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The impact of macroeconomic conditions on credit risk in the Moroccan banking system: empirical evidence from the ARDL model and the Toda-Yamamoto test

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The impact of macroeconomic conditions on credit risk in the Moroccan banking system: empirical evidence from the ARDL model and the Toda-Yamamoto test.

Abstract

This study investigates the impact of macroeconomic conditions on credit risk in the Moroccan banking sector, covering the period from the first quarter of 2009 to the first quarter of 2020. The research employs the Autoregressive Distributed Lag (ARDL) method to effectively assess both the short-term and long-term effects of various explanatory variables on the dependent variable. In addition, the Toda-Yamamoto causality test is utilized to identify which key macroeconomic variables drive credit risk.

The ARDL findings indicate that, in the short term, real GDP, inflation, and the exchange rate have a statistically significant negative impact on the rate of non-performing loans. This result aligns with theoretical expectations. In the long term, however, the unemployment rate shows a positive and statistically significant effect on the credit risk indicator, particularly the non-performing loan rate. Furthermore, a decline in the value of a currency appears to negatively affect the credit risk proxy. The results from the Toda-Yamamoto test reveal that interest rates, the unemployment rate, and currency exchange rates significantly influence the ratio of non-performing loans. These findings corroborate the assertion that banking and financial upheavals are manifestations of economic instability.

keywords: Credit risk, non-performing loans, Macroeconomic déterminants, Morocco.

JEL Classification: E01, G21, C22.

Paper type: Recherche empirique

1. Introduction

The last financial crisis of 2007-2008 has revived attention to the consequences that banking crises could have on the economy (Agnello et al., 2011). The last crisis is associated with what economists (Aglietta, 2017) call secular stagnation. The stability of the banking system is, in fact, a condition for its efficiency necessary to channel savings to the most productive uses (King & Levine, 1993; Brown et al., 2010).

The International Bank for Settlements (2000) considers credit risk the main risk that a banking system runs. According to Anita (2008), credit risk, also called default or counterparty risk, can be defined as the potential loss of assets caused by the probable default of the debtor. Credit risk reflects the quality of the assets and is also the primary cause of bank failure (Samad, 2012; Naili & Lahrichi, 2022).

The volume of non-performing loans (NPLs) reported to total credits, known as the non-performing loans rate, indicates the ex-post credit risk a banking system runs.

The rate of non-performing loans primarily depends on banks' ability to assess the credit risk of loan applicants, which is measured by their probability of default. Consequently, banks establish a tolerable level of default probability; any credit application with a default probability equal to or below this threshold is typically approved. To evaluate the default risk associated with loans, banks increasingly rely on sophisticated and automated statistical models (Nikolic et al., 2013). However, the default risk of a granted loan is not static; it can change due to systemic events that negatively impact the entire economy (Patro et al., 2013). Fiordelisi and Marques-Ibanez (2013) argue that this systemic risk is significantly higher in the banking sector compared to other sectors.

The rapid increase in the non-performing loans (NPLs) rate and its potential repercussions have made the study of its occurrence, movement, and determinants a crucial topic in academic and banking circles, leading to extensive research (Radivojević et al., 2019). Understanding NPLs and the factors influencing their dynamics is vital at both microeconomic and macroeconomic levels (Cortes & Soriano, 2024). On the one hand, risk departments within financial institutions must comply with regulatory standards, evaluate doubtful debts across all credit portfolios, and regularly report these assessments. On the other hand, NPLs bear significant macroeconomic implications; aggregated loan defaults serve as reliable indicators of the overall quality of the banking system's credit (see Berger and DeYoung, 1997; Louzis et al., 2012; or Manz, 2019, among others).

Gaganis et al. (2010) identify four factors that contribute to the stability of the banking system: the regulatory framework, banking system characteristics, the institutional environment, and macroeconomic conditions. These determinants can be classified into bank-specific factors and those related to the broader macroeconomic environment. Figlewski et al. (2012) note that macroeconomic conditions significantly influence debtor solvency and, consequently, the ability of the banking system to recover loans. They categorize these macroeconomic factors into three major classes: general macroeconomic conditions (such as the unemployment rate and inflation rate), economic trends (like economic growth and changes in consumer confidence), and financial market conditions (including interest rates and financial market returns).

Macroeconomic factors are especially significant during banking crises (Demirguc-kunt & Detragiache, 1998; Llewellyn, 2002). Unfavorable macroeconomic conditions, such as slow or negative growth, high unemployment, and high inflation, can destabilize the banking system (Demirguc-kunt & Detragiache, 1998). Furthermore, Festic et al. (2011) assert that changes in macroeconomic conditions lead to variations in the quality of the banking system's credit portfolio.

According to Bank Al-Maghrib, the aggregate sum of non-performing loans within the Moroccan banking sector surpassed 80 billion Moroccan dirhams (MAD) in 2020, representing over 8% of the total loan volume. Such loans continue to pose a significant risk (IMF, 2019). This research aims to thoroughly investigate the macroeconomic factors influencing credit risk within the Moroccan banking sector. Credit risk is a critical concern for Moroccan banks and financial institutions, directly impacting their stability and profitability. To the best of our knowledge, only a single empirical study has thoroughly explored the relationship between the broader macroeconomic environment and the credit risk encountered by the aggregate banking system in Morocco.

To analyze the relationships between macroeconomic variables—such as interest rates, inflation, GDP growth, and exchange rates—and credit risk effectively, we will use the Autoregressive Distributed Lag (ARDL) approach. This method enables us to examine both the short-term dynamics and long-term equilibrium effects of the explanatory variables on credit risk, providing a comprehensive understanding of how these factors interact over time.

Furthermore, we will incorporate the Toda-Yamamoto causality test to enhance our analysis. This statistical technique will enable us to explore the causal relationships between macroeconomic factors and credit risk, helping us discern which factors may directly impact and in what direction these influences operate. By employing these rigorous methodologies, we aim to contribute valuable insights that can inform risk management strategies and policymaking in the Moroccan banking sector.

The structure of this article is as follows: the second section reviews the existing literature on the topic, while Section 3 outlines the data, models, and methodologies utilized in this study. Section 4 presents an empirical analysis and interprets the results, and Section 5 concludes the study and evokes its policy implications.

2. Revue de littérature

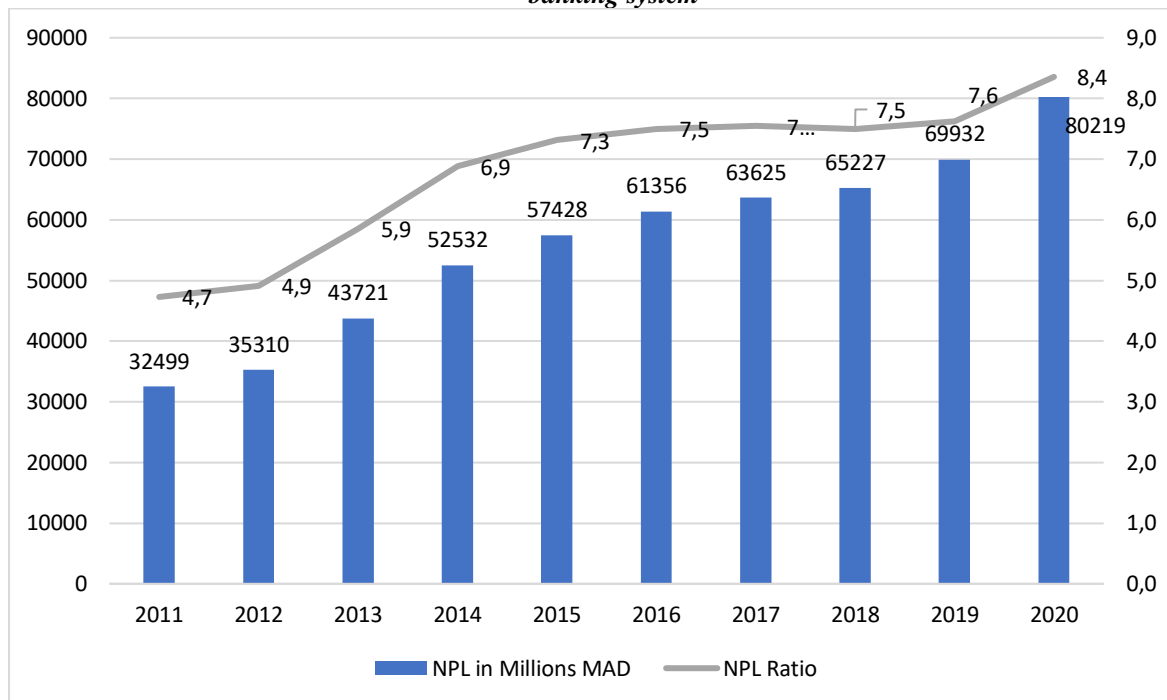
2.1. Evolution of Non-Performing Loans (NPL) within the Moroccan banking system

As of 2020, non-performing loans in Morocco exceeded 80 billion dirhams, dramatically increasing over the past decade. These loans have more than doubled from just over 32 billion dirhams in 2011. This concerning trend is further illustrated by the rise in the non-performing loans ratio, which climbed from 4.7% in 2011 to 8.4% by 2020 (Figure 1).

The growing volume of non-performing loans presents a substantial challenge for Moroccan banks. This situation can severely impact the resilience of these financial institutions, adversely affecting their profitability and constraining their capacity to extend credit to individuals and businesses.

In response to this pressing issue, Bank Al-Maghrib, Morocco's central bank, plans to establish a secondary market for non-performing loans. This market will enable banks to offload these troubled assets, enhancing their financial stability and ability to finance economic activities.

Figure 1: Evolution of Non-Performing Loans (NPL) in terms of volume and ratio within the Moroccan banking system



Source: Bank Al-Maghrib

2.2. Theoretical literature

A considerable body of research has investigated the relationship between the macroeconomic environment and the quality of credit assets, particularly regarding how these factors influence the stability of the banking system during different phases of the business cycle. Significant studies by Fofac (2005) and Jimenez et al. (2007) demonstrate that trends in non-performing loans exhibit a discernible cyclical pattern in alignment with economic fluctuations.

In periods of economic expansion—characterized by growth in GDP, increased consumer spending, and rising employment—financial institutions generally report a marked decrease in non-performing loans. This decline can be attributed to improved borrowers' financial conditions, enhancing their ability to meet debt obligations. Conversely, many borrowers encounter significant financial strain during economic downturns or recessions characterized by declines in economic activity, decreased consumer confidence, and rising unemployment. This often leads to increased difficulties in repaying debts, resulting in a noticeable rise in non-performing loans. These trends highlight the intricate relationship between economic health and credit quality in the banking sector, emphasizing the importance of monitoring macroeconomic indicators to identify potential risks to financial stability.

2.2.1. Economic growth rate

The growth of gross domestic product (GDP) is pivotal in shaping the quality of assets and receivables within the banking sector. In periods of economic expansion, individuals and businesses generally experience greater financial stability, which enhances the soundness of their loans and other financial obligations. However, during the recessionary phases, this relationship shifts markedly. Heightened economic pessimism leads to decreased consumer confidence and spending, weakening the solvency of debtors.

As economic activity declines, debtors—individuals and businesses—often face reductions in income and revenue. Such declines can hinder their ability to meet financial obligations, including loan repayments. Moreover, when a recession coincides with deflation—

characterized by falling prices of goods and services—the value of debtors' assets may also decrease. This combination creates a challenging situation in which debtors increasingly struggle to fulfill their commitments to creditors, including banks.

2.2.2. Unemployment rate

The unemployment rate has a significant effect on non-performing loans. An increase in the unemployment rate typically leads to a decline in household income, which diminishes their ability to repay loans. On the other hand, a decrease in the unemployment rate is associated with an increase in household income, thereby enhancing their capacity to meet loan obligations.

Moreover, the unemployment rate significantly influences the solvency of non-financial enterprises. An increase in unemployment generally leads to a reduction in consumer spending, which in turn diminishes business revenues. This decline in income can adversely affect a company's capacity to fulfill its financial obligations (Louzis et al., 2012).

2.2.3. Interest rate

Fisher (1933) and Minsky (1986) argue that interest rates significantly affect the volume of doubtful debts associated with variable rates. A positive correlation is expected between interest rates and the rate of non-performing loans. When interest rates rise, the burden of debt increases, which may elevate the risk of default among borrowers, ultimately leading to a rise in non-performing loans. Conversely, a decrease in interest rates reduces debt charges and lessens the likelihood of default, resulting in a decline in non-performing loans.

Nwankwo (1991) contends that the critical issue is not the direction of interest rate changes but rather the characteristics of those changes. Unregulated fluctuations in interest rates have a detrimental effect on the quality of banks' loan portfolios. While unexpected changes in interest rates can be harmful, increases tend to be more damaging than decreases, given that asset values are inversely related to interest rates.

2.2.4. Inflation rate

Nkusu (2011) and Klein (2013) investigated the relationship between inflation rates and credit quality. Their central hypothesis, "divine coincidence," posits that achieving price stability is essential for ensuring financial stability and promoting sustainable growth.

Nkusu (2011) asserts that the connection between default risk and inflation can vary based on context. For example, high inflation may enhance a debtor's solvency by diminishing the real value of their debt. However, it can also weaken a debtor's ability to repay by reducing the purchasing power of individuals with fixed incomes. Additionally, Nkusu emphasizes that banks are likely to raise lending interest rates in an inflationary environment, which further limits borrowers' capacity to service their loans.

Moreover, when inflation is volatile, accurately assessing credit risk—particularly regarding non-performing loans—becomes increasingly difficult. A swift and substantial decline in inflation can result in decreased nominal income, adversely affecting both liquidity and solvency. This phenomenon relates to Fisher's (1933) concept of "debt deflation," which describes the over-indebtedness trap that can emerge in deflationary periods.

2.2.5 Exchange rate

The external competitiveness of an economy plays a significant role in determining the level of non-performing loans. Fofack (2005) posits that the real exchange rate considerably impacts non-performing loans, particularly in nations with fixed exchange rates. When the exchange rate is appreciated, it can diminish the competitiveness of export-oriented firms, making it increasingly challenging for them to fulfill their debt obligations. Conversely, a depreciation of

the local currency typically boosts export volumes, enhancing companies' revenues and reducing non-performing loans.

However, currency depreciation can also have adverse effects if a significant portion of receivables is denominated in foreign currencies (Badar et al., 2013; Beck et al., 2013). In such cases, since principal and debt repayments are made in foreign currency, local currency depreciation can exacerbate the debt burden. This increased burden raises the likelihood of default among debtors, potentially leading to a rise in non-performing loans.

2.3. Empirical literature

2.3.1. Developed countries

Keeton and Morris (1987) were among the first to estimate the macroeconomic impact on credit risk. Based on a sample of 2,500 American Midwest banks, the two authors found that macroeconomic variables could explain problematic loans.

Salas and Saurina (2002) found that economic growth and the interest rate spread affect problematic assets of the Spanish banking sector using 1985–1997 data.

Berge and Boye (2007) evaluated the sensitivity of Swedish bank bad loans to changes in real interest rates, oil prices, and domestic demand. They found that unemployment, interest rates, economic growth, and real estate prices directly affect these loans.

Using panel VAR on a large sample of advanced nations, Nkusu (2011) revealed a long-term relationship between macroeconomic performance and non-performing loans. Nkusu (2011) concluded that low growth, high unemployment, and decreasing asset prices drive banking system vulnerabilities, destabilizing the economy. However, economic growth lowers the non-performing loan ratios.

Louzis et al. (2012) investigated the influence of bank management quality and the macroeconomic environment on the credit risk of the Greek banking system separately for each loan category (consumer loans, business loans, and mortgages). They established a significant impact of macroeconomics on credit risk.

Klein (2013) addressed the same topic within the context of Central and Eastern European nations (Bosnia and Herzegovina, Bulgaria, Hungary, Croatia, Czech Republic, Estonia, Latvia, and Lithuania) from 1998 to 2011. His study included three distinct estimating techniques: fixed effects model, differenced GMM, and system GMM. He discovered that excessive loan issuance, unemployment, inflation, and currency rates influence the performance of banks' asset portfolios. He also identified a substantial feedback effect of non-performing loans on macroeconomic performance, encompassing the economic growth, unemployment, and inflation rates.

Wdowiński (2014) explored the same issue in the Polish banking sector, employing quarterly statistical data from 1997 to 2013. The study identifies the GDP growth rate, interest rates, unemployment rate, and fluctuations in exchange rates as the main macroeconomic factors influencing the non-performing loan ratio in banks.

Becket et al. (2015) studied credit risk across 75 nations using panel data analysis. They determined that stock prices, economic growth, the currency rate, and the interest rate are all explanatory variables of non-performing loans.

Anastasiou (2017) empirically examined the impact of credit and the economic cycle on ex-post credit risk (i.e., non-performing loans) in the Italian banking system from 1995 to the first quarter of 2014. Employing fixed and random effects in conjunction with dynamic GMM estimation as econometric methodologies, the results revealed that Italy's increased non-performing loans (NPL) are mostly due to unfavorable macroeconomic conditions and excessive credit expansion. The Granger causality test further corroborated these assertions.

Anastasiou et al. (2019) initially examined the factors influencing nonperforming loans (NPL) in the euro area from the first quarter of 2003 to the first quarter of 2016, subsequently investigating the presence of fragmentation between core and peripheral banking markets. They evaluated the long-term effects of bank-specific and macroeconomic variables on non-performing loans (NPL) using fully modified ordinary least squares (FMOLS) and Bayesian panel-cointegration vector autoregression methods. They found that NPL in the euro area have exhibited a significant upward trend, particularly in peripheral regions, following 2008, primarily attributable to deteriorating macroeconomic conditions.

Koju et al. (2020) examined the banking industry's vulnerability by analyzing non-performing loan (NPL) data from 49 high-income countries between 2000 and 2015 and correlating it with several macroeconomic variables. The results indicate that GDP growth rate, GNI per capita growth rate, GDP per capita growth rate, and unemployment rate significantly influence credit risk trends, with per capita income showing a particularly strong effect.

2.3.2. Emerging countries

Espinoza (2010) regressed non-performing loan rates of Gulf Cooperation Council (GCC) countries using macroeconomic variables. The panel VAR results showed that lower economic growth, higher interest rates, and greater twin deficits increase non-performing loans. Non-performing loans have a short-term, powerful feedback effect.

In a study of the Algerian banking system from 1980 to 2014, Maarouf and Guellil (2017) identified financial development, political stability, money supply, and GDP as major determinants. The first three positively influence non-performing loans, while the last has a negative effect. They employed conventional least squares regression and Granger causality analysis.

Ouhibi et al. (2017) investigated the factors influencing systemic risk in the banking systems of Morocco and Tunisia. The econometric instrument employed is the ordinary least squares (OLS) approach. The analysis determined that inflation, credit levels, gross capital formation, GDP, and the unemployment rate are critical determinants in the formation and accumulation of non-performing loans in Tunisia. In Morocco, only GDP and the exchange rate are deemed significant. This study represents the sole research effort focusing on the effects of macroeconomic conditions on credit risk in Morocco. However, it is important to note that the Ordinary Least Squares (OLS) approach utilized in this analysis relies on certain hypotheses that may not always be directly observable in practice. This dependency suggests that the results could be influenced by assumptions that are difficult to validate, which may impact the overall reliability and applicability of the findings.

Umar and Sun (2018) analyzed the determinants of non-performing loans (NPL) in Chinese banks from 2005 to 2014. Three models were utilized: macroeconomic factors as regressors, banking industry-specific variables as independent variables, and a combination of both as explanatory variables. The results of the GMM demonstrated that the GDP growth rate, effective interest rate, inflation rate, foreign exchange rate, bank type, banks' risk-taking behavior, ownership concentration, leverage, and credit quality are significant determinants of non-performing loans (NPL). The determinants differ between listed and unlisted banks; listed banks are influenced by GDP, risk appetite, and credit quality, whereas unlisted banks are affected by GDP, inflation rate, foreign exchange rate, risk appetite, leverage, and credit quality.

Ahmed et al. (2021) studied macroeconomic and bank-specific factors influencing non-performing loans (NPL) in Pakistani commercial banks from 2008 to 2018. Through dynamic-GMM calculations, they determined that elevated interest rates, currency rates, and political risk substantially augment non-performing loans, whereas GDP growth mitigates NPL.

Subedi (2023) examined the factors influencing non-performing loans in Nepal, utilizing 11 years of data from 16 commercial banks. The data suggested that the inflation and lending

interest rates had a positive, if minor, influence on non-performing loans. The GDP growth rate exerts a negative, albeit marginal, impact on NPL.

Mishra (2024) investigated the factors influencing non-performing assets in 45 Indian commercial banks from 2005-2006 to 2019-2020. The results indicated that lending rates and credit expansion affect non-performing assets. Increased lending rates negatively affect borrowers' capacity to repay, resulting in a rise in distressed assets.

3. Data, model and methodology

3.1. Data and variables

The data utilized in our analysis are secondary and were sourced from Bank Al-Maghrib and the High Commission for Planning (HCP). Our analysis encompasses the period from the first quarter of 2009 to the first quarter of 2020. To eliminate any bias in our findings, we omitted the crises of 2007-2008 and the years impacted by COVID-19. This quarterly dataset comprises 45 observations for each variable, ensuring high reliability.

Table 1 presents a comprehensive overview of the variables utilized in this study. These variables have been selected in accordance with the literature review. All variables were transformed into their natural logarithmic form.

Table 1. Variables

Variable nature	Variable	Proxy	Acronym	Source
Dependent variable	Credit risk	The proportion of non-performing loans relative to total banking credits	LNNPLR	Bank Al Maghrib
Explanatory variables	Macroeconomic conditions	The real Gross Domestic Product (GDP)	LNRGDP	High Commission for Planning
		The rate of unemployment	LNUNEMPR	High Commission for Planning
		The interest rate on loans	LNINTEREST	Bank Al Maghrib
		The consumer price index	LNCPI	High Commission for Planning
		The quarterly average value of the euro relative to the Moroccan Dirham	LNEXCHR	Bank Al Maghrib

Source: Authors

3.2. Methodology

This study seeks to empirically examine the macroeconomic determinants of non-performing loans in the Moroccan banking system. We will use the Autoregressive Distributed Lag (ARDL) methodology to assess the short-term and long-term impacts of the explanatory factors on the dependent variable. The ARDL model presents several notable advantages for econometric analysis (Ghorbal & Belaïd, 2021):

1. The ARDL method can accommodate data that is either integrated of order zero (I(0)) or order one (I(1)), making it suitable for a diverse array of time series datasets, regardless of their stationarity characteristics.

2. This technique is especially advantageous when dealing with small sample sizes, as traditional methods may struggle to yield reliable results (Haug, 2002).

3. Unlike conventional approaches, ARDL allows for the application of different lag lengths for various explanatory variables within the model. This flexibility facilitates a more tailored approach to capturing the underlying dynamics of the data.

4. The ARDL approach effectively mitigates issues related to autocorrelation and endogeneity, enhancing the results' robustness (Jalil & Ma, 2008; Warsame et al., 2021).

We will also use the Toda-Yamamoto approach for causality analysis to investigate the probable impact of macroeconomic variables on credit risk. The Toda-Yamamoto (1995) causality test utilizes Wald's "W" statistic, which adheres to a chi-square distribution. Ewodo-Amougou et al. (2023), Kuma (2018), Wolde-Rufael (2005, 2004), and Zapata and Rambaldi (1997) contended that the modified Wald test (MWALD) addresses the limitations of the traditional Granger causality test by ignoring any non-stationarity or co-integration among the series. The null hypothesis posits the absence of causation between variables. The Toda-Yamamoto causality procedure is advantageous because it does not require pre-testing for unit roots and cointegration, which can be prone to errors and inconsistencies (Amiri & Ventelou, 2012). It is a reliable tool for identifying causality, even in integrated and cointegrated processes. By integrating the ARDL model with the Toda-Yamamoto causality approach, our study utilizes the strengths of both methods to deliver a thorough and rigorous analysis (Daly et al., 2024).

Our analysis will follow this sequence:

- Initially, we will assess the stationarity of the variable series under investigation through unit root tests.
- Subsequently, we will examine the cointegration among the pertinent series. Upon establishing cointegration, we will ascertain the coefficients for both the short-term and long-term connections.
- Ultimately, we will examine causality with the Toda-Yamamoto approach.

3.3. Model

The empirical model to estimate is defined as follows:

$$\text{LNNPL_R} = f(\text{LNRGDP}, \text{LNUNEMPR}, \text{LNINTEREST}, \text{LNCPI}, \text{LNEXCHR})$$

This study delineates the econometric specification utilizing the ARDL model as proposed by Pesaran et al. (2001). This model offers the advantage of facilitating a simultaneous analysis of both short-run and long-run effects of the independent variable on the dependent variable.

The ARDL model can be articulated in the following form: Based on the reviewed theoretical and empirical literature herein, the empirical model to estimate is defined as follows

$$\begin{aligned} \Delta \text{LNNPL_R}_t = & a_0 + \sum_{i=0}^P a_{1i} \Delta \text{LNNPLR}_{t-i} + \sum_{i=0}^Q a_{2i} \Delta \text{LNRGDP}_{t-i} \\ & + \sum_{i=0}^Q a_{3i} \Delta \text{LNUNEMPR}_{t-i} + \sum_{i=0}^Q a_{4i} \Delta \text{INTEREST}_{t-i} \\ & + \sum_{i=0}^Q a_{5i} \Delta \text{EXCHR}_{t-i} + \sum_{i=0}^P a_{6i} \Delta \text{LNCPI}_{t-i} + b_1 \text{LNRGDP}_{t-1} \\ & + b_2 \text{UNEMPR}_{t-1} + b_3 \text{INTEREST}_{t-1} + b_4 \text{EXCHR}_{t-1} + b_5 \text{LNCPI}_{t-1} \\ & + e_t \end{aligned}$$

With Δ first difference operator; a_0 : observed; $a_1 \dots a_6$: short-term effects; $b_1 \dots b_5$: long-term model dynamics; e_t : error term (white noise).

4. Results and discussion

4.1. Descriptive statistics and Correlation

Tables 2 and 3 present the descriptive analysis of these variables and their correlations, respectively.

Table 2 : Descriptive statistics

	LNNPLR	LNRGDP	LNUNEMPR	LNCPI	LNEXCHR	LNINTEREST
Mean	24.56151	26.11009	2.235628	4.735954	2.402043	1.758202
Median	24.67646	26.10857	2.230014	4.733563	2.407576	1.788421
Maximum	24.99938	26.30052	2.370244	4.794964	2.428601	1.894617
Minimum	24.05835	25.87459	2.079442	4.659658	2.364432	1.583094
Std. Dev.	0.319245	0.127118	0.074661	0.038943	0.017847	0.096670
Skewness	-0.188691	-0.086052	-0.149275	-0.124175	-0.504699	-0.373825
Kurtosis	1.393139	1.776542	2.530353	1.820988	2.245842	1.705737
Jarque-Bera	5.108285	2.862128	0.580688	2.722025	2.976826	4.188932
Probability	0.077759	0.239054	0.748006	0.256401	0.225731	0.123136
Sum	1105.268	1174.954	100.6033	213.1179	108.0919	79.11909
Sum Sq. Dev.	4.484367	0.710991	0.245267	0.066727	0.014014	0.411182
Observations	45	45	45	45	45	45

Source: Authors

Table 3: Correlation

	LNNPLR	LNRGDP	LNUNEMPR	LNCPI	LNEXCHR	LNINTEREST
LNNPLR	1					
LNRGDP	0.97222	1				
LNUNEMPR	0.39394	0.331454	1			
LNCPI	0.961467	0.97445	0.396113	1		
LNEXCHR	-0.677021	-0.66122	-0.07245	-0.6252	1	
LNINTEREST	-0.90538	-0.912628	-0.238213	-0.898796	0.7227	1

Source: Authors

4.2. Unit root tests

Table 4 displays the unit root results for the series at both levels and first differences. The results from the Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP) test and Kwiatkowski-Phillips-Schmidt-Shin(KPSS) test indicate that all series are integrated of order 0 or 1. It is important to note that in these instances, traditional cointegration methods are not effective. Therefore, the adoption of the ARDL modeling approach is appropriate. After determining the integration order, the analysis proceeds to explore long-run relationships.

Table 4. Unit root tests

Variables	ADF		PP		KPSS	
	Level	1 st difference	Level	1 st difference	Level	1 st difference
LNNPLR	-4.0001**		1.6953	-8.832***	0.1097	0.2034**
LNRGDP	-1.8264	-7.361***	-2.3634	-10.77***	0.1599**	
LNCPI	-0.5991	-25.13***	-1.2361	-16.69***	0.8435	
LNINTERESTR	-0.8680	-6.738***	-0.5206	-8.395***	0.8149**	
LNEXCHR	-1.9122	-6.963***	-1.8772	-8.947***	0.6769**	
LNUNEMPLR	-1.0436	-5.474***	-6.49***	-31.10***	0.6991**	

N.B.: (***) and (**) refer to 1% and 5% risk of error respectively.

4.3. Pesaran et al. (2001) cointegration test

The ARDL cointegration approach, utilizing the Pesaran cointegration test, is suitable for our

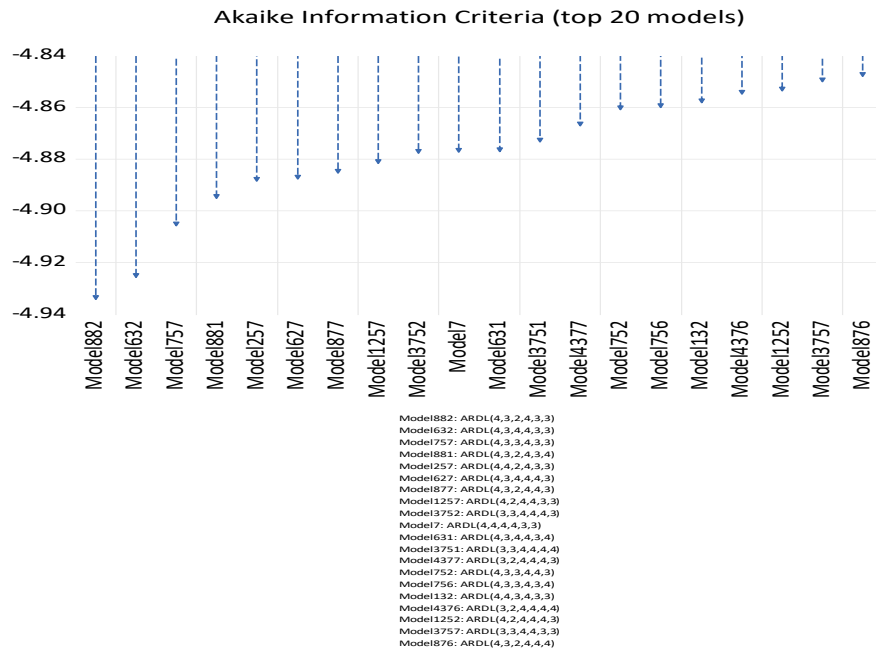
time series data characterized by an integration order of 0 or 1. To perform this test, we will follow the two steps outlined below:

- Determination of the optimal lag, obtained through the application of the information criterion (AIC).
- Application of the Bound test to determine the presence or absence of cointegration.

4.3.1. The optimal estimation lag of the ARDL model

Figure 2 demonstrates that the ARDL model (4,3,2,3,4,3) is the most optimal among the top 20 models since it employs less information and exhibits the lowest AIC.

Figure 2. Selection from the twenty best models based on the AIC criterion.



Source: Authors

4.3.2. Bound test

The F-statistic value surpasses the upper bound at a 1% error level, indicating evidence of cointegration and a long-term relationship between the analyzed series (Table 5). This cointegration allows for an exploration of both the long-term and short-term dynamics between credit supply and the explanatory variables.

Table 5 : Bound test

Sample Size	10%		5%		1%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
40	2.306	3.353	2.734	3.920	3.657	5.256
45	2.276	3.297	2.694	3.829	3.674	5.019
Asymptotic	2.080	3.000	2.390	3.380	3.060	4.150
Test Statistic	Value					
F-statistic	7.247542					

Source: Authors

4.4. Short-term and long-term coefficients

As presented in Table 6, the adjustment coefficient—an important factor that enables convergence toward long-term equilibrium—is observed to be negative, statistically significant,

and falls between 0 and 1 in absolute value. This specific range of the adjustment coefficient indicates a stable error correction mechanism, confirming the existence of a long-term relationship among the variables under investigation.

Additionally, Table 6 provides insights into the short-term dynamics, revealing that real GDP, inflation, and the exchange rate have a statistically significant and negative impact on the rate of non-performing loans (NPL). This finding aligns with theoretical expectations, suggesting that improvements in real GDP, an increase in inflation, and a depreciating exchange rate may contribute to a decline in the incidence of non-performing loans in the banking sector.

Conversely, the long-term analysis indicates that the unemployment rate is positively and statistically significantly related to the non-performing loan rate. This suggests that increases in unemployment tend to elevate the rate of non-performing loans, highlighting the connection between higher unemployment levels and increased credit risk within the banking system. On the other hand, the exchange rate exhibits a contrasting effect; specifically, currency depreciation is associated with a decrease in the non-performing loan rate. This finding may imply that a weaker currency could enhance borrowers' repayment capabilities, potentially by improving export competitiveness.

Moreover, it is important to note that, in the long run, variables such as real GDP, and inflation do not demonstrate any significant impact on the credit risk indicated by the non-performing loan rate in the Moroccan banking context. This lack of a long-term effect suggests that while these economic indicators are relevant in the short term, they do not play a decisive role in influencing credit risk over an extended period.

Finally, interest rates do not affect credit risk, whether in the short term or the long term. Credit risk, which refers to the likelihood that a borrower will default on their obligations, remains unaffected by fluctuations in interest rates.

Table 6: Short-term and long-term coefficients of the regressors

Short-term		
	Coefficient	Prob.
COINTEQ	-0.357360***	0.0000
D(LNNPLR(-1))	0.171495	0.1398
D(LNRGDP)	-0.519837*	0.0536
D(LNCPI)	-2.644928***	0.0000
D(LNINTEREST)	-0.069749	0.4394
D(LNUNEMPR)	-0.017442	0.7463
D(LNEXCHR)	-1.151908***	0.0006
Long-term		
LNRGDP(-1)	1.609257	0.1273
LNCPI(-1)	-2.574308	0.2912
LNINTEREST(-1)	1.118830	0.3824
LNUNEMPR(-1)	2.123622***	0.0000
LNEXCHR(-1)	-11.04983***	0.0008
C	-8.062452	0.6393

N.B.: (***) and (**) refer to 1% and 5% risk of error respectively.

Source: Authors

4.5. Diagnostic tests

Table 7 provides a comprehensive overview of the results from various diagnostic tests conducted to evaluate the reliability and accuracy of the analytical model. The diagnostic assessments reveal that the estimated model does not exhibit autocorrelation of errors, which indicates that the residuals from the model are not systematically related across time periods. Furthermore, the tests confirm the absence of heteroscedasticity, meaning that the variance of the errors remains constant across observations. The distribution of the errors also aligns with

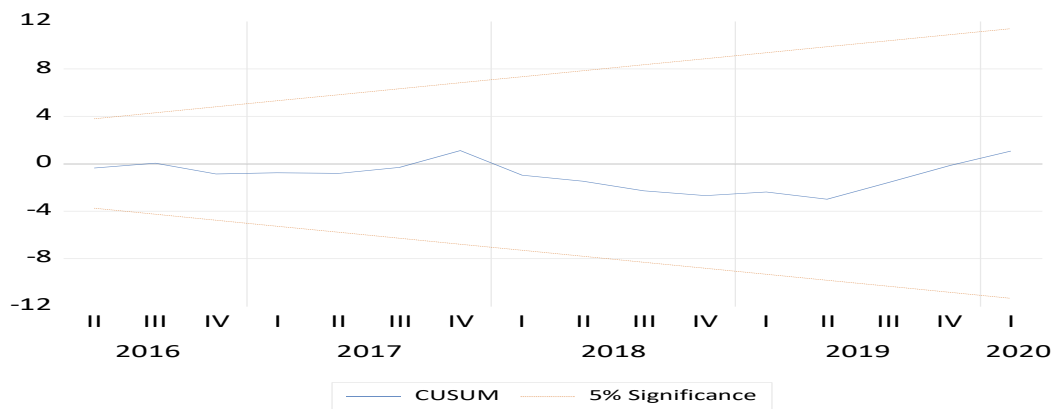
the properties of a normal distribution, which is essential for the validity of many statistical inference procedures. Additionally, the stability of the parameters in the Autoregressive Distributed Lag (ARDL) model is validated through the application of the CUSUM test. This test, illustrated in Figure 3, indicates that the parameters remain stable over time, further supporting the robustness of the model's findings. Overall, these diagnostic tests contribute to the credibility of the analysis and the conclusions drawn from it.

Table 7: Diagnostic tests

	Value	Prob
F-statistic	190.6909	0.000000
Serial Correlation: Breusch-Godfrey Serial Correlation LM Test	0.164692	0.8498
Heteroskedasticity: Breusch-Pagan-Godfrey	1.541057	0.1872
Normality: Jarque-Bera Test	0.7269	0.6952

Source: Authors

Figure 3: Stability test



Source: Authors

4.6. Toda-Yamamoto causality test

We conducted a Toda-Yamamoto causality test to explore the relationships between economic indicators and the rate of non-performing loans. The data presented in Table 8 show that interest rates, the unemployment rate, and currency exchange rates significantly affect the percentage of non-performing loans. These findings align with the results from the ARDL analysis regarding the impact of the unemployment rate and exchange rate on credit risk proxy. However, the causality test revealed a causal effect of interest rate on the NPL rate, which was not identified by the ARDL analysis. Overall, these findings highlight the significant influence of macroeconomic conditions on the credit risk within the Moroccan banking system.

Table 8. Toda-Yamamoto causality test

Dependent variable : LNNPLR			
Excluded	Chi-sq	df	Prob.
LNRGDP	4.983831	5	0.4179
LNCPI	5.215314	5	0.3902
LNEXCHR	9.647171	5	0.0859*
LNINTEREST	13.42585	5	0.0197**
LNUNEMPR	10.41163	5	0.0644*
All	53.09131	25	0.0009

N.B.: (***) and (**) refer to 1% and 5% risk of error respectively.

Source: Authors

5. Conclusion and recommendations

Credit risk has garnered considerable attention, particularly in the aftermath of the 2007-2008 financial crisis, which was instigated by the failures of several financial institutions. Comprehending this issue is of paramount importance. Our research is situated within this framework, correlating credit risk with the economic sphere, specifically macroeconomic factors.

The results from the ARDL analysis indicate that, in the short term, real GDP, inflation, and the exchange rate significantly and negatively affect the non-performing loan (NPL) rate. Specifically, improvements in real GDP, rising inflation, and a depreciating exchange rate can contribute to a decrease in NPL within the banking sector.

In contrast, the long-term analysis reveals a positive correlation between unemployment rates and NPL rates, suggesting that higher unemployment levels increase credit risk. Notably, a depreciating exchange rate appears to lower NPL, likely by enhancing borrowers' repayment capabilities due to improved export competitiveness.

In the long run, real GDP and inflation do not significantly impact credit risk in Morocco, indicating that their effects are largely limited to the short term. Lastly, fluctuations in interest rates do not appear to influence credit risk. Furthermore, the findings of Toda and Yamamoto suggest that interest rates, unemployment, and currency fluctuations significantly affect the portion of non-performing loans.

These findings, while constrained by a relatively brief time frame and a focus on key macroeconomic variables, support the notion that banking and financial turbulence are indicative of economic instability. Financial institutions are urged to integrate current economic conditions into their assessments of asset quality to effectively manage risk exposure. By considering macroeconomic factors, they can enhance their evaluation of borrowers' creditworthiness and make more informed lending decisions. Likewise, policymakers should prioritize financial stability in the formulation of monetary policy, as economic stability is crucial for ensuring financial soundness.

Further research is crucial to enhance the insights gained from these findings. We should investigate the factors influencing credit risk by debtor categories (households and non-financial enterprises) and by the branch activities of non-financial enterprises.

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