financial institutions, banks, and financial intermediaries helps in strengthening countries' finances. The World Bank has defined financial sector development as the process of establishment of financial institutions that reduce the cost of financial transactions and provide availability of financial services. A large body of evidence suggests that financial sector growth is essential for financial sustainability. It helps financial sustainability through capital infusion and technological advancement by increasing the saving rate, mobilising savings, providing investment information, and facilitating the inflow of foreign funds (Zhang and Cheng, 2015). The financial sector development implies a continuous growth in the efficiency, stability, and size of financial institutions and markets. A developed financial institution helps in channelising funds and in generating investment opportunities. (Shahbaz et al., 2015) reiterated that well-developed financial institutions create adequate credit that helps in creating market demand and increases profitability. Previous studies show that developed countries have a well-developed financial sector as compared to emerging countries (Chaibi and Ftiti, 2015). The financial sector of developed countries has well-capitalised banks and financial institutions. The banking structure of developed countries is centralised and properly regulated. Due to a well-capitalised banking structure and monitoring capabilities, the financial and economic uncertainties are comparatively lower in developed countries. Studies show that the after effect of the global economic meltdown of 2008 was less in developed countries because of their well-capitalised and developed financial institutions (Ghosh, 2014; Lin and Treichel, 2012).

On the other side, studies show that emerging countries lack a well-developed financial system (Ozili, 2019). Emerging countries are those countries that are not fully developed but have similar characteristics to a developed economy. Previous studies have suggested that the rate of economic growth is higher in emerging countries. According to the International Monetary Fund (IMF) estimates, emerging countries expect to grow two to three times faster than developed nations (Main et al., 2020). The evolving market demand and increasing growth rate provide considerable opportunities for investments to

new entrepreneurs. The rising trend in economic growth and entrepreneurial abilities among emerging countries requires a developed financial sector. However, the financial sector of emerging countries is not as developed compared to developed countries. Furthermore, to develop the financial sector, emerging economies have taken various steps like creating new banks, inviting foreign banks, and creating new investment avenues. A large body of evidence suggests that the development of the financial sector leads to credit risk. Credit risk increases when the regulatory mechanism is not so efficient (Ozili, 2019). In the quest for developing the financial sector, emerging countries' financial institutions, primarily banks, are subject to credit risk due to the lack of an efficient regulatory mechanism. Thus, this study tries to reaffirm the impact of financial sector development on credit risk among BRICS countries.

The following reasons support the idea of taking BRICS countries. The World Bank has classified BRICS countries as the five biggest emerging countries in terms of output and economic growth. The total population of BRICS countries is around 3.1 billion, which is approximately 42% of the world population, and thus this bloc is gaining more global attention. Since the past two decades, the share of BRICS countries in world output has doubled from 7.2% in 1992 to almost 16% in 2018 (Younsi and Bechtini, 2018; Syed and Tripathi, 2019). Further, in 2017, BRICS economies have contributed around 32% of global GDP (PPP). In context to financial development, the financial sector reforms which began in 1980–1990 have also helped in the growth of the financial market in BRICS countries. The financial sector indicators have significantly improved in BRICS countries. For instance, domestic bank credit of BRICS blocs is almost (the US\$22 trillion), which is 22% of global domestic bank credit, similarly, the combined stock market capitalisation of these economies is (the US\$22 trillion), which represent 17% of the world market capitalisation (Gupta and Rao, 2018). Based on the above facts, we can be reiterated that BRICS countries have made an impressive transition from developing countries to emerging market economies. However, to sustain the need for economic growth and financial sector development, the banking industry of BRICS countries faced immense pressure. The pressure of credit and investment needs has resulted in rising NPLs in BRICS countries, especially in India, Russia, and South Africa. According to the global financial report, in 2019, India and Russia have NPLs of more than 9% of their GDP. Due to low corporate profitability, over investments, cyclic factors, and low profitability turnover, Brazil and China also have NPLs of more than 4% of their GDP. In addition, to the increase in NPLs in BRICS countries, the average recovery rate (30.48%) and insolvency index (10.9 on the scale of 16) is also low in BRICS countries. In light of the above challenging financial scenario, it is essential to investigate how financial sector development affects the credit risk portfolio of BRICS countries. It is also worth noting that very few studies have barely studied the impact of banking sector development on credit risk. Against this backdrop, this study examines the relationship of four pillars of banking sector development (banking stability, banking efficiency, banking growth, banking intermediation) with the NPLs portfolio of BRICS countries.

This study contributes to the extant literature in the following ways. First, this study incorporates the role of financial development, which has not been explored comprehensively in previous studies. Based on the limitation of earlier literature, we have used those proxies which are more specific to banking and financial sector development. Moreover, recently NPLs ratio has become the main topic of discussion in emerging countries. Therefore, the current study will add significantly to the extant literature on

NPLs. Second, this study investigates BRICS countries, thus adding a new dimension to the existing literature of NPLs. As already discussed, BRICS is a dominant bloc both in terms of global economic participation and market opportunities. The NPLs ratio is also high in few BRICS countries, and hence this study will add significantly towards the mitigation strategies to control NPLs. Third, this study employs a novel panel data estimation technique, CUP-FM, and CUP-BC that generates more robust results. As per the author's knowledge, this technique is also not used in earlier studies related to NPLs. Besides, it also points out the issue of cross-sectional dependency (CSD) and also suggests appropriate ways to detect CSD. Thus, also contributing towards the methodology section of previous literature. Due to competition from developed countries, emerging countries are struggling with credit risk and financial sector development. Therefore, the findings will assist in devising policies related to financial sector development, considering the implications of credit risk.

The structure of this paper proceeds as follows: Section 2 explains the review of previous literature, the research gap, and the theoretical background; Section 3 includes the data description, method, and empirical model; Section 4 is the analysis of the model used in the study; Section 5 concludes the study and offer policy suggestions.

## **2 Review literature**

Numerous studies have analysed the determinants of NPLs, by categorising the determinants into macroeconomic and bank-specific determinants. However, there are scant studies that have reviewed the role of financial development on NPLs. Thus, to understand the determinants and to construct the theoretical framework, various studies are reviewed. Table 1 shows the extant details of previous studies.

Table 1 literature shows that various studies have investigated the role of banking and macroeconomic variable on NPLs. These studies have employed different econometric techniques like VAR, GMM, and regression analysis to analyse the determinants of NPLs. However, as per the authors' knowledge, there is no specific study on the role of financial sector development and its impact on NPLs' persistence levels among BRICS countries. Therefore some connection between NPLs and the level of financial sector development can also be established, as NPLs are a significant part of banking performance. Few studies have focused on certain specific financial sector development key indicators while studying banking and macroeconomic determinants of NPLs. For instance, studies conducted by Tanasković and Jandrić (2015) and Giannetti and Ongena (2009) have investigated the role of foreign banks and bank credit to the private sector on NPLs. Naudé (2009) suggested that countries with well-developed financial institutions are least affected by the economic and financial crisis. Demirgüç-Kunt and Huizinga (2000) and Tecles and Tabak (2010) had investigated the role of financial development on banking performance by including banking profitability as a proxy of banking performance. But these studies have not comprehensively evaluated the level of financial sector development on NPLs. Ozili (2019) conducted one of the latest studies on the relationship between financial sector development and NPLs. He concluded that financial intermediation and foreign bank presence have a direct impact on the NPLs. Furthermore, the study also highlighted that banking competition and efficiency help in reducing NPLs.

**Table 1** Detail review of previous studies on NPLs

<i>Authors</i>	<i>Sample</i>	<i>Time</i>	<i>Variables</i>	<i>Techniques</i>	<i>Results</i>
Nkusu (2011)	26 developed countries	1998–2009	Growth and interest rate, unemployment and inflation	Impulse response and VAR	The study highlights that macroeconomic factors like inflation and growth rate have a direct impact on NPLs.
Škarica (2014)	7 Central European countries	2007–2012	Growth rate, exchange rate unemployment and interest rate	Fixed effect model	The findings conclude that growth rate and exchange rate have a direct impact on NPLs.
Castro (2013)	GIPSI countries	1997–2011	Growth rate, interest rate spread, credit growth and stock index	Dynamic panel analysis	NPLs are affected by the house price index, interest rate, financial crisis, and credit deposit ratio.
Chaibi and Fiti (2015)	Germany and France	2005–2011	Growth rate, interest rate, exchange rate and banking inefficiency	GMM	The result indicates that in comparison to Germany, France NPLs are more affected by bank-specific factors. The study also concluded that interest rate, exchange rate, growth rate have a significant impact on NPLs.
Ozili (2019)	138 countries	2003–2014	Bank inefficiency, financial intermediation and private credit to banks	OLS and sensitivity analysis	The study concludes that financial development and banking efficiency indirectly affect NPLs whereas foreign bank presence positively affects NPLs.
Beck et al. (2013)	75 countries	2000–2010	Share price, interest rate, exchange rate and growth rate	GMM	The results highlight interest rate and share price significantly and positively affect NPLs.
Touny and Shehab (2015)	9 Arab countries	2000–2012	Growth rate, government spending, inflation and debt burden	GMM	The findings suggest that growth rate, spending, and inflation indirectly affect NPLs whereas debt burden positively impacts NPLs.

**Table 1** Detail review of previous studies on NPLs (continued)

<i>Authors</i>	<i>Sample</i>	<i>Time</i>	<i>Variables</i>	<i>Techniques</i>	<i>Results</i>
Louzis et al. (2012)	Greek banking	2003–2009	GDP, interest rates, unemployment, inflation and management efficiency	GMM	The study highlights that in Greek banking, NPLs are significantly affected by management efficiency and macroeconomic factors.
Beck et al. (2015)	75 countries	2000–2010	Growth rate, stock movement and exchange rate	Regression model	The study highlights that NPLs are significantly affected by share price movement, interest rates and exchange rates.
Nikolaidou and Vogiazas (2017)	Sub-Saharan African countries	2004–2014	Bank specific factors and money supply	ARDL	The results highlight that in the selected sample countries bank-specific determinants are the reasons for NPLs. However money supply and country-specific conditions also indirectly affect NPLs.
Boudriga et al. (2010)	MENA countries	2002–2006	Credit growth, GDP, bank profitability, capital adequacy ratio and private management	Pooled mean regression	The findings suggest that credit growth has a positive impact on NPLs and regulatory capital has a negative relationship with NPLs.
Espinoza and Prasad (2010)	GCC countries	1995–2008	GDP, interest rate, exchange rate and inflation	VAR	The study concludes that interest rate increases NPLs.
Makri et al. (2014)	14 Eurozone banking system	2000–2008	Bank profitability, return on equity, fiscal deficit, growth rate and unemployment	GMM	The method of moments concludes that profitability and growth rate negatively impact NPLs, whereas unemployment and fiscal deficit have a positive impact on NPLs.

**Table 1** Detail review of previous studies on NPLs (continued)

<i>Authors</i>	<i>Sample</i>	<i>Time</i>	<i>Variables</i>	<i>Techniques</i>	<i>Results</i>
Islam and Nishiyama (2016)	South Asian countries	1997–2012	Banking management, size of banks, inflation, GDP and bank concentration	GMM	The result concluded that bank customer selection and bad management results in NPLs.
Le et al. (2019)	31 Asian countries	2004–2016	Financial Inclusion, efficiency and sustainability	PCA and FGLS	The study suggests that level of financial inclusion have a negatively impact on financial efficiency among the sample countries.
Huhtilainen (2019)	339 Finland Banks	2002–2018	Income diversification and inefficiency in cost	2-system GMM	The result highlights that diversification in banking income helps in reducing NPLs whereas cost inefficiency increases NPLs.
Chen et al. (2018)	31 provinces in China	2005–2016	Size of banks, financial inclusion, education, unemployment, inflation and investment	Regression analysis	The findings suggest that the degree of financial inclusion increases NPLs.

Based on Table 1 literature void, this study focuses on the following theoretical frameworks to establish some relationship between financial sector development and NPLs. The first framework states that financial sector development promotes efficiency in banking management. Increased financial sector development promotes technological advancement, efficient banking management, and adequate resources, leading to better banking performance and lower NPLs. Contrary to the first framework, the second one highlights that an increase in the level of financial development leads to tough competition, undue interference from foreign entities, and creates monopoly tendencies. Thus, lowering banking performance and negatively affecting the NPLs of domestic banks. The third conceptual framework based on the literature strand states that financial sector development promotes financial inclusion. Higher involvement in the financial market can increase the social cost and thus jeopardise financial stability (De la Torre et al., 2011; Syed, 2021). The study also borrows its theoretical background from the concept of bad management hypothesis, which states inefficiency and bad management practices hampers the stability of banks and increases NPLs. The growth in the financial sector without adequate regulatory and institutional regulations makes the banking industry more susceptible to bad management practices, and thus the chances of bad loans increases. Therefore, based on the following conceptual and theoretical framework, this study focuses comprehensively on studying the impact of financial development on NPLs among BRICS countries. This study covers all the aspects of financial sector



development like financial intermediation, level of financial sector efficiency, financial out-reach, foreign bank presence, financial stability, along with certain traditional macroeconomic variables. The study also uses the novel CUP-FM and CUP-BC model and thus significantly adds to the extant literature on NPLs and financial sector development.

**Table 2** Variable description, expected relationship, and the justification for including independent variables

<i>Independent variable's</i>	<i>Expected sign</i>	<i>Reason and logic based on literature</i>
Bank cost to income ratio (BI)	–	High cost and low source of income create inefficiency in banks, thus NPLs increase.
Loan to deposit ratio (LD)	+	High credit disbursement shows that banks are using loose credit policy which may result in high NPLs.
Bank non-interest income to total income (NI)	–	Provisions for other sources of income will reduce the dependability of bank loan income and thus NPLs may show a downfall.
Regulatory capital (RA)	–	Provisions for regulatory capital increase stability and reduces cost thus the probability of NPLs and bank insolvency is low.
Bank deposit to GDP ratio (BDGDP)	–	A higher percentage of the deposit increases credit availability, however, it also increases capital, thus the chances of NPLs are low.
Private credit to GDP (PCGDP)	+	Private credit is more unstable thus chances of NPLs are higher.
Foreign bank asset to total bank asset ratio (FABA)	–	Foreign bank promotes efficiency and competition, therefore low NPLs.
Lerner (CO)	Mixed	Competition increases risk and efficiency and therefore mixed response on NPLs.
Z-score (ST)	–	Stability promotes efficiency, thus low NPLs.
Growth rate (GDP)	–	Growth results in efficiency and income generation, thus a negative impact on NPLs.
Unemployment (UN)	+	Unemployment reduced debt servicing capabilities, hence high NPLs.
Inflation (IN)	+	High inflation affect debt servicing therefore high NPLs
Interest rate (IR)	+	High-interest rate increases the chances of default, thus high NPLs.

### 3 Data methodology and analysis

This study has incorporated various independent variables to evaluate the impact of financial sector development on NPLs among the BRICS (Brazil, Russia, India, China and South Africa) countries. Data is retrieved from the global financial indicator database of the World Bank, covering the period from 1995–2018. To measure the impact of financial development, variables included are private credit to GDP ratio for measuring financial intermediation (Cihak et al., 2012), bank deposit to GDP ratio for measuring the

size of the bank (Demirgüç-Kunt and Huizinga, 2000), and foreign bank asset to total bank asset ratio for measuring financial sector liberalisation (Giannetti and Ongena, 2009). In context to the bank-specific variable affecting NPLs, variables included are bank cost to income ratio for measuring banking efficiency (Lin and Zhang, 2009), loan to deposit ratio for estimating banking liquidity (Van den End, 2016), bank non-interest income to total income ratio for considering bank dependencies on interest income of loans (Ozili and Uadia, 2017), and to measure banking stability, we have used regulatory capital ratio (Caporale et al., 2015).

In addition to the above, we have also used the Lerner index for competitiveness and Z-score for banking stability. Certain control variables are also included, like GDP, interest rate, unemployment, and inflation. Table 2 shows the variables description, their expected relationship, and the reasons for including the above variables.

### 3.1 Methodology

The relationship between non-performing loans (NPLs) and financial sector development among BRICS is expressed as:

$$\ln(NPL_{it}) = \alpha_0 + \ln\alpha_1(Y_{it}) + \mu_{it} \quad (1)$$

where  $NPL$  represent NPLs,  $\alpha$  is intercept,  $Y$  is independent variables and  $\mu_{it}$  is the error term. The study has used advanced panel data analysis techniques to estimate the impact of financial sector development on NPLs, which are summarised as below:

#### 3.1.1 CSD test

CSD is one of the prominent issues from which panel data suffers. The CSD in data is due to the influence of country-specific factors, regional factors, and global interrelations. A large body of evidence shows that panel data also involve correlation and homogeneity issues along with CSD. Hence, it is required to investigate the issue of CSD before proceeding with the cointegration and stationarity analysis. To confirm the presence of CSD, we have employed the Breusch-Pagan Lagrange multiplier (LM) test and Pesaran (2007) CSD test. Both the tests confirm the null hypothesis of no CSD against the presence of CSD. The below equation represents the model of the LM and CSD test.

$$CD = \sqrt{\frac{2}{N(N-1)}} \sum_{b=1}^{N-1} \sum_{k=b+1}^N T_{bk} \widehat{C}_{bk}^2 \rightarrow N(0, 1) \quad (2)$$

$$LM = \sum_{b=1}^{N-1} \sum_{k=b+1}^N T_{bk} \widehat{C}_{bk}^2 \rightarrow \chi^2 \frac{N(N-1)}{2} \quad (3)$$

The result and analysis section contain the results of the CSD and LM tests.

#### 3.1.2 Panel unit root test

Previous studies have advocated that the first-generation unit root test is no longer appropriate for panel unit root analysis as it does not account for CSD. However, to make the study comprehensive, we have used first-generation unit root test, but keeping in mind the issue of cross-sectional dependencies, we have also employed a

second-generation CIPS panel unit root test and cross-sectional augmented Dicky Fuller test (CADF) proposed by Pesaran (2007). The regression equations used for the above test CADF and CIPS test are:

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^s d_{ij} \Delta \bar{y}_{t-j} + \sum_{j=1}^s \delta_{ij} \Delta y_{i,t-j} + e_{it} \quad (4)$$

Note:  $\bar{y}$  and  $(\Delta \bar{y})$  are averages of 1st difference and lagged level. The t-estimate of equation (3) is used to estimate the CIPS statistic, shown as equation (4).

$$CIPS = N^{-1} \sum_{i=1}^N CADF_i \quad (5)$$

The analysis section summarises the results of the CADF and CIPS tests. Both of the second-generation unit root tests check the null hypothesis of non-stationarity against the alternative hypothesis of otherwise. Next, the study proceeds with checking the long-run relationship via panel cointegration analysis.

### 3.1.3 Cointegration investigation

Like the first-generation unit root test, conventional cointegration techniques like Pedroni's (1999) also do not account for CSD. Therefore, to evaluate the relationship between independent and dependent variables and avoid the issue of CSD, the study has used the robust panel bootstrap cointegration approach given by Westerlund (2007). The Westerlund panel cointegration method considers CSD via the bootstrap mechanism. Under this method, a total of four tests are conducted; two groups mean test and two-panel test for the whole panel, respectively. The structure of Westerlund (2007) cointegration test, along with two groups and the two-panel is as follows:

$$\Delta y_{it} = \delta_i k_t + \alpha_i (y_{i,t-1} - \beta_i' x_{i,t-1}) + \sum_{j=1}^{r_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{s_i}^{s_i} y_{ij} \Delta x_{i,t-j} + e_{it} \quad (6)$$

Note:  $k_t$  represents deterministic components and  $r_i$  and  $s_i$  are the lead and lag orders.

$$G_t = \frac{1}{N} \sum_{i=1}^N \frac{\hat{\alpha}_t}{SE_{\hat{\alpha}_t}} \quad (7)$$

$$G_\alpha = \frac{1}{N} \sum_{i=1}^N \frac{T \hat{\alpha}_t}{\hat{\alpha}_t(1)} \quad (8)$$

$$P_t = \frac{\hat{\alpha}_t}{SE_{\hat{\alpha}_t}} \quad (9)$$

$$P_\alpha = T \hat{\alpha} \quad (10)$$

The analysis section summarises the result of the Westerlund (2007) cointegration test. Finally, to study the magnitude of the relationship between the dependent variables and independent, panel regression analysis is employed, discussed in the subsequent section.

### 3.1.4 Panel regression analysis: CUP-FM and CUP-BC

There are various techniques to estimate long-run relationships when the time dimension is greater than cross-sections. However, different methods have some or other limitations, for example, frequently used techniques like DOLS and FMOLS can tackle the above issue, but they cannot control the problem of CSD. Similarly, methods like the generalised method of moments, fixed and random OLS, which provide robust estimates in case of endogeneity, are not appropriate when the time dimension is more than cross-sections. Furthermore, in various current studies, in order to resolve the issue of CSD dynamic seemingly unrelated cointegrating regression (DSUR) is employed. However, the DSUR technique is not suitable to deal with the issue of residual correlation.

In brief, different techniques have different limitations, but when it comes to long-run estimation CUP-FM and CUP-BC technique is considered to be more appropriate (Ahmed and Le, 2021). Therefore, to estimate the long-run relationship between financial sector development and NPLs, CUP-FM and CUP-BC panel regressor estimator technique proposed by Bai et al. (2009) is employed. This estimation technique is continuously updated till it provides robust estimates called CUP-FM. Similarly, asymptotic bias is additionally revised and assessed in this process, denoted as CUP-BC estimation (Hassan et al., 2020). The equation used for CUP-FM and CUP-BC is as follows:

$$\begin{aligned} \hat{\beta}_{cup} = & \left[ \sum_{i=0}^n \left( \sum_{t=1}^T \hat{y}_{it} + (\hat{\beta}_{cup}) \times (x_{i,t} - \bar{X}_i) \right. \right. \\ & \left. \left. - T \left( \lambda_i (\hat{\beta}_{cup}) \hat{\Delta}_{Kci} + (\hat{\beta}_{cup}) + \Delta_{\mu ei} + (\hat{\beta}_{cup}) \right) \right) \right] \\ & \times \left[ \sum_{i=1}^n \sum_{t=1}^T (x_{i,t} - \bar{X}_i)(x_{i,t} - \bar{X}_i)' \right]^{-1} \end{aligned} \quad (11)$$

where  $\hat{\Delta}_{Kci}$  are  $\mu ei$  estimated one side covariance. This technique is best suited when the estimators are of the mixed level of integration and provide robust results in case of endogeneity, besides dealing with CSD, heteroskedasticity, autocorrelation, and fractional integration (Bai et al., 2009). Furthermore, this technique is also widely used in estimating long-run relationships in the case of small sample size data (Dogan et al., 2020; Hassan et al., 2020). Based on these qualities and a flexible approach, we have used this technique for long-run estimation.

### 3.2 Result analysis

Before proceeding with the empirical analysis, descriptive statistics of all the variables are calculated. Table 3 shows the results of descriptive statistics, which shows that the mean value of NPLs, unemployment, interest rate is high among the BRICS countries compared to other developed countries. Descriptive statistics also highlight that the mean value of growth rate, foreign bank presence, banking stability, competitiveness, regulatory capital, and bank cost to income ratio is low in BRICS countries compared to globally developed standards.

**Table 3** Descriptive statistics

<i>Variable's</i>	<i>Mean</i>	<i>Median</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Std. dev.</i>
<i>NPLs</i>	5.49	3.72	29.8	0.95	5.06
<i>BI</i>	56.96	55.93	98.87	31.04	15.04
<i>LD</i>	131.47	111.37	315.60	59.31	73.38
<i>NI</i>	37.63	35.52	95.26	7.96	17.63
<i>RA</i>	13.76	13.60	20.90	2.50	3.81
<i>BDGDP</i>	77.36	70.16	165.30	18.46	32.72
<i>PCGDP</i>	64.61	57.25	156.30	13.63	34.57
<i>FABA</i>	11.46	10.00	25.00	1.00	8.56
<i>CO</i>	0.24	0.25	0.41	0.01	0.09
<i>ST</i>	14.45	15.01	22.99	5.64	4.16
<i>GDP</i>	5.10	5.17	14.23	-7.82	3.83
<i>UN</i>	10.13	6.65	27.33	3.49	7.97
<i>IN</i>	6.46	5.85	21.5	-0.08	4.13
<i>IR</i>	9.72	4.48	48.34	-12.28	14.87

**Table 4** LM and CD

	<i>LM test</i>	<i>CD test</i>
<i>Log BI</i>	24.512 (0.0000)*	8.462 (0.0000)**
<i>Log LD</i>	31.691 (0.0000)*	14.752 (0.0000)*
<i>Log NI</i>	16.963 (0.0000)**	4.646 (0.0000)*
<i>Log RA</i>	68.428 (0.0000)*	6.250 (0.0000)**
<i>Log BDGDP</i>	16.913 (0.0000)**	12.801 (0.0000)*
<i>Log PCGDP</i>	26.452 (0.0000)*	8.915 (0.0000)*
<i>Log FABA</i>	18.726 (0.0000)*	7.318 (0.0000)*
<i>Log CO</i>	41.592 (0.0000)**	13.753 (0.0000)**
<i>Log ST</i>	34.535 (0.0000)*	9.532 (0.0000)*
<i>Log GDP</i>	12.453 (0.0000)*	4.396 (0.0000)**
<i>Log UN</i>	38.916 (0.0000)**	12.531 (0.0000)*
<i>Log IN</i>	18.932 (0.0000)*	9.424 (0.0000)*
<i>Log IR</i>	10.289 (0.0000)*	8.719 (0.0000)*

Notes: \* and \*\* at 1% and 5% level of significance.

Further, moving with the result analysis of techniques discussed above, the result of the cross-section dependency test is presented in Table 4 which concludes that the null hypothesis of CSD among the regressors cannot be rejected. The results show that there is CSD among the regressors, which means that shock in one country causes spill-over effects within the sample countries.

After checking the CSD, the analysis proceeds with checking the unit root among the samples. The result of the first generation unit root test attached in Table 5 confirms that except for a few variables all the other variables are integrated at the first difference. The

result of the first generation unit root test collaborates with the findings of the second generation, CIPS and CADF unit root test attached in Table 6. The CIPS unit root test and CADF test is employed as it provides better estimation in the presence of CSD.

**Table 5** First generation unit root test

	<i>Levin, Lin, and Chu</i>				<i>Im, Pesaran and Shin W-stat</i>			
	<i>At levels</i>		<i>First difference</i>		<i>At levels</i>		<i>First difference</i>	
	<i>Stats</i>	<i>P-value</i>	<i>Stats</i>	<i>P-value</i>	<i>Stats</i>	<i>P-value</i>	<i>Stats</i>	<i>P-value</i>
Log <i>BI</i>	-2.122	-0.003*	-2.921	-0.000*	-2.832	-0.000*	-1.324	-0.000*
Log <i>LD</i>	-1.453	-0.000*	1.121	-0.000*	-1.642	-0.012*	-2.293	-0.000**
Log <i>NI</i>	1.602	-0.000*	-1.521	-0.000*	-2.924	-0.000*	-2.532	-0.000*
Log <i>RA</i>	-2.341	-0.002*	-2.004	-0.000*	1.453	-0.000*	-1.831	-0.000*
Log <i>BDGDP</i>	2.002	-0.065	-1.371	-0.000*	-2.673	-0.710	-2.593	-0.000*
Log <i>PCGDP</i>	-1.352	-0.012*	-3.429	-0.000**	-1.442	-0.000*	-1.192	-0.042*
Log <i>FABA</i>	-2.843	0.271	-2.294	0.000*	-2.129	0.003*	-2.166	0.000*
Log <i>CO</i>	-2.432	-0.000*	-2.992	-0.000*	2.845	-0.000*	-1.002	-0.000*
Log <i>ST</i>	-2.432	-0.001*	-1.995	-0.000**	-1.852	-0.000*	-1.672	-0.000*
Log <i>GDP</i>	-1.649	-0.000*	-3.003	-0.000*	2.042	-0.002*	-2.221	-0.000*
Log <i>UN</i>	-0.114	-0.081	-1.251	-0.000**	-2.112	-0.000*	-1.801	-0.000*
Log <i>IN</i>	-2.113	-0.000*	-2.843	-0.000*	-1.932	-0.000*	-2.042	-0.000*
Log <i>IR</i>	-1.332	-0.000*	-2.942	-0.000*	-2.712	-0.070	-2.901	-0.000*

Notes: \* and \*\* at 1% and 5% level of significance.

After checking the issues of CSD and unit roots, the investigation proceeds to determine cointegration among the variables. The Westerlund cointegration approach is employed to estimate the cointegration among the variable. The results of Westerlund panel cointegration reported in Table 7 show that the variables are cointegrated, meaning financial sector development plays a crucial role in estimating credit risk among the BRICS countries. The probability value of most of the estimated statistics shows that the null hypothesis of cointegration cannot be rejected.

Moving further with the analysis, the results of long-run estimation technique in table 8 shows that NPLs are significantly affected by the level of financial sector development in BRICS countries. The results conclude that non-interest income, banking stability, and regulatory capital help reducing NPLs in BRICS countries. In other words, banking efficiency and regulatory mechanism help in lowering NPLs in BRICS countries. The results analysis also supports the findings of Huutilainen (2019). Concerning banking intermediation and size of banks, bank deposit to GDP ratio and private credit to GDP ratio, result in increasing NPLs. A higher rate of deposits results in higher loan disbursement, and due to the lack of efficient recovery mechanisms among BRICS countries, NPLs increase, thus further supports the findings of Chen et al. (2018). In context to financial liberalisation, the presence of foreign banks has an insignificant effect on the NPLs. The banking structure of BRICS countries is predominantly

dominated by state-owned banks, thus the influence of foreign banks on NPLs is insignificant. The above finding is contrary to the study of Ozili (2019).

**Table 6** CIPS and CADF unit root test result

<i>CIPS test</i>		<i>CADF test</i>	
<i>At levels</i>	<i>First difference</i>	<i>At levels</i>	<i>First difference</i>
-3.135	-4.363*	-2.135	-3.463*
-2.890	-3.429*	-2.290	-3.352**
-3.247	-3.094*	-2.247	-2.361*
-2.235	-3.302*	-3.235	-4.342*
-3.753	-4.012*	-2.231	-3.367*
-2.892	-3.113**	-2.267	-3.542*
-3.631	4.175*	-2.146	-3.412*
-3.138	-4.024*	-3.362	-3.361*
-0.608	-2.612*	-2.321	-3.734*
-2.571	-3.092*	-3.233	-3.346**
-1.345	-3.129*	-2.112	-3.431*
-0.692	-2.342*	-3.364	-3.652*
-2.864	-3.174*	-2.234	-3.432*

Notes: \* and \*\* at 1% and 5% level of significance.

**Table 7** Westerlund cointegration analysis

<i>Model</i>	<i>Statistic</i>	<i>Value</i>	<i>Z-value</i>	<i>P-value</i>
(1)	$G_t$	-3.231	-2.428	0.0000
	$G_a$	-5.425	-3.021	0.0000
	$P_t$	-4.982	-5.612	0.0001
	$P_a$	-5.244	3.234	0.0007
(2)	$G_t$	-8.431	-7.648	0.0010
	$G_a$	-10.452	4.532	0.0000
	$P_t$	-14.431	-3.214	0.0003
	$P_a$	-13.532	-2.421	0.0000
(3)	$G_t$	-9.421	-3.521	0.0002
	$G_a$	-7.242	3.134	0.0007
	$P_t$	-8.811	-4.453	0.0056
	$P_a$	-6.221	-3.532	0.0001
(4)	$G_t$	-10.111	-4.566	0.0000
	$G_a$	-8.242	3.491	0.0013
	$P_t$	-3.214	2.562	0.0001
	$P_a$	2.231	-4.642	0.0180

Notes: \* and \*\* at 1% and 5% level of significance, SIC is used for optimum lag criteria.

The analysis further concludes that banking competitiveness has a direct relationship with NPLs. To capture the market share, banks resort to target selling of loans, which often results in NPLs due to a lack of inefficient know your customer's norms. The CUP-FM and CUP-BC models also highlight that macroeconomic variables also significantly

affect NPLs. Economic growth has an indirect relationship with NPLs, whereas unemployment, interest rate, and inflation have a direct and significant relationship with NPLs.

**Table 8** CUP-FM and CUP-BC

	<i>CUP-FM</i>		<i>CUP-BC</i>	
	<i>Coefficient</i>	<i>t-value</i>	<i>Coefficient</i>	<i>t-value</i>
Log <i>BI</i>	0.060*	12.45	0.070**	26.64
Log <i>LD</i>	0.047*	11.42	0.056**	32.42
Log <i>NI</i>	-0.227*	44.56	-0.342*	67.32
Log <i>RA</i>	-0.372*	32.35	-0.361**	45.23
Log <i>BDGDP</i>	0.120*	23.53	0.221**	54.23
Log <i>PCGDP</i>	0.381*	14.12	0.381*	26.42
Log <i>FABA</i>	0.189	31.92	0.189	34.63
Log <i>CO</i>	0.114***	42.93	0.119***	53.12
Log <i>ST</i>	-0.319*	12.10	-0.489*	25.63
Log <i>GDP</i>	-0.913*	31.45	-0.910*	45.12
Log <i>UN</i>	0.782**	33.25	0.674*	43.12
Log <i>IN</i>	0.112*	22.15	0.110*	33.32
Log <i>IR</i>	0.012**	44.18	0.067*	56.32

Notes: \*, \*\* and \*\*\* significance level at 1%, 5% and 10%.

#### 4 Conclusions and discussion

This study explores the long-run relationship between financial sector development and NPLs in BRICS countries covering the period from 1995–2018. To fulfil the above objective LM and CSD test is applied to check CSD and the CIPS and CADF tests are used to check data stationarity among the sample. Westerlund panel cointegration test is also employed to investigate the cointegration among the variables. Further, CUP-FM and CUP-BC estimator is used to estimate the long-run relationship between financial sector development and NPLs. Based on the above tests, our study concludes the following results:

- a CSD test confirms that there is CSD among the sample countries.
- b CIPS and CADF test confirms that the sample data is stationary at the level and the first difference.
- c Westerlund panel cointegration test confirms that there is cointegration among the variables.
- d The CUP-FM and CUP-BC technique substantiate a long-run relationship between financial sector development and NPLs among the sample countries.

The study concludes that the level of financial sector efficiency, regulatory mechanism, and stability is essential to mitigate the issue of NPLs in BRICS countries. Financial



sector liberalisation, on the other hand, is not as important for the sample countries, as the effect of foreign bank presence on NPLs is negligible. The influence of state-owned banks and financial institutions is considered high in BRICS countries. Therefore, incremental efforts are required to improve the efficiency of state-owned banks rather than concentrating on foreign banks. The results further highlight that financial sector intermediation and size of banks negatively affect NPLs in BRICS countries because the banking structure in BRICS countries is more fragmented, resulting in poor management practices, especially in India, Brazil, and South Africa. Our study also concludes that unnecessary competition to capture the market share among the banks in sample countries is also the reason for the rise in NPLs (Ozili, 2019; Syed and Aidyngul, 2020). To capture the market share, banks resort to loose banking practices, like loan disbursement without proper borrowers' scrutiny, which often results in higher NPLs. Besides the above findings, our results also reconfirm that macroeconomic variables like growth rate, inflation, unemployment, and interest rate are also significant factors that affect NPLs in BRICS countries.

Based on our results, policymakers should concentrate on the following points to improve the financial sector development in BRICS countries: first, policymakers in BRICS countries should promote consolidated banking, with a small number of well-capitalised banks replacing a large number of small banks. Second, maintaining a balance between banking stability and the degree of financial intermediation should be a priority, as banking stability reduced NPLs. Third, to avoid unethical loan disbursement practices, steps should be taken to minimise unhealthy competition among banks by introducing a capping mechanism. Fourth, measures should be taken to encourage banks to diversify their sources of non-interest income to reduce their reliance on bank loans. Fifth, good governance and regulatory practices are required to scrutinise and track the loans disbursed to corporations and individuals. Sixth, since foreign banks have a negligible effect on NPLs, state-owned banks should be promoted in their place. More control and authority should be granted to state-owned banks. It is necessary to create professional asset management firms that can assist in securitisation and the sale of bad debts. Few recent studies highlighted that corruption also plays a significant role in increasing NPLs in emerging countries. The corruption index is higher in BRICS countries as compared to developed countries. Therefore, appropriate measures are required to reduce corruption in the banking industry. Profession loan screening agencies are needed for the final screening of large loans. In BRICS countries, a large sum of bad debts are from the corporate sector, and thus the approval of loans at the final stage of such big borrowers should be done by impartial professional screening agencies. The institutional framework of BRICS's banking industry is not so competitive as compared to developed countries. Hence institutional regulation and framework need to be improved by removing undue interference of third parties, who can manipulate the banking business. Banks should also resort to taking the benefits of cyber-security measures and fintech technologies to mitigate the problem of NPLs, apart from improving their technical efficiency and risk management practices. Finally, measures must be taken to ensure stable macroeconomic conditions and a viable environment for BRICS countries' progressive financial sector development.

- *Practical implication of the study:* The study provides significant findings to understand the situation of NPLs and financial sector development in BRICS countries. The study draws attention to the fragmented structure of the banking

industry in the sample countries. The results show how financial intermediation, size of banks, laxity in supervision, foreign bank presence, competition, and financial stability affect NPLs. Based on these outcomes the study provides significant policy-oriented suggestions which support the practical implication of the current study.

- *Limitations of the study:* The study covers only the countries of the BRICS bloc, thus serve as a limitation. However, it also creates the opportunity for future research by incorporating other emerging economies and evaluating the impact of financial sector development on NPLs. Besides, this study includes only specific variables related to financial sector development. Thus, the researcher can incorporate other variables like trade openness, foreign direct investment and investigate their relationship with NPLs in emerging market economies.

## Data availability statement

The data which supports the findings of the study is available with the corresponding author upon request.

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