

Article

Industry-Specific and Macroeconomic Determinants of Non-Performing Loans: A Comparative Analysis of ARDL and VECM

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Abstract: With the growth of an economy, the banking industry expands and the competitiveness becomes intense with the increased number of banks in the economy. The objective of this research was to discover the influence of industry-specific and macroeconomic determinants of non-performing loans (NPLs) in the entire banking system of Bangladesh. We performed an analysis for the period from 1979 to 2018 by an autoregressive distributed lag (ARDL) model and checked the robustness of the results in the vector error correction (VEC) model. The outcomes of this research suggest that both industry-specific and macroeconomic factors influence NPLs significantly. Among the industry-specific determinants, bank loan growth, net operating profit, and deposit rates negatively impact NPLs with statistical significance while bank liquidity and lending rates have a significant positive affiliation with NPLs. Gross domestic product (GDP) growth and unemployment, among the macroeconomic variables, have a negative connection with NPLs. Whereas, domestic credit and exchange rates have a significant positive association with NPLs. The contribution of this research is that the outcomes found by means of econometric models can be used for predicting and measuring NPLs in upcoming years, not only for Bangladesh but also for developing and emerging economies. Individual banks, as well as the banking sector, by and large, can get a guideline from this research.

Keywords: loan expansion; GDP; NPL; ARDL; VECM; Johansen test of co-integration; unit root

JEL Classification: C58; G21; E60

1. Introduction

Non-performing loans (NPLs) are a threat to sustainable development for developing countries. NPLs are considered as the major indicator of the financial stability of the banking sector. In developing economies, banks usually take greater risks to increase their market shares. With the chance of higher profit, risk increases, which ultimately results in non-performing loans [1]. NPLs have become a matter of concern for all countries in the world, and as a prerequisite to reinstate the functionality of financial markets, NPLs and its determinants should be addressed carefully [2]. Ex-post credit risk as an element of non-performing loans is one of the key features of the banking system and economic downturn [3,4]. Banks at risk of failing have significant proportions of NPLs in their portfolios of loans before collapse or financial distress [5].

Banks are intertwined and operate with other banks in a competitive industry. Hence, the bad performance of a bank can affect the entire sector and cause performance variability and create fear. Degraded loan quality creates threats of systemic risk, fear and causes drainage of deposits, a hindrance

to financial intermediation, and finally, slows down the pace of economic growth and development. Non-performing loans play a crucial part in creating a poor performance of banks [6,7]. Banks are restrained from an intermediation role to the real economy and economic growth by NPLs [8,9]. NPLs have been termed “financial pollution” for their negative impacts on the economy [10,11]. If regulatory authorities implement any policy, the underlying determinants of NPLs should be taken care of first. As per Basel II, a loan unpaid for more than 90 days is considered as uncollectible.

After the global financial crunch of 2007 and 2008 followed by the share market scam in 2010 and 2011 in Bangladesh, the country faced financial turbulence in the economy, and the banking sector went through a transition time. Fifteen new banks have received licenses to operate in the economy in the last 10 years, and 11 banks in the last 5 years. At present, a total of 59 banks are operating in the economy. Hence, there is acute competitiveness in the industry.

After 2010, non-performing loans started to increase rapidly (Figure 1). In 2011, they were 2.70 billion US dollars; in 2012, they were 5.09 billion US dollars, and in 2018, breaking all records, they soared up to 13.20 billion US dollars. For a developing country like Bangladesh, it is a matter of concern and a threat to sustainable development.

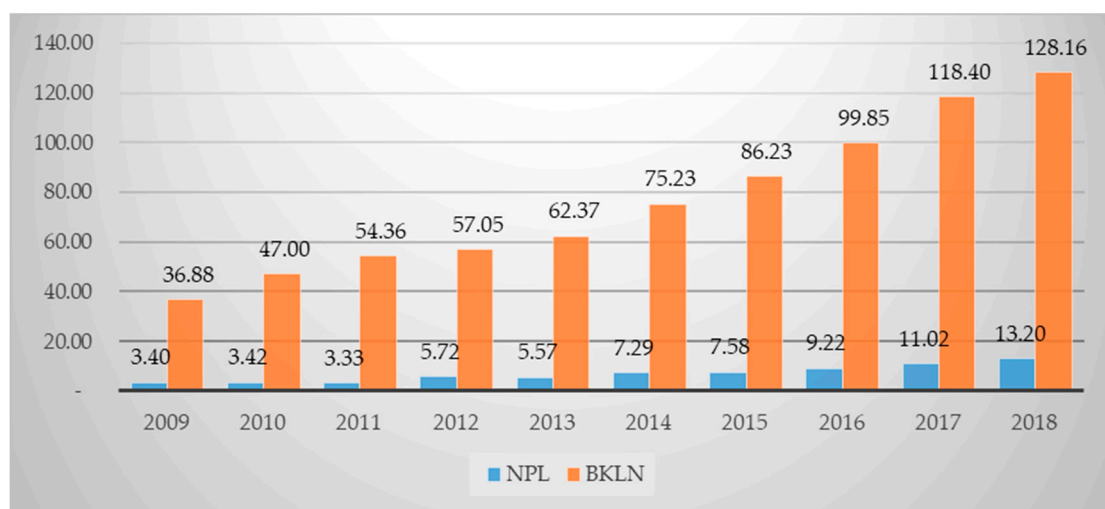


Figure 1. Non-performing loan (NPL) and bank loan (BKLN) growth in Bangladesh (in billion USD); Source: Bangladesh Bank.

The Non-Performing Loan Ratio (NPLR) reached 40.65% in 1998, which is the highest ever in the history of Bangladesh. Although it gradually came down, this was not enough as it had been 10.30% in 2018 (Figure 2). Total banking sector NPLs were around 4% of the total GDP in 2018. This current research examines both industry-specific and macroeconomic components of NPLs of all 59 banks in the economy for the period from 1979 to 2018. In our study, we used data from the whole banking sector using a time series dataset with an annual frequency. This study can be considered as a reference to understand and measure the determinants of NPLs in Bangladesh and for developing countries like Bangladesh. To analyze our dataset, we first used the ARDL model and then by finding co-integration with the variables through the Johansen test of co-integration, we conducted a VEC model. Results found in both the models are analogous, indicating the robustness of the study. To know the stability of the models used in the study, we performed some diagnostic tests.

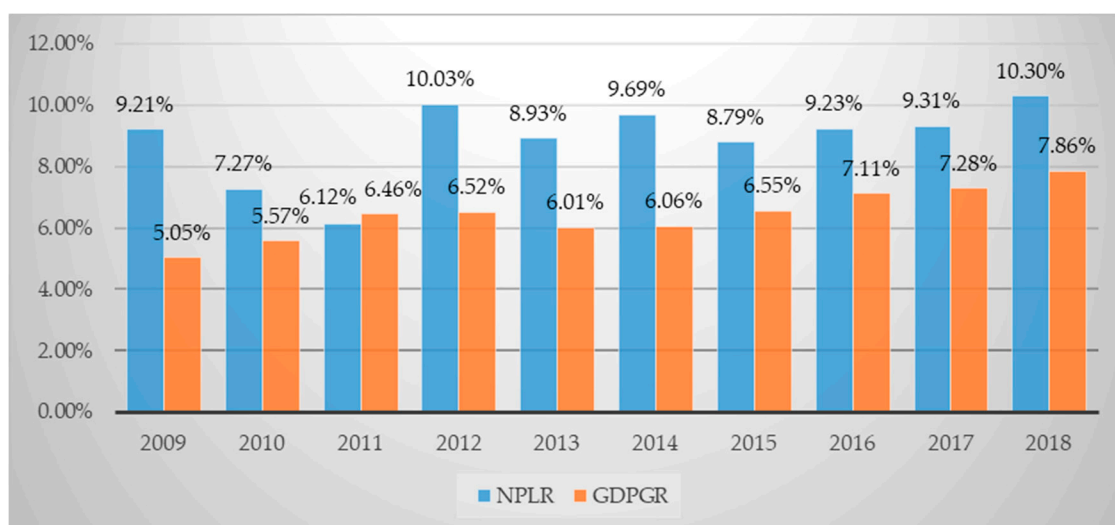


Figure 2. Non-performing loan ratio (NPLR) and gross domestic product growth rate (GDPGR) in Bangladesh; Source(s): Fred and WDI Database.

2. Theoretical Background

During our study, we went through many literary works to know the variables, models, and backgrounds on which research was conducted already. We found that factors of NPLs are broadly categorized into two major sources. The macroeconomic sources are GDP and inflation [2,12], unemployment [8], and real interest rates [13,14] and the industry-specific factors are management efficacy [4,15] and bank size [3,5], which may impact the ability to repay loans.

Researchers have found an affiliation between macroeconomic determinants and loan quality, which is a crucial yardstick of the banking sector's health. Previous findings suggest that bad loans decrease with the expansion of the economy. Borrowers have enough income to repay on time. During economic growth, loans are likely to be approved irrespective of the creditworthiness of the customers while during the economic downturn, NPLs tend to increase (Messai and Jouini 2013). Keeton and Morris (1987) studied 2470 commercial banks in the US from 1979 to 1985, which suggested the regional economy and inferior performance of industries had been the key factors for in loan losses. Espinoza and Prasad [16] found relationships of NPLs with economic advancement, risk aversion, and interest rates. NPL used to increase when there is a decreasing trend in economic growth and an increase in risk aversion and interest rates. Louzis, Vouldis et al. [3] looked into types of loans, i.e., consumer, business, mortgage, etc., to find determinants impelling NPLs. They found that macroeconomic variables, such as gross domestic product, interest rates, unemployment, and public debts, can impact the growth of NPLs.

Skarica [17] found that prime sources of NPLs are the economic (GDP) downturn, lack of employment, and the rate of inflation. In a study in France and Germany, it was found that macroeconomic variables influence NPLs [18]. Researchers also found the French economy to be vulnerable to bank-specific factors compared to Germany. Economic expansion and unemployment is positively associated with the reduction of NPLs. Macroeconomic variables, including unemployment and economic development, significantly influence NPLs while industry-specific variables, such as management skill and risk preferences, have consequences on future NPLs [19].

As our quest for literature went on, we found a good number of industry-specific determinants impacting NPLs, i.e., profitability expressed as return on asset (ROA) or return on equity (ROE), capital size expressed as the capital adequacy ratio (CAR), and performance as managerial efficiency. Of these aspects, ROE and ROA have been used as variables to explain managerial efficiency. Weak credit monitoring and poor control over operating expenses led to decreased cost efficiency, which supports the bad management theorem [5]. The bad management theory is also found by [20]

while applying NPL as technical efficiency. Shreds of evidence were found on the “too big to fail” syndrome in the US banking sector and it was also argued that an increase in income negatively impacts NPLs [21]. Cost efficiency also impacts NPLs. Poor management and moral hazards have been positively associated with variations in NPLs. Managerial efficiency as a proxy to ROA has negative connections with NPLs [22]. Podpiera and Weill [4] used cost efficiency to describe management quality to find an underlying relationship with NPLs. They performed Granger causality tests to show the unconditional connection of inefficiency to NPLs. Louzis, Vouldis et al. [3] using dynamic panel data found management quality along with GDP, unemployment, interest rate, and public debt are the determinants of NPLs. In a very recent study (2019) on the banking system structure of Bangladesh, Barun Kumar Dey [23] found that poor follow-up of loans after disbursement and lack of willingness to write off bad loans are the root causes that cause NPLs to increase. He also argued that NPLs limit lending capacity, the trickle-down effect of which slows down economic growth in the long run. Also, a high level of NPLs leads to higher requirements of loan loss provisioning, which in turn affects ROA and ROE and creates a threat for solvency and liquidity. Finally, NPLs change the nature risk preferences of the managers that leads to a higher cost of funds and less efficiency.

Vardar and Özgüler [24] found the presence of a steady and long-run affiliation between non-performing loans, macroeconomic variables, and bank-specific factors. Inflation and unemployment were found to be positively and significantly associated with NPLs. Bardhan and Mukherjee [25] found results supporting the ‘bad management hypothesis’ predicting negative future relationships with NPAs (non-performing assets). They used performance as a proxy for managerial efficiency. They also found capital adequacy ratio (CAR) requirements had an impact on the NPAs of banks. According to their research, large banks have more default rates compared to smaller ones.

Rajan, Bardhan, and Mukherjee [25,26] identified that future NPLs are related to past earnings and increases in profit can reduce NPLs. They also explained that managers could manipulate their power to alter credit policies to inflate current earnings, change the terms of the loan, and relax the conditions, which may lead to bad loans. Using the data of 129 Spanish banks from 1993 to 2003 García-Marco and Robles-Fernández [27] found that higher ROEs had been the key reason to boost risk and higher default rates. ROE has positive associations with elevated NPLs [28].

Changes in credit management policy, loan interest rates, fees, and commissions are also other determinants of NPLs. GDP and ROA have a negative impact while unemployment and interest rates have a positive impact on NPLs [14]. In a study in the United States, it was found that elevated interest rates and superfluous lending as internal aspects and economic conditions as external aspects have a significant positive connection to NPLs [29]. Structural differences between countries can create differences in the efficiency of banks as well [30].

Kjosevski [31] conducted sector-wise research and found NPLs of both the enterprise and household were negatively sensitive to profitability, loan growth, and better economic conditions while banks’ solvency and unemployment were positively correlated. The authors of [19] examined NPLs determinants in the Eurozone and, like past examinations, found bank-specific and macroeconomic elements had a remarkable impact clarifying variations in NPLs [32,33].

We found researches on Bangladesh covering a research period of 5 to 20 years. A synopsis is given in Table 1.

Table 1. Empirical studies related to Bangladesh.

Author(s)	Data and Methodology	Findings
[34]	Panel data: 2003 to 2014 of NBFI; Regression and correlation;	Loan growth, firm size, and broad money have statistical significance with NPLs. The researcher found NPL ratio has significant relationships neither with GDP nor with Inflation. The study has been conducted on Non-Banking Financial Institutions (NBFI).
[35]	Panel data: 2010–2014 Simple linear regression	NPLs have positive connections to Net Interest Margin (NIM), inefficiency ratio and aggregate deposit while CAR, solvency ratio, and aggregate credit have a negative relationship with NPLs.
[36]	Primary data: 50 respondents; Secondary data: 2011 to 2015 five commercial banks; Linear regression	Non-performing loan ratio negatively influences return on assets (ROA) and return on equity (ROE) with statistical significance.
[37]	Data: 2012 to 2016; Linear regression	Excess liquidity can moderately impact non-performing loans.
[38]	Data: 2009 to 2017; Least Square Multiple Regression	Loan loss provision (LLP) has a significant negative relationship with profitability.
[39]	Primary data: 150 respondents; Descriptive statistics.	Researchers found aggressive credit expansion, the willingness of borrowers are the determinants that help increase NPLs.
[40]	Data: 2010 to 2015 for 20 banks; Linear regression	Researchers found a positive relationship of NPLs with Credit-deposit ratio, net interest margin. While the capital adequacy ratio and return on assets negatively impact NPLs. NPLs are also influenced by the sensitive sector's loan and priority sector's loan. Unsecured loans, investment deposit ratio, capital adequacy ratio, return on assets, profit per employee, have a negative control on NPLs.
[41]	Data: 2000 to 2017, ARDL Method	The researcher of this study disagrees with the point that NPLs are impacted by GDP or inflation. Rather he found no statistical relationship using the ARDL method in his research.
[42]	Primary Data: 30 managers and Secondary Data: 1999 to 2008; Linear regression	From survey research, researchers found political influence and economic condition directly cause non-performing loans. In the quantitative analysis, they found that collection efforts by banks also play a significant role in a loan to become bad.
[43]	Data: 2011 to 2015; 8 Islamic banks; Descriptive Statistics; Varimax rotation	This research put light on the Islamic banking system in Bangladesh and found a significant negative liaison with non-performing investments (NPIs) and profitability. Researchers also argued that creditworthiness, employed ethics, and bureaucracy influence NPIs.
[44]	Data: 2008 to 2017 40 banks; Linear Regression	A significant negative relationship between ROA and NPLs has been established by this study.
[45]	Data: 2008 to 2017; 40 banks; Regression	This research suggests that capital adequacy is negatively impacted by the level of non-performing loans in banks of Bangladesh. The researchers also argued that variations in CAR could significantly influence profitability, deposit rates, liquidity, and overall corporate governance of the banks.
[46]	Penal Data: 2004 to 2013; 18 banks; Pearson correlation test, Unit root test, Granger causality test	Researchers in this study found the theoretical establishment of the concept that GDP and inflation impact true in empirical findings. GDP impacts NPLs negatively, while inflation impacts NPLs positively. They also found that interest spread of the banks is inversely related to NPLs.
[47]	Time Series Data: 2008 to 2013; 30 banks; Regression	NPLs have a significant negative relation with the Net profit margin (NPM).
[48]	Panel Data: 1997 to 2012; 259 South Asian banks; Multiple regression, Unit root, GMM	Modal hazard type II and adverse selection problems, poor management of the banks can cause non-performing loans. Researchers also found that the global financial crisis had been another reason for NPLs.
[49]	Data: 2005 to 2014; 22 banks; ADF unit root test, Pearson Correlation Matrix, Granger Causality Test	Through econometric analysis, researchers reached the conclusion that NPLs are negatively associated with inflation rate and interest rate spread. Again, NPLs are positively analogous to GDP and the unemployment rate.
[49]	Data: 2013 to 2017; 30 banks; Pooled OLS Regression	The research findings of this study are that return on assets (ROA) is influenced by the capital adequacy ratio (CAR) and non-performing loans. The suggestion from researchers is that banks should go for timely legal action to collect the bad loans.

3. Research Objective, Methodology, and Data

3.1. Research Objective

The purpose of this study was to identify the significance of industry-specific and macroeconomic determinants of non-performing loans (NPLs) of the banking sector. We conducted our study on a developing country and compared the results in autoregressive distributed lag (ARDL) and vector error correction (VEC) model. The findings of this study will help to understand the underlying causes of NPLs in developing economies and help individual banks to take measures to sustain in the competitive industry.

3.2. Methodology

3.2.1. Model Specification

This paper suggests that NPLs in the economy of Bangladesh depend both on macroeconomic and industry-specific elements. We discuss the functional relationship of the determinants as follows:

$$NPLR_t = f(IS_t, ME_t) \quad (1)$$

where ' $NPLR_t$ ' (non-performing loan ratio) is the dependent determinants of time t ; ' IS_t ' comprises the industry-specific determinants for time t ; and ' ME_t ' contains the macroeconomic determinants causing the banking sector for time t .

To evade the hidden multi-collinearity problem, which can ascend from correlated independent variables, we made two different models. Log was used for all variables, and two regression models were developed as:

Model: 1

$$\begin{aligned} \ln NPLR = \beta_0 + & \beta_1(\ln GDPGR)_t \\ & + \beta_2(\ln CPI)_t + \beta_3(\ln DOCR)_t + \beta_4(\ln UNEM)_t + \beta_5(\ln EXR)_t \\ & + \varepsilon_t \end{aligned} \quad (2)$$

Model: 2

$$\begin{aligned} \ln NPLR = \alpha_0 + & \alpha_1(\ln BKLN)_t \\ & + \alpha_2(\ln LIQ)_t + \alpha_3(\ln NOP)_t + \alpha_4(\ln LDR)_t + \alpha_5(\ln DPR)_t + \varepsilon_t \end{aligned} \quad (3)$$

where " \ln " indicates the logarithmic form of the variables under investigation. β_0 and α_0 are the coefficients of the constant. $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \alpha_1, \alpha_2, \alpha_3, \alpha_4$, and α_5 represent the partial coefficients of the independent variables. Lastly, ε_t represents the stochastic term.

3.2.2. Unit Root Tests

We checked the unit root of the series used in this study using the ADF (Augmented Dickey-Fuller) and PP (Philip and Perron). The null hypothesis indicates that the series have a unit root, whereas the alternative hypothesis suggests stationarity. At $\phi = 1$, variables have a unit root, and at $\phi < 1$, it becomes stationary (Equation (4)). The regression for the ADF test is given below:

$$\Delta Y_t = \Phi Y_{t-1} + \sum_{i=1}^p \alpha_i Y_{t-i} + \mu_t. \quad (4)$$

3.2.3. ARDL (Autoregressive Distributed Lag) Model

An autoregressive distributed lag (ARDL) model is an ordinary least square (OLS) used for the time series dataset. ARDL is widely accepted for the co-integration of non-stationary variables

corresponding to error-correction (EC) dynamics and it also finds a parametric equation in the EC form [50,51]. An important benefit related to the ARDL modeling approach is that it is useful regardless of regressors being (0) or I (1). Again, ARDL permits a large number of lags. Finally, it accepts the development of a dynamic error correction (EC) model that coordinates short-run elements with the long-run stability, thus losing no long-run data [52–54]. The following equation explains the ARDL model:

$$\Delta Y_t = \beta_0 + \sum_{(i=1)}^p \beta_i \Delta Y_{(t-i)} + \sum_{(i=1)}^p \beta_j \Delta X_{(t-i)} + \lambda_1 Y_{(t-1)} + \lambda_2 X_{(t-1)} + \varepsilon_t \quad (5)$$

3.2.4. Co-Integration Test

As all series were stationary at the first differentiation I (1), Johansen co-integration analysis was used to persuade the convergence in the long run (Johansen and Juselius 1990). The Johansen test recommends the existence of co-integration for at least one co-integrating vector.

3.2.5. Vector Error Correction (Vec) Model

When there are co-integrations among the variables, VECM can be applied to find long-run equilibrium associations. Co-integration is confirmed by Johansen tests for co-integration. We developed the following models to assess the short-run and long-run coefficients of the variables:

$$\begin{aligned} \Delta \ln NPLR \\ = \beta_0 + \sum_{(i=1)}^n \beta_1 \ln NPLR_{(t-j)} + \beta_2 (\Delta \ln GDPGR)_{(t-j)} \\ + \beta_3 (\Delta \ln CPI)_{(t-j)} \\ + \beta_4 (\Delta \ln DOCR)_{(t-j)} + \beta_5 (\Delta \ln UNEM)_{(t-j)} + \beta_6 (\Delta \ln EXR)_{(t-j)} + \beta_7 \varepsilon_{(t-1)} + \mu_t \end{aligned} \quad (6)$$

$$\begin{aligned} \Delta \ln NPLR \\ = \alpha_0 + \sum_{(i=1)}^n \alpha_1 \ln NPLR_{(t-j)} + \alpha_2 (\Delta \ln BKLN)_{(t-j)} \\ + \alpha_3 (\Delta \ln LIQ)_{(t-j)} \\ + \alpha_4 (\Delta \ln NOP)_{(t-j)} + \alpha_5 (\Delta \ln LDR)_{(t-j)} + \alpha_6 (\Delta \ln DPR)_{(t-j)} + \beta_7 \varepsilon_{(t-1)} + \mu_t \end{aligned} \quad (7)$$

The variation in the independent variables is demonstrated by ‘ Δ ’, and the error correction term is expressed by ‘ $\varepsilon_{(t-1)}$ ’. β_1 and α_1 are the speed of adjustment by which short and long-run disequilibrium is adjusted. ‘ μ_t ’ is the error term.

3.3. Data

Time series data were tested in this paper. We collected data from the Civil, Environmental, and Infrastructure Engineering (CEIE) databases, the World Development Indicators (WDI) databases, and the Bangladesh Bank (the central bank of Bangladesh) databases. We collected data for 40 years, from 1979 to 2018, of all 59 commercial banks for the last 40 years (Table 2).

Table 2. Variable Definition.

Variables		Interpretation
Macroeconomic Variables	lnNPLR	Non-performing loan ratio: Doubtful and bad loans to total loan ratio
	lnGDPGR	Gross domestic product growth rate: The annual gross domestic product growth rates of Bangladesh.
	lnCPI	Consumer price index: The weighted average prices of consumer goods and services. The year 2006 has been considered a base year.

Table 2. Cont.

Variables		Interpretation
Industry-specific Variables	lnDOCR	Domestic Credit: The aggregate of net dues on the central government and dues on other segments of the national economy.
	lnUNEM	Rate of unemployment: The annual unemployment rate in Bangladesh.
	lnEXR	Exchange rates: The annual exchange rates of BDT (currency of Bangladesh) against USD.
	lnBKLN	Banking sector gross loan: The annual aggregate loan disbursement by the entire banking sector of Bangladesh
	lnLIQ	Bank liquidity: The annual liquid asset ratio provided by Bangladesh Bank. Liquid assets include cash and government securities. It measures the capacity of banks to meet their obligations.
	lnNOP	Net operating profit: The annual net operating profit of the entire banking sector.
	lnLDR	Bank lending rate: The rate at which banks lend to their customers. Bangladesh bank provides weighted average lending interest rates of all sorts of loans including short term and long term loans.
	lnDPR	Bank deposit rate: Deposit rates are the weighted average interest rates banks at which collect funds from its customers for investment.

4. Results and Discussion

4.1. Unit Root Test

Unit root tests (Table 3) for macroeconomic variables with ADF found two macroeconomic variables of lnGDPGR and lnEXR found to be stationary at the level I (0) while lnCPI, indoor, and lnUNEM became stationary at first differentiation as indicated by I (1) at the 5% level of confidence. On the other hand, in PP, only lnGDPGR was stationary at the level I (0); all other variables became stationary, except lnCPI, after first differentiation I (1) at a 5% confidence level. lnCPI became stationary at first differentiation I (1) with 10% at the confidence level. Unit root tests (Table 3) for industry-specific variables with ADF found two macroeconomic variables, lnNOP (at 10% confidence level) and lnDPR, to be stationary at the level I (0) while lnBNLN, lnLIQ, and lnLDR became stationary at first differentiation as indicated by I (1) at the 5% level of confidence. On the other hand, in PP, all the variables became stationary after first differentiation I (0).

Table 3. Augmented Dickey-Fuller (ADF) and Philip and Perron (PP) Unit Root Tests.

Variables		ADF				PP			
		At the Level		First Differentiation		At the Level		First Differentiation	
		T-Statistics	0.10	Test Statistics	0.10	T-Statistics	0.10	T-Statistics	0.10
Macroeconomic variables	lnNPLR	−0.7110	−2.6140	−2.977 **	−2.6160	−1.0060	−10.4800	−28.861 ***	−10.4600
	lnGDPGR	−3.4870 ***	−2.6140	−9.335 ***	−2.6160	−33.898 ***	−10.4800	−63.73 ***	−10.4600
	lnCPI	−0.1780	−2.6140	−3.232 **	−2.6160	−0.913 *	−10.4800	−11.298 ***	−10.4600
	lnDOCR	1.1930	−2.6140	−6.169 ***	−2.6160	0.3640	−10.4800	−34.838 ***	−10.4600
	lnUNEM	−1.7120	−2.6140	−5.145 ***	−2.6160	−2.3000	−10.4800	−45.254 ***	−10.4600
	lnEXR	−3.5180 ***	−2.6140	−4.798 ***	−2.6160	−2.269 **	−10.4800	−30.731 ***	−10.4600
Bank-specific variables	lnBKLN	−0.3000	−2.6140	−5.661 ***	−2.6160	−0.2920	−10.4800	−32.355 ***	−10.4600
	lnLIQ	−2.4120	−2.6140	−3.213 **	−2.6160	−8.5110	−10.4800	−29.317 ***	−10.4600
	lnNOP	−2.763 *	−2.6140	−5.162 ***	−2.6160	−11.782*	−10.4800	−37.632 ***	−10.4600
	lnLDR	−1.951 ***	−2.6140	−3.76 ***	−2.6160	−4.6360	−10.4800	−24.115 ***	−10.4600
	lnDPR	−3.181 **	−2.6140	−4.51 ***	−2.6160	−8.2240	−10.4800	−20.525 ***	−10.4600

*, **, and *** stand for 10%, 5%, and 1% levels of significance, respectively.

4.2. ARDL Model

We constructed two different models to reduce the multi-collinearity problem among the variables. The co-integration relationship was examined among the determinants (i.e., analyzing the zero hypotheses ($H_0: \lambda = 1, \lambda = 2 \dots \lambda_n = 0$)). From the ARDL bounds test, it is apparent that (Table 4) the F statistics are 30.609 and 15.34 for the first and second models. The F values are significant, and in both models, the F statistics are greater than the upper limit. So, we reject the null hypothesis and agree that there are co-integrations among the determinants. Then, we used Akaike's information criterion (AIC) criterion to choose optimal lag lengths for each model (Table 5). For macroeconomic variables, the AIC selects the ARDL (4,3,4,3,2,1) specification and for industry-specific variables (3,3,4,1,4,2). The reason for using AIC is that AIC provides a smaller standard deviation than the Schwarz information criterion (SIC) when running in a model (Pesaran & Pesaran, 1997). We tested both long-run associations and short-run dynamics (error correction model) in the ARDL model (Tables 6 and 7). The coefficients were found to have multiple connotations between NPLs and macroeconomic and industry-specific variables.

Table 4. Pesaran/Shin/Smith (2001) ARDL (Autoregressive Distributed Lag) Bounds Test.

Category	F Statistics	At 10%		At 5%		At 2.5%		At 1%	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Macro-economic	30.609	2.2600	3.3500	2.6200	3.7900	2.9600	4.1800	3.4100	4.6800
Industry-specific	15.337	2.2600	3.3500	2.6200	3.7900	2.9600	4.1800	3.4100	4.6800

Table 5. VAR (Vector Autoregression) Lag Order Selection Criteria.

Lag Rank	Akaike's Information Criterion (AIC)		Schwarz Information Criterion (SIC)	
Macroeconomic Variables	0	−13.364	−13.1001	
	1	−25.2891	−23.4417	
	2	−27.2268	−23.7958 *	
	3	−28.5331	−23.5186	
	4	−29.3804 *	−22.7824	
Industry-specific Variables	0	−2.9061	−2.64219	
	1	−12.9529	−11.1055	
	2	−13.3905	−9.95959	
	3	−14.4065	−9.39201	
	4	−18.4346 *	−11.8366 *	

Note: * denotes the number lag(s).

Table 6. Long-Run coefficients of ARDL Model.

Macroeconomic			Industry-Specific		
Determinants	Coefficients	Standard Error	Determinants	Coefficients	Standard Error
lnGDPGR	−1.396011 **	0.5629	lnBKLN	−0.5203392 ***	0.0367
lnCPI	−0.9602321	0.7484	lnLIQ	2.669881 ***	0.5103
lnDOCR	1.066338 *	0.5631	lnNOP	−0.0192367 ***	0.0032
lnUNEM	−7.639355 ***	2.0093	lnLDR	3.790614 ***	0.3349
lnEXR	3.756394 ***	1.1450	lnDPR	−0.7667929 ***	0.1571
Cons	0.207973	0.2722	Cons	−3.784955 ***	0.6260
R-squared = 0.9618; Adj. R-squared = 0.8971			R-squared = 0.9338; Adj. R-squared = 0.8219		

*, **, and *** stand for 10%, 5%, and 1% levels of significance, respectively.

Table 7. Short-Run coefficients of ARDL Model.

Macroeconomic			Industry-Specific		
Determinants	Coefficients	Standard Error	Determinants	Coefficients	Standard Error
lnGDPGR	0.364553 ***	0.1142	lnBKLN	0.2050954	0.1857
lnCPI	−5.017027 ***	0.9689	lnLIQ	−2.247147 ***	0.4446
lnDOCR	−0.279248	0.1682	lnNOP	0.0092824 ***	0.0028
lnUNEM	2.445047 ***	0.2168	lnLDR	−1.591485 ***	0.3374
lnEXR	−0.8860041 **	0.3653	lnDPR	0.2151	0.2027
Cons	0.207973	0.2722	Cons	−3.784955 ***	0.6260
R-squared = 0.9618; Adj. R-squared = 0.8971			R-squared = 0.9338; Adj. R-squared = 0.8219		

*, **, and *** stand for 10%, 5%, and 1% levels of significance, respectively.

4.2.1. ARDL Long-Run Results

Among the macroeconomic variables, the results identified that lnGDPGR has a significant negative effect on the lnNPLR, meaning that as the economy becomes stronger, bad lending decreases. If there is an increase of 1% in economic growth, non-performing loans will decrease by 1.40% in the long run in Bangladesh.

lnCPI also has a negative relationship with lnNPLR, but in this case, the relationship is insignificant in the long run. Domestic credit growth (lnDOCR) and exchange rates (lnEXR) both have significant positive relationships with the bad loan ratio (lnNPLR) while unemployment (lnUNEM) in the country has a significant negative relation with increasing bad loans. With every 1% increase in both the domestic credit and exchange rates, there is a 1.07% and 3.76% increase in non-performing loans, respectively. Surprisingly, with the decrease of non-performing loans by 7.64%, there is a 1% increase in unemployment.

The long-run results of industry-specific variables show that bank loan growth (lnBKLN) has a negative association with the non-performing loan ratio (lnNPLR). Net operating profit (lnNOP) and deposit rates (lnDPR) also have the same impact over non-performing loans with significant *p* values, which means that with the growth of bank lending by 0.52%, there will be a decrease of 1% bad loan, which indicates healthy behavior by the banking sector. NPL reduces bank profitability by 0.02% when it increases by 1%, and also a 1% increase in lnNPLR reduces the capacity of the banks to provide depositors good returns, which is 0.76%. Finally, a 1% increase in lending rates (lnLDR) and liquidity (lnLIQ) increase non-performing loans by 3.79% and 2.67%, respectively.

In both models, the R^2 and the adjusted R^2 were remarkably good. The R^2 and the adjusted R^2 for macroeconomic variables are 0.9618 and 0.8971, respectively, while for industry-specific variables, it is 0.9338 and 0.8219, respectively, meaning the models fit quite well, which means that the models can explain 96.18% and 93.38% of the changes in non-performing loans.

4.2.2. ARDL Short-Run Results

The short-run outcomes suggest the growth of GDP has a significant positive influence on lnNPLR. Meaning that if there is a growth of 1% in GDP in Bangladesh, the non-performing loans of banks will rise by 0.36%. Then, only lnUNEM has a significant positive relation with NPLR. A 1% increase in unemployment will cause a 2.45% decrease in bad loans in the short run. The other three variables, lnCPI, lnDOCR, and lnEXR, affect lnNPLR negatively, with lnDOCR being the only insignificant variable. To be specific, a 1% increase in all these variables can cause a 5.01%, 0.27%, and 0.88% decrease consecutively in lnNPLR.

The short-run results of industry-specific variables show that bank loan growth (lnBKLN) has an insignificant positive relationship with non-performing loans (lnNPLR). Net operating profit (lnNOP) and deposit rates (lnDPR) also have the same impact over non-performing loans, which

is statistically significant, while liquidity (lnLIQ) and lending rates (lnLDR) were found to have a statistically significant negative connection with non-performing loans.

4.3. Co-Integration Test

We found four co-integration relationships in the first model and for the second model, we found two co-integrating connections. We considered trace statistics to figure out the co-integrating equations at a the 5% level of significance. The existence of more than one co-integrating equation indicates a long-run convergence of the two models (Table 8).

Table 8. The Johansen Tests for Co-integration.

	Max. Rank	Parms	LL	Eigenvalue	T. Statistics	5% Critical Value
Macroeconomic Variables	0	42	485.4188		206.5194	94.1500
	1	53	527.6884	0.8919	121.9803	68.5200
	2	62	553.1712	0.7385	71.0147	47.2100
	3	69	570.5570	0.5995	36.2430	29.6800
	4	74	581.3974	0.4348	14.5622 *	15.4100
	5	77	588.6645	0.3178	0.0281	3.7600
	6	78	588.6785	0.0007		
Industry-specific Variables	0	42	273.84		112.7982	94.1500
	1	53	294.81	0.67	70.8531	68.5200
	2	62	308.84	0.52	42.7962 *	47.2100
	3	69	319.77	0.44	20.9224	29.6800
	4	74	325.67	0.27	9.1303	15.4100
	5	77	330.05	0.21	0.3664	
	6	78	330.24	0.01		

Note: * denotes the number of co-integrating equation(s) at 5% significance. At * we reject the null hypothesis with a 5% level of significance.

4.4. Vector Error Correction (Vec) Model Results

The VECM was applied to assess the long-run and short-run coefficients (Table 9). We found two lag periods for macroeconomic variables and four lag periods for industry-specific variables using the Schwarz information criterion. We selected the lag length of SIC criterions as it gives better results than AIC criterions. We then calculated the long and short-run coefficients, putting lag length outcomes in the VECM.

Table 9. Vector Error Correction Model (VECM) Results.

Description	Macroeconomic Variables				Industry-Specific Variables			
	Variables	Coefficient	Standard Error	T Statistics	Variable	Coefficient	Standard Error	T Statistics
Speed of Adjustment	$\Delta \ln \text{NPLR}$	−0.2557821 ***	0.0246683	−10.37	$\Delta \ln \text{NPLR}$	−0.1885038	0.1307467	−1.44
Short-run coefficients	$\Delta \ln \text{GDPGR}$	−0.6820223 ***	0.0918552	−7.42	$\Delta \ln \text{BKLN}$	−0.1901149	0.2513614	−0.76
	$\Delta \ln \text{CPI}$	0.6937023 ***	0.1355197	5.12	$\Delta \ln \text{LIQ}$	0.4885987 **	0.2136399	2.29
	$\Delta \ln \text{DOCR}$	−0.0501226	0.1408345	−0.36	$\Delta \ln \text{NOP}$	0.2759852	0.2599934	1.06
	$\Delta \ln \text{UNEM}$	−0.3287384	0.2686674	−1.22	$\Delta \ln \text{LDR}$	0.6160724 *	0.3157054	1.95
	$\Delta \ln \text{EXR}$	0.2371722	0.1514736	1.57	$\Delta \ln \text{DPR}$	0.7740481 ***	0.2054191	3.77
Long-run coefficients	$\ln \text{GDPGR}$	0.4780902 **	0.2441085	1.96	$\ln \text{BKLN}$	0.3681242 ***	0.0323276	11.39
	$\ln \text{CPI}$	0.1832198	0.4663795	0.39	$\ln \text{LIQ}$	−0.424397	0.3814911	−1.11
	$\ln \text{DOCR}$	−0.5250594 **	0.2479925	−2.12	$\ln \text{NOP}$	0.0602165 ***	0.0046823	12.86
	$\ln \text{UNEM}$	6.997589 ***	0.6446684	10.85	$\ln \text{LDR}$	−4.923853 ***	0.2398030	−20.53
	$\ln \text{EXR}$	−3.293177 ***	0.5921451	−5.56	$\ln \text{DPR}$	2.718319 ***	0.2358060	11.53

*, **, and *** stand for 10%, 5%, and 1% levels of significance, respectively.

The first model states that $\ln NPLR$ converges to long-run equilibrium with a 25.58% speed of adjustment every year by the influence of the variables, $\ln GDPGR$, $\ln CPI$, $\ln DOCR$, $\ln UNEM$, and $\ln EXR$. The second model suggests an 18.85% speed of adjustment in $\ln NPLR$ by the influence of $\ln BKLN$, $\ln LIQ$, $\ln NOP$, $\ln LDR$, and $\ln DPR$. The results from both the models recommend that long-run adjustment in the independent variables has substantial influence compared to short-run variables on $NPLR$. The long-run equations are explained in the following manner:

Model 1:

$$\begin{aligned} \ln NPLR = \beta_0 - & 0.4780902(\ln GDPGR)_t \\ & - 0.1832198(\ln CPI)_t + 0.5250594(\ln DOCR)_t \\ & - 6.997589(\ln UNEM)_t + 3.293177(\ln EXR)_t + \varepsilon_t \end{aligned} \quad (8)$$

Model 2:

$$\begin{aligned} \ln NPLR = \alpha_0 - & 0.3681242(\ln BKLN)_t \\ & + 0.424397(\ln LIQ)_t - 0.0602165(\ln NOP)_t + 4.923853(\ln LDR)_t \\ & - 2.718319(\ln DPR)_t + \varepsilon_t \end{aligned} \quad (9)$$

Model 1: In the case of macroeconomic variables, when $\ln GDPGR$ has a negative movement by 1%, non-performing loans $\ln NPLR$ will rise by 0.4780902%. $\ln CPI$ and $\ln UNEM$ have the same negative relationship as $\ln GDPGR$, with 0.1832198% and 6.997589%, respectively. Meanwhile, domestic credit $\ln DOCR$ and exchange rates $\ln EXR$, if appreciated by 1%, will cause an escalation in non-performing loans ($\ln NPLR$) by 0.5250594% and 3.293177% respectively.

Model 2: Among industry-specific variables, when bank lending ($\ln BKLN$) is decreased by 1%, non-performing loans ($\ln NPLR$) will increase by 0.3681242%. Net operating profit ($\ln NOP$) and deposit rates ($\ln DPR$) also have an inverse relationship with $\ln NPLR$. When $\ln NOP$ and $\ln DPR$ decrease by 1%, $\ln NPLR$ increases by 0.0602165%, and 2.718319% respectively. On the contrary, at a 1% increase in banks' liquidity ($\ln LIQ$) and lending rates ($\ln LDR$), bad loan ($\ln NPLR$) is hyped by 0.424397% and 4.923853%, respectively.

To check if there is any autocorrelation, we performed the Lagrange-multiplier test (Table 10). Both models are free from the autocorrelation problem.

Table 10. VECM Diagnostic Tests (Lagrange-Multiplier Test).

Nature of Test	Industry-Specific Variables			Macroeconomic Variables		
	Lag Order	p Value	Interpretation	Lag Order	p Value	Interpretation
Auto-correlation test	Lag 1	0.7811	No	Lag 1	0.1264	No
	Lag 2	0.6193	Autocorrelation	Lag 2	0.8915	Autocorrelation

4.5. Robustness of the Study

The overall stability of the models was examined through a few diagnostic tests of the ARDL model (Table 11). The Durbin–Watson tests (for autocorrelation) suggest that neither the macroeconomic nor the industry-specific variables have autocorrelations among them. Again, for the Jarque–Bera, Breusch–Godfrey (serial correlation test), and White's tests (homoscedasticity test), we cannot reject the zero hypothesis as all the coefficients are not significant, and hence, the models are normal; there is no serial correlation among the variables and the models are free from the heteroscedasticity problem. We checked autocorrelation for VECM and found no autocorrelation problem through the Lagrange-multiplier test. The CUSUM (cumulative sum) was tested to check the model stability (Figures 3 and 4). The model with macroeconomic variables seems okay, with a slight deviation in the middle. Again, the results of VECM are consistent with ARDL estimates as the signs of the coefficients are similar (Table 12).

Table 11. Diagnostic Tests for ARDL.

Tests Detail		Macroeconomic Variables		Industry-Specific Variables	
Tests Performed	Nature of Tests	Score/ <i>p</i> Value	Interpretation	Score/ <i>p</i> Value	Interpretation
Durbin-Watson d-statistic	Autocorrelation Test	2.2850	No Autocorrelation	2.4313	No Autocorrelation
Jarque-Bera test	Normality Test	0.2483	Normal	0.3731	Normal
Breusch-Godfrey LM test	Serial Correlation Test	0.2395	No Serial Correlation	0.0692	No Serial Correlation
White's test	Homoscedasticity Test	0.4215	Homoscedastic	0.4215	Homoscedastic

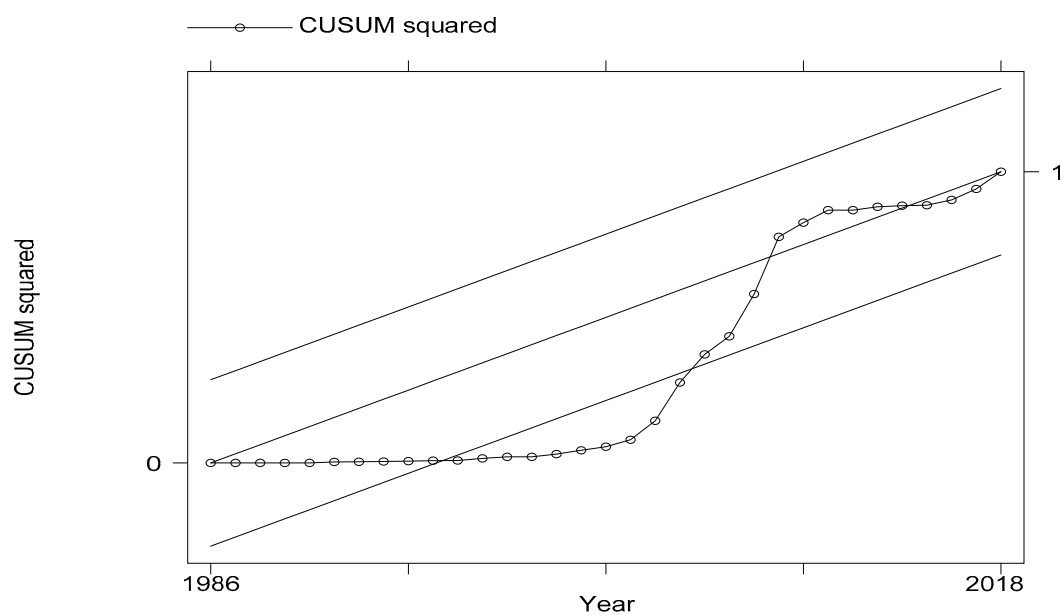
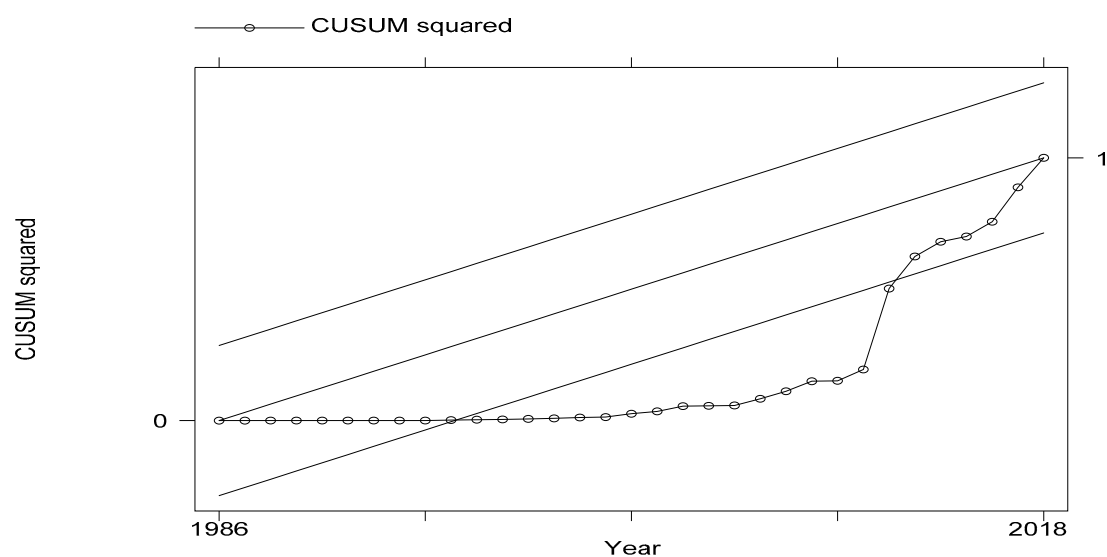
**Figure 3.** Cumulative Sum (CUSUM) Test for Macroeconomic Variables.**Figure 4.** Cumulative Sum (CUSUM) Test for Industry-Specific Variables.

Table 12. Comparison of ARDL and VECM Coefficients.

Macroeconomic Variables			Industry-Specific Variables		
Determinants	ARDL Coefficients	VECM Coefficients	Determinants	ARDL Coefficients	VECM Coefficients
lnGDPGR	−1.396011 **	−0.4780902 **	lnBKLN	−0.5203392 ***	−0.3681242 ***
lnCPI	−0.9602321	−0.1832198	lnLIQ	2.669881 ***	0.424397
lnDOCR	1.066338 *	0.5250594 **	lnNOP	−0.0192367 ***	−0.0602165 ***
lnUNEM	−7.639355 ***	−6.997589 ***	lnLDR	3.790614 ***	4.923853 ***
lnEXR	3.756394 ***	3.293177 ***	lnDPR	−0.7667929 ***	−2.718319 ***

*, **, and *** stand for 10%, 5%, and 1% levels of significance, respectively.

5. Conclusions

Throughout the study, we found significant shreds of evidence that our hypothesis of industry-specific and macroeconomic determinants influencing non-performing loans in Bangladesh is being established. To the best of our information, this research is the first to discover the impact of both industry-specific and macroeconomic determinants of NPLs in Bangladesh at a time horizon of 40 years. Also, very few studies, we found, had been conducted comparing the results in ARDL and VECM. Hence, it can be considered a robust study.

Long-run convergences of ARDL show that non-performing loans negatively impact economic growth. That means as the economy advances to good shape, entrepreneurs are more capable of repaying loans. The movement of exchange rates is another important factor, the consequence of which has a positive impact on NPLs. Results show as the exchange rate increases, entrepreneurs have to pay more on their imports causing a reduction in the capacity to repay. Again, with the increase in NPLs, unemployment rises in the short run, which can create instability in the economy as well.

Loan growth in the long run decreases non-performing loans. As the lending horizon has been increasing during the last decade in small and medium enterprises (SMEs) and micro-finances, non-performing loans have decreased proportionately. We may look into this fact in our future research as this is not the focal point of this study. In the short run, NPLs increase with loan growth. Banks' profitability decreases with higher NPLs as banks need to increase the base of loan loss provisions for future losses. This has a spillover effect on the lending interest rates and the deposit rates as well. Lending interest rates increase and deposit rates decrease with the growth of NPLs. Finally, the liquidity of banks needs to be handled carefully so that banks do not become too ambitious and make bad lending. There is a high chance of excess liquidity being wrongly managed by the bankers, as our research found a positive correlation between bad loans and liquidity. Central banks and policymakers can step into this to act as a guide in this regard. Banks may be controlled by implementing contractionary lending policies during an economic downturn and expansionary lending policies during economic growth to ensure their sustainability in the long run. Regulatory bodies may carefully monitor the growth of domestic credit and exchange rate fluctuation to scale down the impact of bad loans in the economy.

The results obtained piloting econometric examination can be used to project fundamental grounds of NPLs in the economy of Bangladesh. It will help policymakers of developing countries like Bangladesh to take enough measures to control NPLs or take precautions against it. The contribution of the current study puts light on future research. For example, future research can be conducted in the developing and emerging economies like Bangladesh.

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