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Examination of the Relationship between Non-performing Loans and Macro-economic Variables in Banking Sector: The Case of Turkey (2003-2020)

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Abstract

Although loans are a profitable product for banks, they inherently contain an element of risk. The financial sector in terms of the fact that a loan transferred to the economy is not paid in due time and becomes problematic, firstly affecting the bank that made the loan and then other banks. On the other hand, it affects the real sector in terms of reducing the amount of loan to be transferred to the economy and increasing the cost of loan. In other words, the existence and control of non-performing loans is very important for the activities of both the banking sector and the real sector. In this study, the relations between the amount of non-performing loans, real effective exchange rate, inflation rate, economic growth and interest rates were analyzed by ARDL analysis method. It covers the periods from 2003; Q1 to 2020; Q4. As a result, it has been determined that other variables other than the inflation rate affect non-performing loans.

Keywords: Credit, Non-Performing Loans, Credit Risk, Turkish Banking Sector.

Introduction

With globalization, the relationship of the real sector with the banking sector, where it meets the need for funds, continues to increase day by day. Failure to pay a loan transferred to the economy on time and turning into a non-performing loan negatively affects the bank that issued the loan at first, then the financial sector and the real sector with the domino effect. As a natural consequence of this, the presence of non-performing loans emerges as an important risk factor for the stability of national economies. The most striking increase in non-performing loans in the Turkish banking system was experienced with the 2001 banking crisis. In 2001, the non-performing loans ratio reached its historical peak and increased to the level of 29.3%. Considering the unrealized effects of non-performing loans on both the financial economy and the real economy, it has become important to evaluate and take precautions against the effects that cause non-performing loans. In this study, after presenting the literature on the subject, non-performing loans will be examined within a conceptual framework and reasons, early warning signs, effects on financial and real sector will be explained. In the last part of the study, in order to determine the possible determinants of the amount of non-performing loans in the Turkish economy, the relationship between the amount of non-performing loans and selected macroeconomic variables will be investigated. 72 observations between the periods 2003: Q1-2020: Q4 will be tested and interpreted with ARDL bounds test and Toda-Yamamoto causality testing methods.

Development of Non-performing Loans in the Turkish Banking System

Depending on globalization, Turkey has transitioned to a free market economy since the 1980s. "The policies followed after 1980, the chronic inflation experienced, the increase in foreign currency and interest risk, and the increase in loan costs brought along the problem of uncollectible accounts and non-performing loans (Sahbaz and Inkaya, p.71).

The most striking increase in non-performing loans in the Turkish banking system was experienced with the 2001 banking crisis. During this period, an increase in real interest rates, a decrease in production and a significant deterioration in the balance sheets of firms led to a contraction in the credit volumes of banks. While the ratio of non-performing loans was 11.5% in 2000, with the effect of the 2001 crisis, it increased dramatically to 29.3% (Sahbaz and Inkaya, p.72).

The non-performing loans ratio in the Turkish banking sector by years is given in Figure 1.

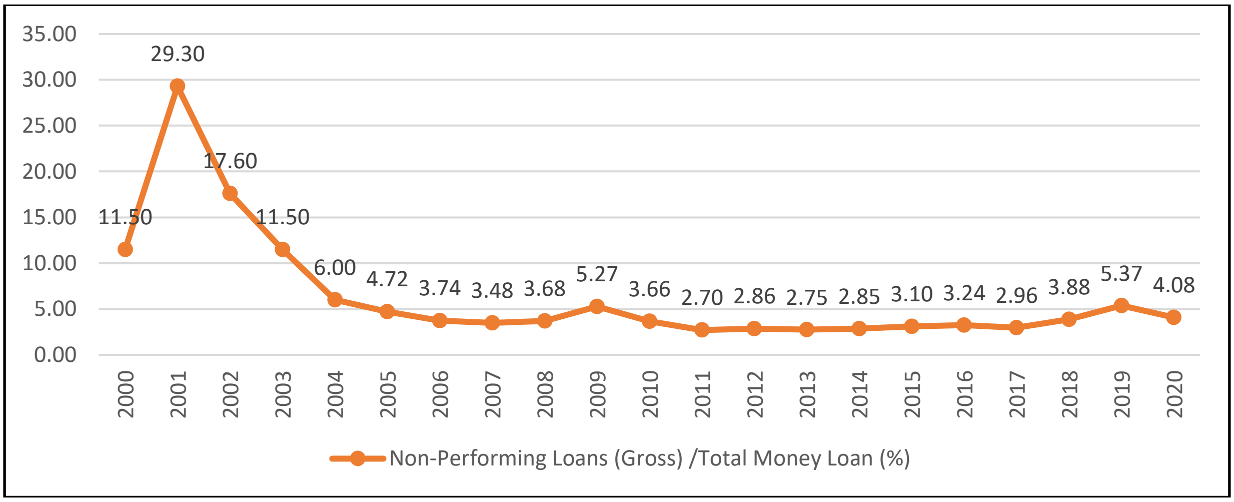


Figure 1. Non-Performing Loans Ratio (%)
Source: BRSA

Following 2001 crisis, non-performing loans ratio decreased significantly until 2007, due to the fundamental changes in the Turkish banking sector since 2002, the establishment of an effective supervision and regulation system, and the improvements in the economic conjuncture (Yucemis and Sozer, p. 46). Non-performing loan ratio, which decreased to 3.48% in 2007, increased to 5.27% in 2009 with the effect of the global financial crisis. Non-performing loan ratio decreased by the effect of the increase in the loan volume and the decrease in the non-performing loan balance in 2010, when the effects of the 2008 global financial crisis were relatively diminished, and resulted in 3.66% (Torun and Altay, p.183). Between 2010 and 2018, non-performing loan ratio exhibited a relatively horizontal trend.

However, with the effect of the increase in the external debt of the real sector and the upward exchange rate movements in 2018, non-performing loan ratio increased, resulting in 5.37% in 2019 (Kaya, p.193). In order to reduce the impact of the covid-19 virus pandemic that has affected the world since December/2019, low-interest, long-term and government-supported loans have been channeled to the economy, primarily through public banks in Turkey. Although the impact of the pandemic has moderated relatively, banking errors made during the lending process and their impact on upward exchange rate movements are likely to turn into non-performing loans.

In Figure 2, the details of the amount of non-performing loans are given on the basis of "(i) Consumer loans and credit cards, (ii) SME loans, (iii) Commercial loans". Non-performing loans have consistently maintained an upward trend over the years. The amount of non-performing loans, which was 64 billion TL in 2017, increased due to the economic problems experienced in 2018 and reached 152 billion TL in the period of December 2020. When analyzed on the basis of credit segmentation, the most significant increase was experienced in commercial loans, which rose to 77 billion TL in December 2020. Commercial loans are followed by SME loans with 58 Billion TL, consumer loans and credit cards with 17 Billion TL, respectively.

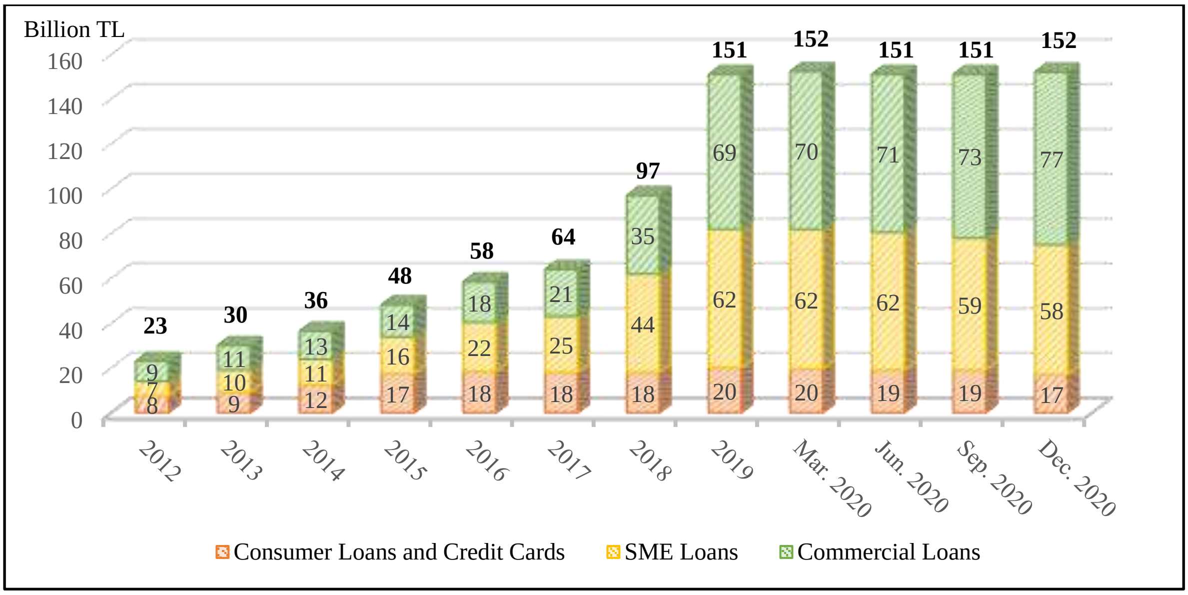


Figure 2. Amount of Non-Performing Loans
Source: BRSA, 2020

In Figure 3, Non-performing loan ratios are given on the basis of credit segmentations. When Figure 2.3 is analyzed, it is seen that the non-performing loans ratio of SME loans is higher than the other two loan segments. In addition, it is observed that the non-performing loans ratio of commercial loans was on an increasing trend since 2017 and was above the non-performing loans ratio of consumer loans and credit cards since 2018.

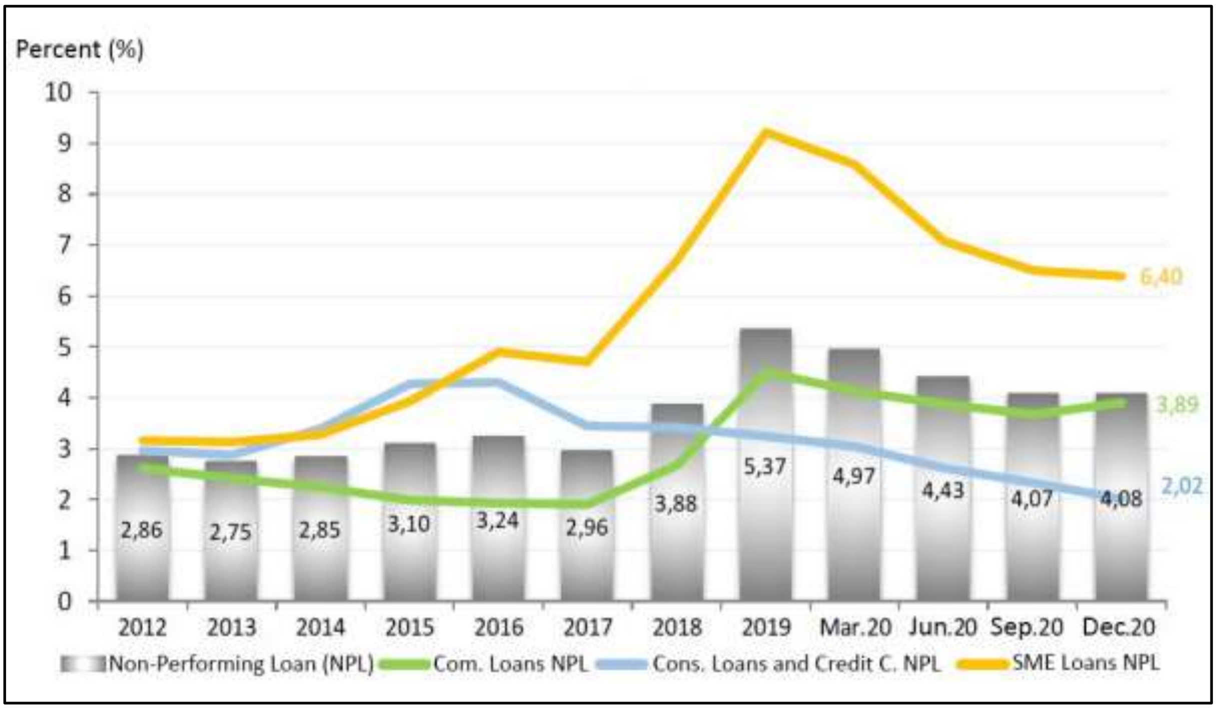


Figure 3. Non-Performing Loan Ratios on The Basis of Credit Segmentation
Source: BRSA, 2020

In Figure 4, non-performing loan ratios for selected sectors are given. When Figure 2.4 is analyzed, the construction sector has the highest non-performing loan ratio with a ratio of 9.29%, while the metal main industry and processed metal production industry sector has the lowest non-performing loan ratio with a rate of 3.14%.

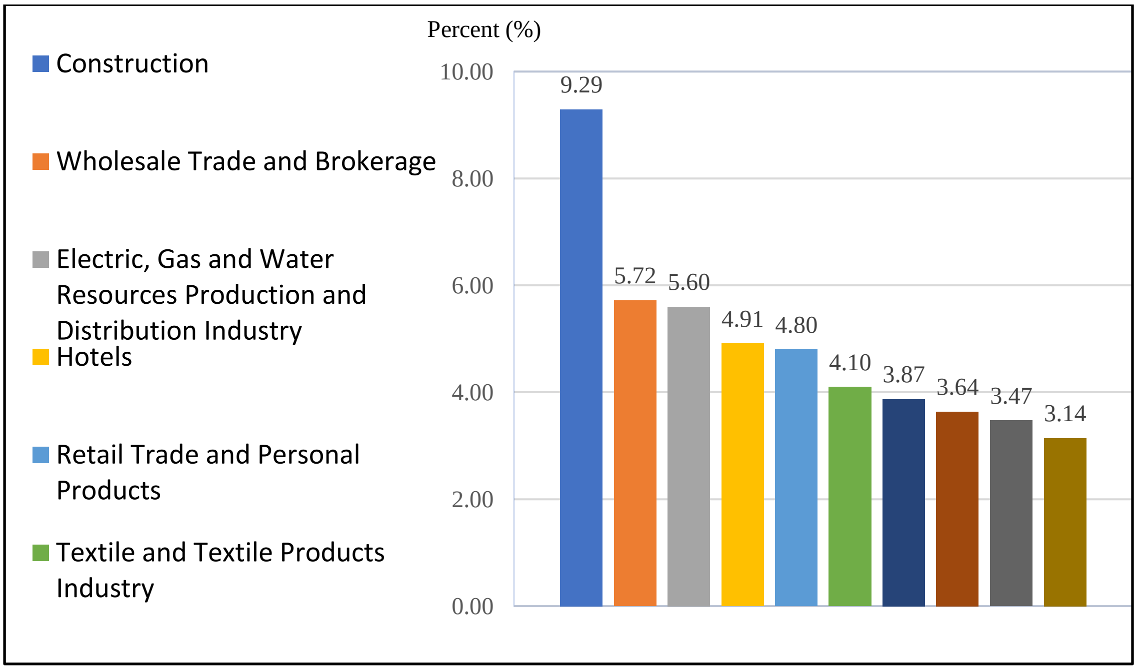


Figure 4. Non-Performing Loan Ratios Regarding Selected Sectors
Source: BRSA,2020

Literature

There are international and domestic studies examining the relationship between non-performing loans and macroeconomic variables. Some of these studies are summarized below.

Fofack (2005) studied the relationship between macroeconomic variables such as economic growth, real exchange rate increase, real interest rate, net interest profitability and bad debts in Sub-Saharan Countries with Panel Data Analysis method. In the study, data for the years 1995-2009 were used. As a result of the study; it was revealed that there is a relationship between the variables.

Espinoza and Prasad (2010) analyzed non-performing loans and the macroeconomic effects of non-performing loans with the VAR method, by using the data of 80 banks operating in the Gulf Countries between 1995 and 2008. As a result of the study, it was determined that there was an increase in non-performing loans in periods when economic growth was low and banks' risk taking rates were high.

Nkusu and Muhleisen (2011) analyzed the relationship between non-performing loans and macroeconomic variables in 26 developed countries using the Panel Regression Analysis method. In the study, the data for the years 1998-2009 were used. As a result of the study; it was determined that the deterioration in macroeconomic variables caused an increase in non-performing loans.

Mileris (2012), using the Logistic Regression Analysis method, with the data of 22 European Union Countries for the years 2008-2010, studied to find the macroeconomic determinants that significantly affect the change in credit portfolio, credit risk in banks and to estimate the ratio of bad debts and non-performing loans. As a result of the study; it was determined that macroeconomic variables such as “unemployment rate, inflation rate and growth rate” have influence on non-performing loans.

Klein (2013) examined the relationship between non-performing loans and macroeconomic variables in Southeast, Eastern and Central European countries using the Panel Data Analysis method with the data of 1998-2011 years. As a result of the study; it was determined that macroeconomic variables “(GDP growth, unemployment and inflation rates)” had a significant effect on non-performing loans.

The relationship between non-performing loans and macroeconomic variables in “Greece, Ireland, Portugal, Spain and Italy” for the 1997:Q1-2011:Q3 periods was studied by Castro (2013) using the Regression Analysis method. As a result of the study; it was determined that there is a relationship between non-performing loans and macroeconomic variables (growth rate, inflation rate, interest rate and loan growth rate).

The data of seven Central and Eastern European countries between 2007:Q3-2012:Q3 were studied by Skarica (2014) using panel data analysis method. As a result of the study; it was determined that the increase in unemployment rate and inflation increase the non-performing loan ratios, and the growth in real GDP has a negative effect on non-performing loans.

The relationship between the data of 2005-2011 and non-performing loans macroeconomic variables in Germany and France was examined by Chaibi and Ftiti (2015) by using the Dynamic Panel Data Analysis method. As a result of the study; it was determined that growth, interest rate, unemployment rate and exchange rates affect non-performing loans in both countries' economies.

The determinants of non-performing loans in the Greek banking sector were studied by Konstantakis et al (2016) in the light of the data between 2001:Q4-2015:Q1 by using the VEC method. It was determined that macroeconomic (growth, unemployment rate) and financial factors affect non-performing loans in the country.

Gabeshi (2017) investigated the connection between macroeconomic developments and banking credit risk in Albania. In the study, the data between 2005 and 2014 years were tested with a multiple linear regression model. It was determined that the change in macroeconomic variables has influence on non-performing loans.

An analysis was conducted by Top Mavili (2008) with the Logit Regression Model, using 47 financial variables belonging to 46 companies to predict the causes of non-performing loans. The data used in the analysis belong to 2003. As a result of the analysis, statistically significant results were obtained.

Vatansever and Hepsen (2013) used the data between 2007:Q1-2013:Q3 to investigate whether there was a significant relationship between macroeconomic indicators, bank-level factors and non-performing loan ratio in Turkey using Linear Regression Model and Co-Integration Analysis method. As a result of the study; it was determined that macroeconomic variables did not have a significant effect on the explanation in the multivariate perspective.

The data between 2002:Q4-2013:Q1 covering 26 commercial banks, the macroeconomic and bank level determinants of non-performing loans were studied by Yagcilar and Demir (2015) by using the Panel Data Analysis method,. As a result of the study; it was determined that the impacts of interest rates, net interest margin and inflation variables on non-performing loans were not statistically significant, while other variables were found to be statistically significant.

Yuksel (2016) studied the factors that determine the non-performing loans ratio of banks in Turkey by using the data between 1988-2014 with the Mars method. As a result of the study, with non-performing loans; It was determined that the increase in the USD exchange rate has a positive effect, while the increase in the interest income of the banks and the economic growth rate has a negative effect.

The relationships between bank-specific and macroeconomic variables and non-performing loans were investigated by Islatince (2016) using the Vector Error Correction Model with Granger causality, impulse-response functions and variance analysis methods. Within the scope of the study, data for the periods 2001:Q1-2015:Q3 were used. As a result of the study; it was concluded that all variables used in the model are the cause of non-performing loans Granger in the long run. No relationship was found between non-performing loans and basic macroeconomic variables such as inflation rate and growth.

In order to determine the macroeconomic and bank-level determinants of non-performing loan ratios, Altunoz (2018) analyzed the data of 26 commercial banks which operated continuously in the Turkish Banking Sector between 2002:04-2013:01 using Panel Data analysis method. As a result of the study; it was concluded that loan loss provisions in Turkey were determined by economic growth, exchange rate and money supply.

The relationship between foreign exchange rates and non-performing loans was analyzed by Bas and Kara (2020) by using ARDL analysis method for the period 2005:Q4-2017:04 and addressing the commercial loan interest rate, loan volume and inflation variables. It was determined that there was a direct relationship between the real effective exchange rate, commercial loan interest rate, the loan volume of the banking sector, inflation and non-performing loans, and the increase in the real effective exchange rate both in the long and short run also increases the non-performing loans.

Dataset and Methodology

Purpose and Scope

The research was conducted to determine the possible determinants of the amount of non-performing loans in the Turkish economy. In this context, it is aimed to examine the relationships between non-performing loan amount and real effective exchange rate, inflation rate, economic growth and interest rates. The research includes 72 observations between the 1st quarter of 2003 and the 4th quarter of 2020.

The research model created for research purposes is as in equation 1.

$$Log(NLP)_t=\alpha+\beta_1 REER_t+\beta_2 INT_t+\beta_3 INF_t+\beta_4 GDP_t+\varepsilon_t \qquad (1)$$

The t sub index in the research model represents the time series model of the model. While α is the constant term, ε is the error terms of the equation, βi (i=1, 2, 3, 4) are the coefficients that express the estimations of the effects of the explanatory variables on the dependent variable. Dependent and independent variable definitions are as in Table 1.

Table 1
Variable Definitions

Variable	Definition	Source
Log (NPL)	Natural log of total non-performing loans in period t	B.R.S.A
REER	CPI Based Real Effective Exchange Rate	C.B.R.T. (E.D.D.S)
INT	Up to 1 Year Term (Deposits Opened in TL) Interest Rate	C.B.R.T. (E.D.D.S)
INF	Inflation rate	C.B.R.T. (E.D.D.S)
GDP	% increase in Gross Domestic Product (Economic Growth)	C.B.R.T. (E.D.D.S)

Data Analysis

Variables in the time series model in Equation 1; after being compiled as 72 units between 2003/1 quarter and 2020/4 quarter, in order to avoid the spurious regression phenomenon in the model estimations to be made due to the fact that the series are frequency series (non-annual), was examined in the first step with the seasonal F test whether the variables included seasonal effects. Since no statistically significant seasonal effect was detected in any of the variables in the data set, no seasonal adjustment was required.

In the next stage, "unit root tests" were applied to the variables in order to determine the stationarity of the variables.

There are conditions for the variables in the regression models of the time series to be stationary, and the regression model to be established between two or more non-stationary variables will form a spurious regression model. In short, if the variables form any trend in the time series, the relationship manifests itself in the form of an unreal, namely false regression (Tari, 1999, p.367; cited in Uzgoren and Uzgoren, 2005, s.2). In the case of spurious regression, the predicted models have generally been found to yield good results. However, despite high R2 and statistically significant parameters, the estimated parameters are usually insignificant. The main reason for this is not that the variables are related to each other, but that non-stationary variables move in the same direction randomly (Gujarati, 1995, s.709; cited in Uzgoren & Uzgoren, 2005, s.2). Spurious regression may occur between two completely

unrelated non-stationary variables, as well as in interrelated macroeconomic and financial series (Sevutekin & Cinar, 2017, s.559).
The ADF unit root test is used to determine whether the series is stationary. This method is an improved version of the Dickey and Fuller (DF) unit root test (Gujarati, 1995, p.709; cited in Uzgoren and Uzgoren, 2005, p.2). The ADF unit root test has taken into account the autocorrelation problem compared to the DF unit root test. ADF proposes the solution of three equations to answer whether a Yt series is stationary in level with the unit root test. These equations are;
for Y_t ~ I(0)
Equation without constant and without trend : 〖〖ΔY〗_t=β_1 Y_(t-1)+∑〗_(i=1)^p σ_i ΔY_(t-i) (2)
Equation with constant: : 〖ΔY_t=β〗_0+β_1 Y_(t-1)+∑〗_(i=1)^p σ〗_i ΔY_(t-i) (3)
Equation with constant and trend :ΔY_t=β_(0)+β_1 Y_(t-1)+β_(2) Trend+∑_(i=1)^p σ_i ΔY_(t-i) (4)
ADF test requires an OLS (ordinary least squares) estimation of one, some, or all of the regression specifications in equations 2, 3, and 4. Two conditions must be met for the series to be stationary; first, the coefficient β1 should be negative, and second, the coefficient should be statistically significant, the null hypothesis and an alternative hypothesis for the ADF test are as follows

H0: There is a unit root in the series.
H1: There is no unit root in the series.

In most specifications, deterministics are constant and trend. Unnecessary inclusion of constant or trend variable reduces the power of the test. Depending on the situation in question, it may cause the decision that the stationary series is not stationary. The dependent variable lags in the equation are intended to eliminate the possible autocorrelation problem in the error terms. As a result of the test, if all three specifications point to the unit root in the same place or indicate the absence of a unit root, the decision is made (Dickey and Fuller, 1979, pp.427-431).
It is known that visible structural breaks in time series may mislead unit root tests. Therefore, it was decided to apply the DF test, which is one of the structural break unit root tests for series with structural break, in addition to the ADF test. Structural break in the series may occur in four different types. For the structural break unit root test, there are 4 basic models in equations 5-6-7 and 8, depending on the type of structural break. The said models are as follows;
Model 0: Level break in trendless series

$$y_t = \mu_0 + \Theta DU_t(T_b) + y_t^* \qquad (5)$$

Model 1: Level break in series with trend

$$y_t = \mu_0 + \beta_t + \Theta DU_t(T_b) + y_t^* \qquad (6)$$

Model 2: Trend and level break in series with trend

$$y_t = \mu_0 + \beta_t + \Theta DU_t(T_b) + \gamma DU_t(T_b) + y_t^* \qquad (7)$$

Model 3: Trend break in series with trend

$$y_t = \mu_0 + \beta_t + \gamma DT_t(T_b) + y_t^* \qquad (8)$$

Here, $DU_t(T_b)$ is the level break dummy variable created for the break time, $DT_t(T_b)$ is the trend break dummy variable created for the break time, and y_t^* is the error terms of the equations, and the series are the trendless series. The approach is two-stage. First, the series is de-trended with the help of the above equations. In the second stage, the existence of unit root is investigated with the following test equations (Yamak & Erdem, 2017, s.101).
For Models 0,1 and 2;

$$y_t^* = \sum_{i=0}^{k} w_i D_{t-i}(T_b) + \alpha y_{t-i}^* + \sum_{i=0}^{k} c_i \Delta y_{t-i}^* + \mu_i \quad (9)$$

For Model 3;

$$y_t^* = \alpha y_{t-i}^* + \sum_{i=0}^{k} c_i \Delta y_{t-i}^* + \mu_i \quad (10)$$

“If the variables to be used in regression models are non-stationary, a frequently used method is to make them stationary by taking the differences of the variables. However, it was stated by Granger and Newbold that it was not appropriate to use non-stationary variables in such way as they removed the information about the long-term relationship (Granger and Newbold, 1977).”
A linear combination of non-stationary series may be stationary, such variables are referred to as cointegrated variables. Linear composition is often associated with economic theory. According to the economic interpretation of cointegration, if two or more series are related to each other in such a way as to form a long-term equilibrium, even if the series contain a scholastic trend (not stationary), they move closely with each other over time and the difference between them is stable, that is, stationary. In this case, the concept of cointegration means that the economic system converges over time and there is a long-run equilibrium relationship (Harris and Sollis, 2003, p.22).
Although the concept of cointegration was introduced to the literature by Engle-Granger, there are also many cointegration tests based on the application of unit root tests to residuals calculated from the cointegration model. In the research, ARDL bounds test method was used to determine the existence of cointegration relations. At the point of choosing the ARDL limit test, it was considered important that the test could detect the existence of a cointegration relationship without taking into account the stationarity properties of the variables. In other words, the ARDL bounds test method becomes more useful than Engle-Granger (1987) and Johansen (1989) tests in terms of allowing the examination of the cointegration relationship between the series that are integrated with different degrees. Since the variables in the research model were integrated to different degrees, ARDL bounds test approach was adopted in the research.
ARDL test is one of the cointegration tests that enables the examination of the relationships between non-stationary variables in econometrics. Although the ARDL bounds test method has some advantages over other cointegration tests, these advantages are; it gives a coefficient for the long-term, can be applied to variables that are equally non-stationary and integrated of different order at most I(1), have a wide range of trend and constant specifications, are error correction based, and works when long-run deviations are balanced. In addition; it is not enough just to have long-term equilibrium. It also requires balancing the deviations from the long term in addition to the equilibrium by the error correction term.
The ARDL bounds testing approach consists of two stages. In the first stage, the existence of long-term relationships between variables is tested. In the second stage, the short- and longterm coefficients of the series that are determined to be cointegrated in the first stage

are calculated. For better understanding, the following equation is estimated to test the long-term relationship in the boundary test approach for a bivariate research model.

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 X_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + \sum_{i=0}^{q} \lambda_i \Delta X_{t-i} + \mu_t \qquad (11)$$

Symbols in Equation are expressed as follows;
p= optimal number of lags in the dependent variable
q = optimal number of lags in the independent variable
β_0 , β_1 β_2 , $\delta_i$ve λ_i coefficients
Δ = difference of the variable.
The null hypothesis for the cointegration relationship between variables is as follows;

$$H_0: \beta_1 = \beta_2 = 0$$

If the calculated test statistic is less than the specified lower critical limit, the null hypothesis, which states that there is no cointegration relationship, cannot be rejected. If the test statistic is greater than the specified upper critical limit, the null hypothesis is rejected and it is decided that the cointegration has been established. If the test statistic is between the lower and upper limit values, no decision can be made regarding the cointegration.
After determining that there is cointegration between the series, the ARDL(p,q) model is estimated. The ARDL(p,q) model is shown in the equation below.

$$Y_t = \beta_0 + \sum_{i=1}^{p} \delta_i Y_{t-i} + \sum_{i=1}^{p} \lambda_i X_{t-i} + \mu_t \qquad (12)$$

In the ARDL(p,q) model, the long-term coefficients for the independent variable are estimated as follows.

$$\frac{\lambda_0 + \lambda_p + \cdots . \lambda_p}{1 - \delta_1 + \delta_2 + \cdots \delta_q} \qquad (13)$$

After estimating the long-term coefficients, the short-term coefficients are obtained by establishing the error correction model.

$$\Delta Y_t = \beta_0 + \beta_1 EC_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta X_{t-i} + \mu_t \qquad (14)$$

The EC in the equation represents the error correction term. In order to test the existence of a causality relationship from the independent variables to the dependent variable, the error correction term should be meaningful and must be in the range of 0 to -2.
The Akaike information criterion was taken into account to determine the optimal lag lengths for the ARDL(p,q) model. Many different lag length specifications can be created and compared based on the Akaike information criterion. However, the latest econometric package programs determine the optimal delay length according to the specified comparison criteria and save the researcher from this trouble.
Finally, causality tests were performed for the series that were found to be cointegrated with the help of ARDL bounds test. The Toda-Yamamoto (1995) approach, which is suitable for series with different degrees of integration, was used. In the Toda-Yamamoto causality approach, a VAR model is estimated with the level values of the variables, regardless of whether the variables are cointegrated or not. The co-significance of the coefficients calculated for different lag lengths of the variables over the estimated VAR model is tested with the Wald test.

The Toda-Yamamoto causality analysis is based on the extended VAR model. The extended VAR model includes two different delay lengths. The first of these is the optimal lag length (k) of the standard VAR model, and the second is the highest degree of integration (dmax) of the variables included in the VAR model. The examination of mutual causality for two variables is performed as follows;

$$Y_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} Y_{t-1} + \sum_{i=k+1}^{k+d_{max}} \beta_{2i} Y_{t-i} + \sum_{i=1}^{k} \delta_{1i} X_{t-i} + \sum_{i=k+1}^{k+d_{max}} \delta_{2i} X_{t-i} + \mu_{1i} \quad (15)$$

$$X_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} X_{t-1} + \sum_{i=k+1}^{k+d_{max}} \alpha_{2i} X_{t-i} + \sum_{i=1}^{k} \theta_{1i} Y_{t-i} + \sum_{i=k+1}^{k+d_{max}} \theta_{2i} Y_{t-i} + \mu_{2i} \quad (16)$$

"After the equations are estimated with the var system, the co-significance of the coefficients of the explanatory variables is tested with the Wald test." The fact that the coefficients are non-zero together is interpreted as a causal effect of the explanatory variable on the explained variable (Toda & Yamamoto, 1995).

Results

In this part of the study, the findings obtained as a result of data analysis are interpreted with tables and figures.

The time course graphs of the variables in the research are as in Figure 2

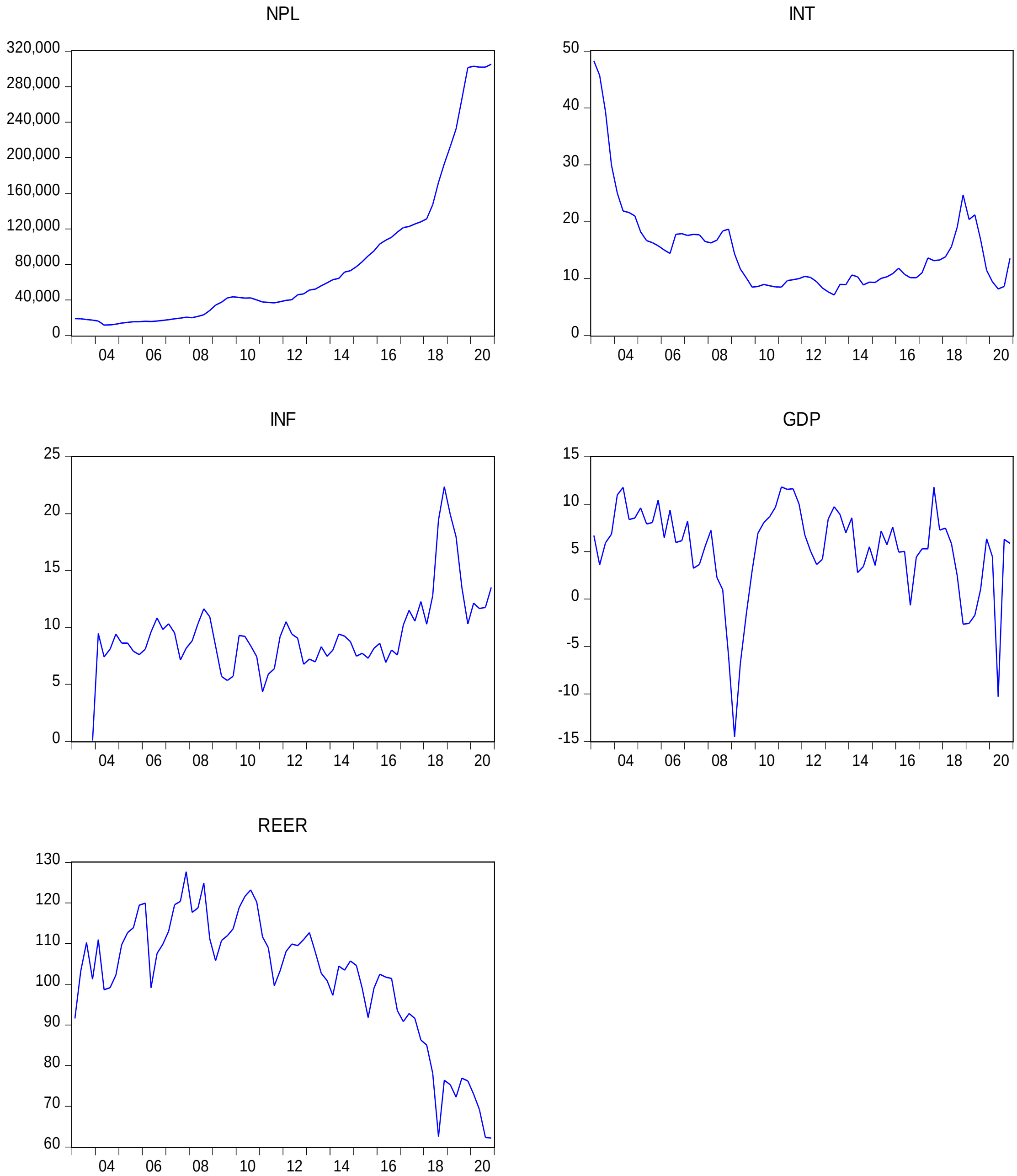


Figure 2. Variable Time Course Charts

When Figure 2 is examined, it is seen that the dependent variable Log(NPL) is a variable with an upward trend without structural break. When the trend of the variable is examined, it is observed that it has a logarithmic trend rather than a linear one. Since the dependent variable trend is very important for the correct determination of ARDL model specifications, linear, logarithmic and square trend regressions of the variable were created and it was seen that the trend structure providing the best fit was in the logarithmic trend. For this reason, it should be established and determined logarithmically in the trend in the ARDL model.
When the independent variables are examined, it can be said that the INT variable has a downtrend and does not show a significant structural break, the INF variable has a structural break and a small amount of uptrend, the GDP variable has a structural break and does not

have a clear trend, and the REER variable has a downward trend and does not show a significant structural break.
It was thought that it would be beneficial to apply structural break unit root tests in addition to the classical unit root tests in order to determine the stationarity status of INF and GDP variables, which have distinctive structural break characteristics.
The findings of the ADF unit root test applied to the variables are presented in Table 2

Table 2
ADF Unit Root Test Findings

Variable	Augmented Dickey-Fuller Test Statistics		
	Without Constant	**Constant**	**Trend and Constant**
Log(NPL)	5.161[7] (1.000)	4.843[7] (1.000)	2.823[7] (1.000)
Δ Log(NPL)	-2.679[0]* (0.080)	-3.118[0]** (0.029)	-5.845[6]*** (0.000)
INT	-2.672[0]*** (0.008)	5.276[1]*** (0.000)	-4.801[1]*** (0.001)
INF	-0.231[4] (0.751)	-1.467[4]*** (0.000)	-3.801[4]** (0.022)
Δ INF	-7.953[3]*** (0.000)	-7.929[3]*** (0.000)	-7.743[3]*** (0.000)
GDP	-2.5395[0]** (0.011)	-3.811[0]*** (0.004)	-3.888[0]** (0.018)
REER	-0.666[0] (0.425)	-0.833[0] (0.803)	-2.943[0] (0.157)
Δ REER	-9.558[0]*** (0.000)	-9.574[0]*** (0.000)	-6.813[5]*** (0.000)

"* (10%), **(5%), *** (1%) represent stationarity at the significance level. (brackets include ADF test probability values (p)) Δ=represents the first-circuit difference of the variable.[The square brackets contain the optimal lag lengths selected for the ADF regression.] The Schwarz Information Criterion was used for the optimal lag length of the ADF regression (Max.Lag:8)."
When the findings of the ADF unit root test are examined in the table, it is seen that the dependent variable Log(NPL) is a series that is not stationary at the level ($p>0.10$) but becomes stationary at the first cyclical difference. ($p<0.05$). When the stationarity findings of the independent variables are examined, it is seen that the INT and GDP variables are stationary at the level values ($p<0.01$), the INF and REER variables are not stationary at the level ($p>0.10$), but it is a series that becomes stationary at the first cyclical difference. ($p<0.01$).
Due to the structural breaks of the INF and GDP variables in the course of time, it was thought that it would be useful to examine the stationarity of the variables with a unit root test that takes into account the structural breaks.
DF unit root test findings with structural break are as in Table 3.

Table 3
DF Unit Root Test Findings with Structural Break

Model Specifications				
		Trend and Constant		
		Break Specifications		
Variable	**Constant**	**in Constant**	**in Trend**	**Trend and Constant**
INF	-5.946[2]*** (0.000)	-5.908[2]*** (0.000)	-4.474[1]* (0.057)	-5.709[2]** (0.011)
GDP	-5.946[2]*** (0.000)	-5.908[2]*** (0.000)	-4.4748[1]*** (0.058)	-5.709[2]*** (0.011)

“* (10%), **(5%), *** (1%) represent stationarity at the significance level. (brackets include

ADF test probability values (p)) Δ=represents the first-circuit difference of the variable.[The square brackets contain the optimal lag lengths selected for the ADF regression.] Schwarz Information Criterion was used for the optimal lag length of the ADF regression (Max.Lag:8) Dickey Fuller Min t statistics were used for the selection of break periods.

According to the structural break DF unit root test findings of INF and GDP variables in the table, it is seen that both variables are stationary at level value. While the structural break DF unit root test findings of the INF variable are different with the ADF, the stationarity level of the GDP variable is the same for both tests.

When the unit root tests of the variables are examined together, it is seen that some of the variables in the model are stationary at the level (≈I(0)) and some are non-stationary at the level and stationary at the first periodic difference. (≈I(1)). In order to examine the relationships between the time series that are stationary at different degrees, it was decided to analyze the research model with the ARDL bounds test, since it was known that the ARDL bound test method was appropriate. In order to determine the optimal values for the variable lag numbers in the Autoregressive part of the ARDL model, the values of the Akaike information criterion were taken as a basis. Values including the comparison of corrected Akaike information criterion values for different delay specifications are presented in figure 3.

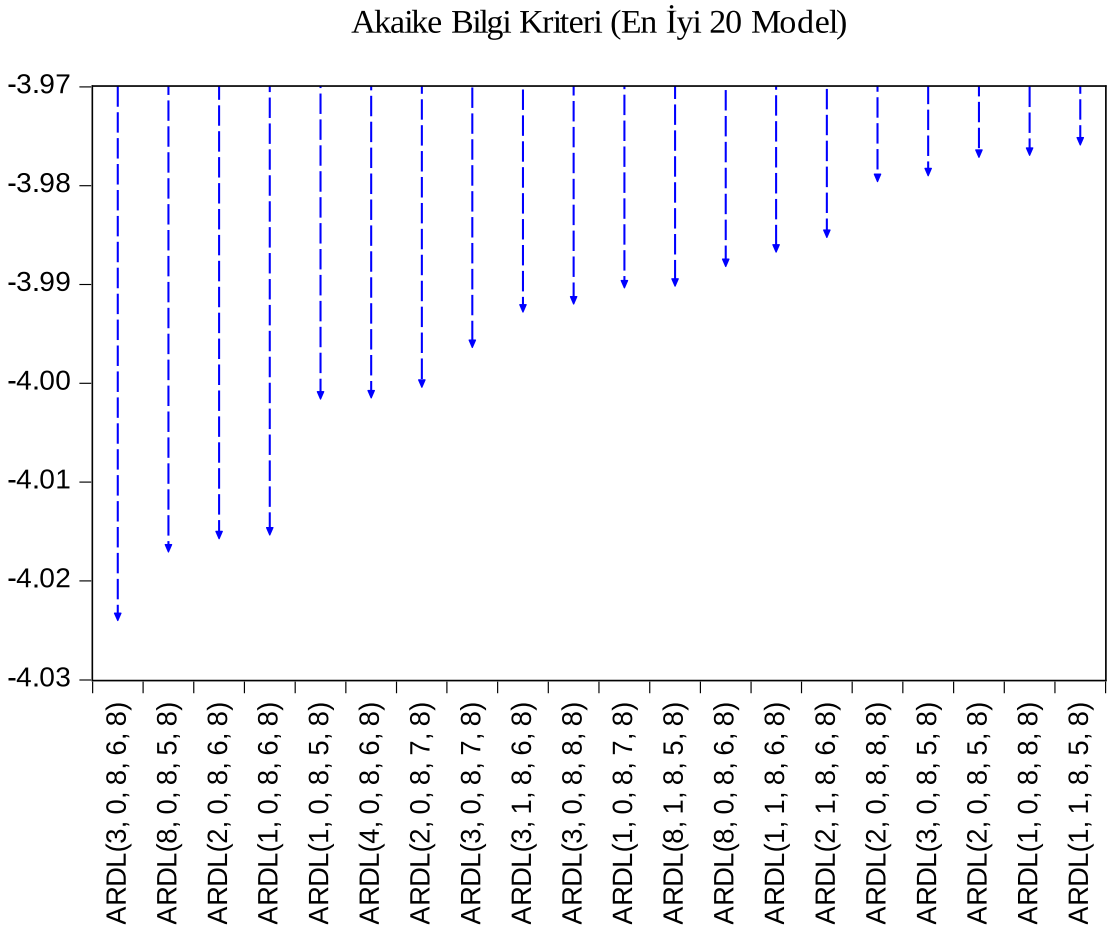


Figure 3. Akaike Information Criteria Values for Optimal Delays

When comparing the 20 models for which the smallest Akaike Information Criteria value is calculated, it is seen that the optimal model is ARDL (3, 0, 8, 6, 8). To put it more clearly, in the Autoregressive part of the ARDL model, the dependent variable is included with 3 lags, REER 0 latency, INT 8 latency, INF 6 lag and GDP 8 lag.
ARDL (3, 0, 8, 6, 8) model findings are summarized in Table 4

Table 4
ARDL (3, 0, 6, 6, 8) Model Estimation Findings

Long Term Statistics				
Variable	**β**	**S.H**	**t**	**p**
REER	-0.009	0.004	-2.261**	0.031
INT	0.034	0.019	1.724*	0.094
INF	0.021	0.028	0.761	0.452
GDP	-0.031	0.014	-2.226**	0.033
Error Correction Model Statistics				
Variable	**β**	**S.H**	**t**	**p**
ECM	-0.177	0.032	-5.500***	0.000

F- bounds Test Statistics				
	Sig.		**I(0)**	**I(1)**
F=5.397* **	%10		2.45	3.52
	%5		2.86	4.01
	%1		3.74	5.06
Diagnostic Tests				
Goodness of Fit Test			F=159.754***	p=0.000
Determination			R^2=0.999	D.R^2=0.999
Breusch-Pagan-Godfrey Heteroskedasticity Test			F(30, 33)=0.781	p=0.752
Breusch-Godfrey Autocorrelation Test		Lag(1)	F(1, 32)= 0.439	p=0.512
		Lag(2)	F(2, 31)= 0.216	p=0.807
		Lag(3)	F(3, 30)= 0.383	p=0.766
		Lag(4)	F(4, 29)= 0.285	p=0.885
Disturbance Terms		$\bar{X}\approx0$	J.B=1.527	J.B(p)=0.465

***(1%) signify statistical significance at the level of significance. S.H: Standard error, Brackets

include test degrees of freedom. (SD1, SD2). D. R2: Adjusted Coefficient of Determination"
When the diagnostic tests are examined in the table, no variance problem was found in the model according to the findings of the Breusch-Pagan-Godfrey Heteroskedasticity test (F(30, 33)=0.781, p>0.10). According to the results of the Breusch-Godfrey Autocorrelation test, which was checked for up to 4 lags, it can be said that no autocorrelation problems were encountered in the model up to 4 lags. (p>0.10). It is seen that the model error terms are normally distributed (J.B=1.527, p>0.10) with a zero mean ($\bar{X}\approx0$). Since it was seen that there were no assumptions violations in the model, no extra action was required regarding the assumptions.
When the F bounds test statistic for the estimated model is examined, it is seen that the calculated test statistic is greater than the critical values given for the 1% significance level. ($F=5.397>F_{Critical}(0.01)$) In this case, it can be said that there is a long-term equilibrium relationship between the variables at the 1% significance level.
When the error correction mechanism of the model is examined, it is seen that the error correction term is statistically significant at the 1% significance level and is negative and greater than -2 as expected. (ECM=-0.177, p<0.10) In this case, it can be said that the error correction mechanism works in the model. In other words, it can be said that the deviations from the determined long-run equilibrium are brought back to equilibrium by the error terms throughout the periods.
Interpretation of the parameters calculated for the long term will be statistically significant thanks to the fact that the F bounds test indicates the existence of long-term equilibrium and the error correction mechanism works.
When the long-term coefficients are examined;

It is seen that the REER variable has a statistically significant and negative effect on the Log(NPL) variable at the 5% significance level. ($\beta 1=-0.009$, $p<0.05$). To put it more clearly, a 1-unit increase (increase in TL value) in the CPI-based real effective exchange rate during the period under consideration caused a 0.9% decrease (approximately 1%) in non-performing loans.

It is seen that the INT variable has a statistically significant and positive effect on the Log(NPL) variable at the 10% significance level. ($\beta 2=0.034$, $p<0.10$). To put it more clearly, a 1-unit increase in short-term interest rates during the period under consideration causes an increase of 3.4% in non-performing loans.

There was no statistically significant effect of INF variable on Log(NPL). ($\beta 3=0.021$, $p>0.10$).

It is seen that the GDP variable has a statistically significant and negative effect on the Log(NPL) variable at the 5% significance level. ($\beta 4=-0.031$, $p<0.05$). To put it more clearly, 1 unit in economic growth causes a 3.1% decrease in non-performing loans during the period discussed.

The findings of the "Cusum and Cusum Square tests" conducted to examine whether the calculated long-term parameters are stable in the long-term are shown in Figure 4.

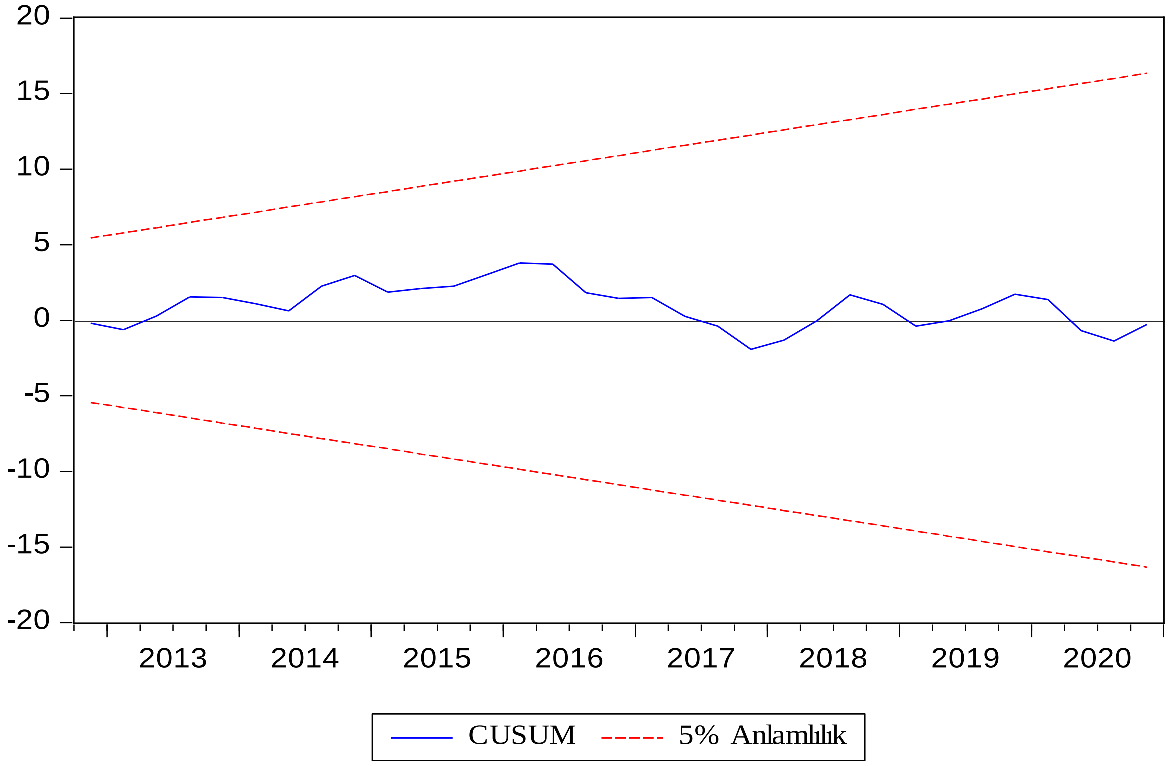
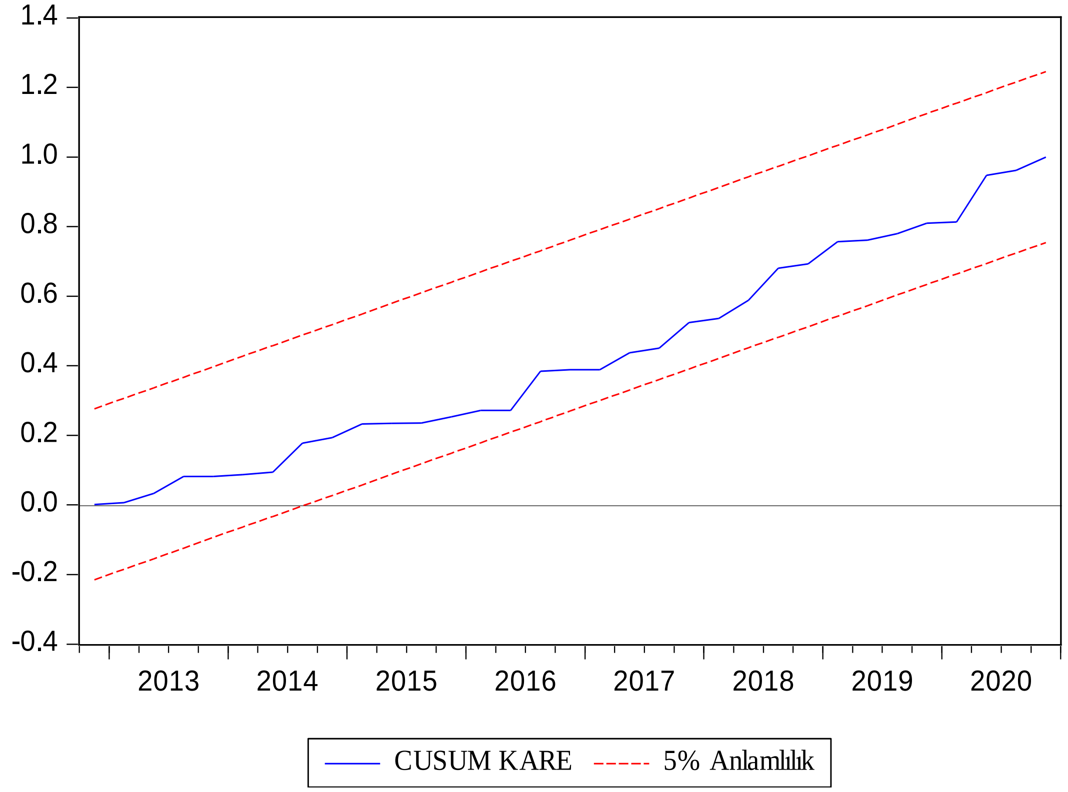


Figure 4 Cusum and Cusum Square Stability Tests



When Figure 4 is examined, it is seen that both Cusum and Cusum Square statistics are within the 5% significance band throughout all periods. In this case, it can be said that the long-term parameters calculated in the ARDL model are stable parameters at the 5% significance level. Comparisons of information criteria in order to select the optimal lags of the variables for the VAR model to be established before the Toda-Yamamoto causality analysis are as in Table 5

Table 5
VAR System Lag Length Information Criteria for Toda-Yamamoto

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-786.9958	-	38580.30	24.74987	24.91853	24.81631
1	-476.1299	563.4446	5.103538	15.81656	16.82853*	16.21523*
2	-446.6832	48.77099*	4.506165*	15.67760	17.53289	16.40849
3	-428.3899	27.43994	5.765709	15.88719	18.58579	16.95030
4	-412.5456	21.29087	8.247574	16.17330	19.71522	17.56864
5	-381.0345	37.41939	7.606934	15.96983	20.35506	17.69739
6	-345.3172	36.83341	6.610276	15.63491	20.86346	17.69470
7	-315.3431	26.22736	7.613445	15.47947	21.55133	17.87148
8	-265.8725	35.55702	5.537043	14.71477*	21.62994	17.43900

*Indicates optimal values.

When the table is examined, it is seen that 1 lag is optimal according to SC and HQ information criteria, and 2 lags according to LR and FPE criteria. It was decided that the optimal lag for the model to be established before the Toda-Yamamoto causality test is 2. Since the highest degree of integration is 1, it is solved by establishing a 3-delay VAR model. (2+1=3)
Toda-Yamamoto causality analysis statistics obtained by Wald tests after apparently unrelated regression system solution obtained from VAR model are as in table 6.

Table 6
Toda-Yamamoto Causality Test Results

Causality	Test Statistics	p	Causality
REER→ Log(NPL)	χ^2(02)=10.834***	0.004	There is
INT→ Log(NPL)	χ^2(02)=19.783***	0.000	There is
INF→ Log(NPL)	χ^2(02)=19.243***	0.001	There is
GDP→ Log(NPL)	χ^2(02)=58.521***	0.001	There is

*** Indicates the existence of a causal relationship at the 1% significance level.

When the table is examined, it is seen that the REER variable is a statistically significant cause of the Log(NPL) variable at the 1% significance level. (χ^2(02)=10.834, p<0.01). The INT variable is a statistically significant cause of the Log(NPL) variable at the 1% significance level. (χ^2(02)=19.783, p<0.01). The INF variable is a statistically significant cause of the Log(NPL) variable at the 1% significance level. (χ^2(02)=19.243, p<0.01The GDP variable is a statistically significant cause of the Log(NPL) variable at the 1% significance level. (χ^2(02)=58.521, p<0.01).

Conclusion

In the study, the relationships between CPI-based real effective exchange rate, interest rate up to one year, inflation rate and economic growth variables and the sum of non-performing loans were analyzed by ARDL analysis method for the 2003;01 quarter and 2020;04 period, and the following results were obtained.

When the long-term coefficients are examined

It is observed that the REER variable (CPI-based real effective exchange rate) has a statistically significant and negative effect on the Log (NPL) variable at the 5% significance level. (β1=-0.009, p<0.05). To put it more clearly, a 1-unit increase in the CPI-based real effective exchange rate caused a 0.9% decrease (approximately 1%) in non-performing loans.

It is observed that the INT variable (short-term interest rates) has a statistically significant and positive effect on the Log (NPL) variable at the 10% significance level. (β2=0.034, p<0.10). To put it more clearly, a 1-unit increase in short-term interest rates during the period under consideration causes an increase of 3.4% in non-performing loans.

There was no statistically significant effect of the INF variable (inflation rate) on Log (NPL). (β3=0.021, p>0.10).

It is seen that the GDP variable (economic growth) has a statistically significant and negative effect at the 5% significance level on the Log (NPL) variable. (β4=-0.031, p<0.05). To put it more clearly, it is concluded that a 1-unit increase in economic growth during the period under consideration causes a 3.1% decrease in non-performing loans.

Recommendations

In the Turkish banking sector, low-interest, long-term and state-supported loans have been channeled to the economy, especially through public banks, since December 2019. The process of transforming some of the loans related to the effect of banking errors, upward exchange rate movements and unstable interest policies into non-performing loans has accelerated. The non-performing loans, which were 23 billion TL in 2012, reached 152 billion TL in 2020. In order to reduce this increase in non-performing loans, banks need to organize their units evaluating loan applications according to a more detailed evaluation process. In addition, when the examples from the world are examined, In the solution of such bottlenecks, it is seen that the public supports the solution in different ways, sometimes by guaranteeing non-performing loans, sometimes by establishing debt management companies for non-performing loans, and sometimes acting as a shareholder. These options should also be evaluated in Turkey.

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