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Inverted U Dynamics in the Financial System: An Empirical Analysis on the Loan-to-Deposit Ratio and Interest Rates

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ABSTRACT

Purpose – This study investigates the nonlinear relationship between the Loan-to-Deposit Ratio (LDR) and various interest rates namely deposit, commercial loan, consumer loan, auto loan, and mortgage loan interest rates in the Turkish banking sector.

Design/methodology/approach – Using monthly data from June 2010 to February 2024, the analysis employs quadratic regression models inspired by the Environmental Kuznets Curve (EKC) framework, capturing the inverted U-shaped dynamic behavior of LDR over time.

Results – The results confirm that the LDR initially increases to a peak and subsequently declines, mirroring EKC patterns. Regression findings indicate that increases in interest rates significantly affect the LDR, with the consumer and deposit interest rates showing the strongest impacts. The stationarity of the regression residuals, tested via the Kapetanios, Shin, and Snell (KSS) nonlinear unit root test, supports the existence of long-term equilibrium relationships between LDR and interest rates.

Discussion – These findings provide valuable insights for financial policymakers aiming to design balanced credit and deposit strategies. In particular, it reveals that the system contains a turning point and exhibits high sensitivity to interest rates.

1. Introduction

The impact of bank-provided loans on the economy was first presented by Schumpeter (1927). Schumpeter examined the influence of the financial sector on the real economy by referring to the credit creation potential of the modern banking system (İçke, 2014).

The banking sector plays an important role in gathering idle funds not included in the economic system, accumulating savings, and creating capital accumulation. Resources collected in the system are injected into the economy through the credit mechanism, promoting investment, employment, and economic growth (Ertay, 2016). Banks' funding sources include deposits, domestic and foreign loans, bond and stock returns, funds obtained from the interbank market, funds from central bank sources, and equity capital. Among these, deposits are the most important. The cost of funding sources is the key determinant in banks' loan pricing. Generally, banks price loans based on their weighted average funding costs.

To achieve economic development, countries need sustainable sources of financing. Some countries obtain funds through monetary channels, others through capital markets. Particularly in developing countries, financial systems are largely bank-centered. Interest rates on loans issued by banks the key players in financial markets are extremely important for financing commercial activities (Depren et al., 2018). Therefore, it is critical to maintain low interest rates, especially in banking, where banks are at the center of the financial system (Tumwine et al., 2018).

However, achieving the desired low interest rates may not always be possible. Factors such as high inflation, political and economic risks, uncertainties, and a limited supply of loanable funds influence interest rates. The total amount of deposits the main funding source for banks also limits the amount of funds that can be provided as loans. One key indicator in the banking system is the ratio of total deposits to total loans, known as the Loan-to-Deposit Ratio (LDR). This ratio shows how effectively the collected funds are utilized and up to which level rational credit policies are pursued.

In addition, there is a mutual interaction between the Loan-to-Deposit Ratio (LDR) and interest rates. Some

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studies argue that an increasing LDR causes interest rates to rise (Kartal, Çetin, and Tan, 2021). The LDR tends to increase during favorable economic conditions, when market funding is abundantly available to support credit growth. In contrast, under stressful market conditions when wholesale funding replaces retail savings and credit growth slows the LDR generally stabilizes (Van den End, 2016).

A high LDR poses risks for banks by signaling aggressive lending and potential liquidity shortages, while a low LDR indicates that, despite sufficient resources, banks are not sufficiently supporting the real sector through credit expansion. Thus, when the LDR is excessively high, banks assume excessive risks, and when it is excessively low, banks' profitability falls below expected levels (Aydemir et al., 2018).

Although previous studies have largely approached the relationship between LDR and interest rates within a linear framework, the financial sector often exhibits nonlinear dynamics, particularly under changing macroeconomic conditions. This study suggests that the behavior of the LDR over time may follow a nonlinear pattern similar to the Environmental Kuznets Curve (EKC) namely, an inverted U-shaped trajectory. Initially, the LDR may rise as economic conditions improve and credit expands, but after reaching a certain point, constraints such as funding shortages and rising risks could cause the LDR to decline.

Against this background, the objective of this study is to analyze the nonlinear relationship between the Loan-to-Deposit Ratio (LDR) and various interest rates in Turkey using a quadratic (second-degree) regression model. Furthermore, to test the existence of a long-term equilibrium relationship, the Kapetanios, Shin, and Snell (KSS) nonlinear unit root test is employed, allowing for nonlinear dynamics in the adjustment process.

In this context, this paper contributes to the literature by investigating whether the LDR follows an inverted U-shaped path over time and by revealing how different types of interest rates (deposit, commercial loan, consumer loan, auto loan, and mortgage loan rates) impact the LDR. The results of this study are expected to offer important insights for financial policy makers in designing effective credit and deposit management strategies.

The remainder of the paper is organized as follows: Section 2 reviews the related literature; Section 3 describes the dataset, variables, and econometric methods; Section 4 presents the empirical findings; and Section 5 concludes with policy recommendations.

2. Literature Review

The relationship between bank lending, interest rates, and economic performance has been extensively explored in the financial literature. Overall, empirical studies have consistently emphasized the critical role of the banking sector in transmitting monetary conditions to the real economy, though the strength and direction of these effects vary across contexts and periods.

A considerable body of research has focused on the pass-through from policy interest rates to bank credit interest rates. Uğur and Bingöl (2018), analyzing the Turkish banking sector between 2002 and 2016, applied unit root tests, Toda-Yamamoto causality methods, and frequency domain causality tests. Their results showed no mutual effect between policy and auto loan interest rates according to traditional analysis, yet revealed that banking credit rates influenced policy rates in the long run through frequency domain analysis. Similarly, Uslu (2020) found that commercial loan interest rates in Turkey increased inflation in the short term and were themselves influenced by inflation and time deposit rates. His findings suggested that while the Fisher Effect held in the long run, it was not valid in the short run, and that causality primarily ran from inflation to deposit rates rather than vice versa.

In terms of the broader interaction between financial development and economic growth, Vurur and Özen (2013) found that in Turkey between 1998 and 2012, deposit growth caused increases in both economic growth and credit expansion, while economic growth also fueled loan growth. Their findings were consistent with the view that banking development facilitates real sector performance. Complementing this, İbicioğlu and Karan (2009) focused on consumer credit demand, showing that it was sensitive to interest rate fluctuations but less so to consumer confidence or stock market indicators.

The dynamics between inflation, deposit, and credit interest rates have also been extensively examined. Pazarcı, Kar, and Altıntaş (2023) demonstrated through Engle-Granger cointegration analysis that inflation had statistically significant and asymmetric effects on loan and deposit interest rates in Turkey between 2011 and 2021, with a stronger impact observed on credit rates. In a similar vein, Nugroho et al. (2022) extended this

analysis to a regional setting, finding that macroeconomic variables such as inflation significantly influenced loan and deposit rates in Indonesia, Thailand, and the Philippines over the 2012–2020 period.

Another stream of literature has concentrated on the determinants and implications of the loan-to-deposit ratio (LDR). Kartal, Çetin, and Tan (2021) provided evidence of a causality relationship between LDR and selected interest rates in Turkey from 2006 to 2019, suggesting that controlling LDR could help prevent excessive increases in interest rates. Similarly, Aydemir, Övenç, and Koyuncu (2018) found that LDR initially had a positive and linear relationship with bank profitability, but beyond a certain threshold, further increases in LDR negatively impacted profitability. Yüksel (2024) confirmed the existence of a nonlinear relationship, showing that while a rising LDR enhanced bank profitability up to a certain point, excessive LDR levels led to diminished profitability for both domestic and foreign banks.

Regional analyses further highlight the variability of these relationships. Çelikkol and Elevli (2016) analyzed the Black Sea region in Turkey from 1993 to 2014, identifying uncontrolled variability in LDR mainly driven by economic crises and political instability. Similarly, Van den End (2016), examining 11 EU countries, found that during periods of credit growth, the LDR approached its upper bounds, while deposit-driven periods brought the ratio closer to its lower bounds. He also confirmed a statistically significant interaction between loans and deposits, emphasizing the liquidity management implications of LDR fluctuations.

Bank-specific factors influencing profitability have also been analyzed. Harahap (2019) studied Indonesian banks during 2010–2016, finding that non-performing loans and operational costs negatively affected profitability, while net interest margins and LDR had positive effects. Pala (2023) examined the determinants of interest rate derivative usage among Turkish banks, finding that banks' derivative use was positively associated with higher bank capital and non-performing loan ratios, but negatively related to liquidity, with large banks exhibiting greater speculative use of derivatives compared to smaller ones.

Finally, international comparisons provide additional insights into the interplay between deposit rates, credit supply, and regulatory frameworks. Mashamba, Magweva, and Gumbo (2014) found a positive relationship between deposit interest rates and deposit mobilization in Zimbabwe between 2000 and 2006. In contrast, Adebayo and Adofu (2021), focusing on Nigeria between 1986 and 2019, showed that interest rate deregulation, while encouraging credit distribution, also induced an inverse relationship between deposit rates and lending, with higher deposit rates discouraging bank credit supply.

Taken together, the existing literature highlights the complex and dynamic interactions among interest rates, loan-to-deposit ratios, credit supply, and economic performance. These findings underscore the importance of maintaining balanced credit-deposit dynamics and stable macroeconomic conditions for achieving sustainable banking sector development.

3. Methodology

This section details the dataset and variables used in the study. The analysis period, variable definitions, and data sources are specified. Moreover, the econometric methods employed namely the KSS unit root test, cointegration analysis, and asymmetric causality test are summarized. These elements constitute the methodological foundation of the study.

3.1. Data

This study utilizes monthly data pertaining to the Turkish economy. The analysis period covers June 2010 (2010:M06) to February 2024 (2024:M02). The dataset was obtained from the monthly publications of the Banking Regulation and Supervision Agency of Turkey (BDDK) and the Central Bank of the Republic of Turkey (CBRT). While data on loans and deposits were sourced from BDDK, interest rate data including deposit interest rates, commercial loan interest rates, consumer loan interest rates, auto loan interest rates, and mortgage loan interest rates were obtained from CBRT.

The Loan-to-Deposit Ratio (LDR) is a fundamental indicator used to measure credit expansion within the financial system. The Deposit Interest Rate (dep) reflects the return earned by savers from deposit accounts. The Commercial Loan Interest Rate (com) measures the financing costs faced by businesses, while the Consumer Loan Interest Rate (con) represents the cost borne by individuals to finance consumption expenditures. The Auto Loan Interest Rate (auto) refers to the interest rate on automotive sector loans, and the Mortgage Loan Interest

Rate (mort) captures the cost of financing in the real estate sector.

The basic information regarding the variables is presented in Table 1.

Table 1. Basic Information on Variables

Variable	Definition	Unit of Measurement
ldr_t	Loan-to-Deposit Ratio	Percentage
dep_t	Deposit Interest Rate	Percentage
com_t	Commercial Loan Interest Rate	Percentage
con_t	Consumer Loan Interest Rate	Percentage
$auto_t$	Auto Loan Interest Rate	Percentage
$mort_t$	Mortgage Loan Interest Rate	Percentage

In this study, the time series graphs for the variables are presented in two separate figures.

Figure 1 illustrates the temporal evolution of the Loan-to-Deposit Ratio (LDR). As the LDR is a fundamental indicator measuring credit expansion within the financial system and possesses a different scale and dynamic structure compared to the interest rates, it is presented in a separate graph to more clearly display its behavior over time.

Figure 2 shows the time series evolution of the deposit interest rate (dep), commercial loan interest rate (com), consumer loan interest rate (con), auto loan interest rate (auto), and mortgage loan interest rate (mort). Since these interest rates share similar scales, they are presented together in the same graph. This approach provides a more convenient and coherent presentation for comparing relationships and trends among the different interest rates.

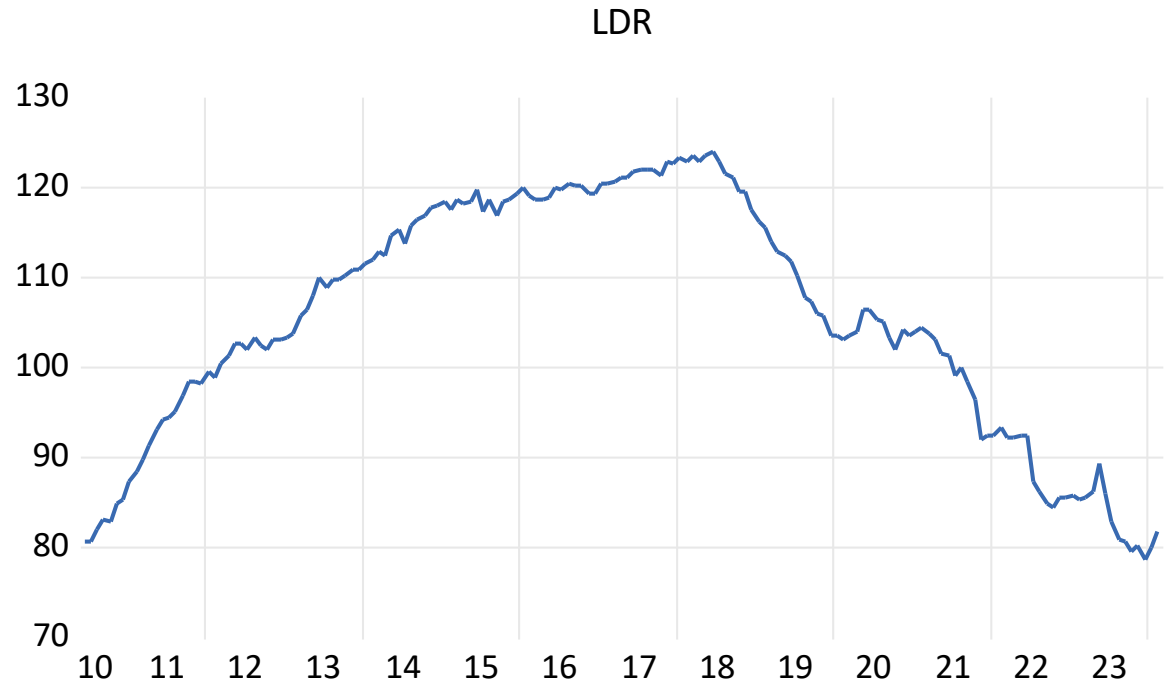

Figure 1. Time Series Graph of the Loan-to-Deposit Ratio (LDR)

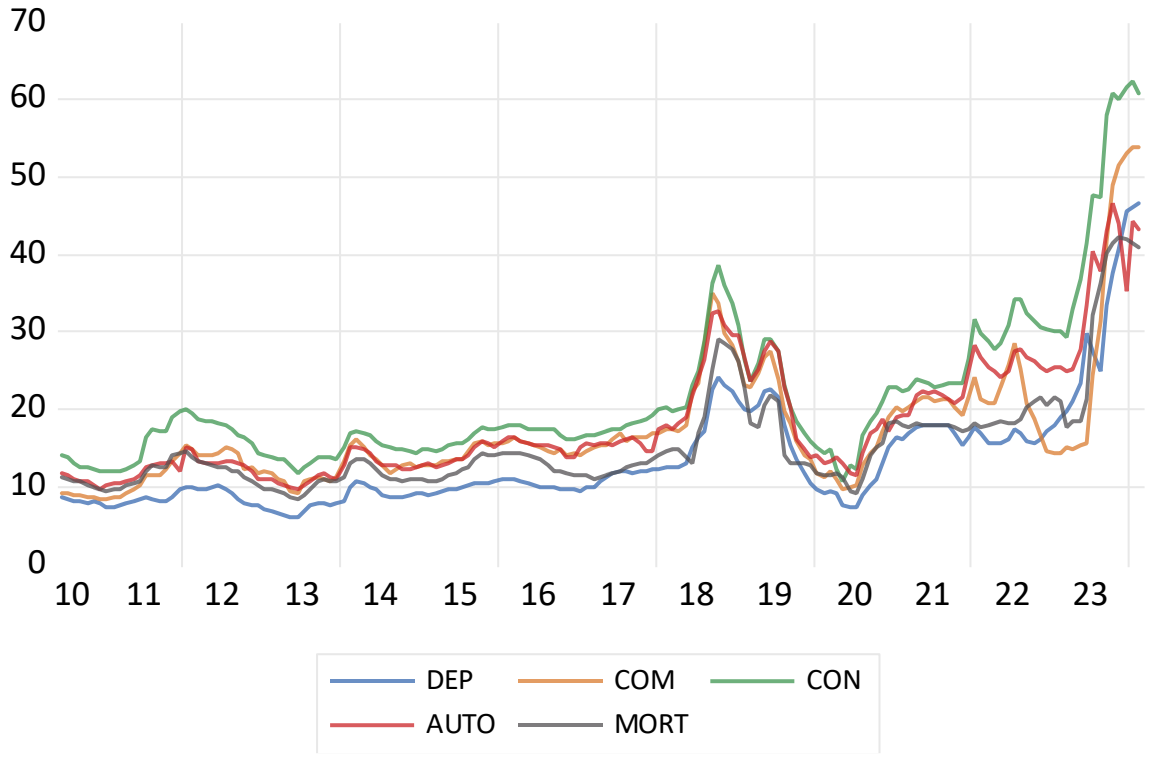

Figure 2. Time Series Graph of Interest Rates

When examining the time evolution of the Loan-to-Deposit Ratio (LDR) series, a distinct pattern of fluctuations and trends is observed. Particularly since 2010, there has been an upward trend in LDR values; however, this increase is interrupted at certain periods. After 2018, a significant downward trend in LDR values is noted. This decline can be associated with financial uncertainties in the Turkish economy, the sharp increase in exchange rates, and rising interest rates. Fluctuations in LDR reflect changes in banks' credit expansion policies and deposit mobilization strategies. Furthermore, the balance between economic growth and financial stability also appears to have a substantial impact on LDR.

When analyzing the interest rate series (deposit interest rate, commercial loan interest rate, consumer loan interest rate, auto loan interest rate, and mortgage loan interest rate), it is observed that these series follow a relatively parallel trajectory over time. Especially after 2018, a pronounced upward trend in interest rates is evident. This trend can be explained by inflationary pressures within the Turkish economy, fluctuations in exchange rates, and changes in central bank policies. Among the interest rates, the deposit interest rate tends to remain at lower levels compared to others, whereas the commercial loan and mortgage loan rates persist at higher levels. This pattern reflects the rising financing costs faced by businesses and individuals. These trends in interest rates offer valuable insights into economic policies and prevailing market conditions.

In this study, the relationship between LDR and other financial variables is investigated by drawing upon the Environmental Kuznets Curve (EKC) framework. The main rationale for this approach is that the LDR series exhibits an inverted U-shaped trajectory over time. This dynamic suggests that after a period of increase, the LDR reaches a peak point and subsequently begins to decline, resembling the relationship observed between environmental degradation and economic growth in the EKC framework.

To model the inverted U-shaped behavior of LDR, quadratic (second-degree) regression models are employed. These models explain the relationship between LDR and other variables in a nonlinear manner. Specifically, a time trend variable (t) and its square (t^2) are included to capture the phases of increase and decrease in LDR over time. This approach provides an appropriate method for explaining the observed inverted U-shaped pattern.

Additionally, to investigate the long-term relationship between LDR and other variables, cointegration analysis is conducted. This analysis tests whether a long-run equilibrium relationship exists among the variables. The stationarity of the residuals from the regression models is tested using the Kapetanios, Shin & Snell (KSS; 2003) nonlinear unit root test, which accounts for nonlinear dynamics in the data.

This modeling framework offers a suitable approach for explaining the inverted U-shaped behavior of LDR and for analyzing the relationships among financial variables in a nonlinear context. By drawing inspiration from the Environmental Kuznets Curve, this study provides an important perspective for financial policy analysis by modeling the dynamic behavior of LDR over time.

3.2. Econometric Approach

This section introduces the econometric methods employed in the study. The analysis is inspired by the Environmental Kuznets Curve (EKC) framework, which explains the relationship between environmental degradation and economic growth. According to the EKC theory, environmental degradation increases during the initial stages of economic growth but begins to decrease after surpassing a certain income threshold, resulting in an inverted U-shaped curve.

Analogously, the Loan-to-Deposit Ratio (LDR) in this study exhibits a similar inverted U-shaped pattern over time. This dynamic suggests that after a period of increase, the LDR reaches a peak and subsequently declines, resembling the structure described by the EKC framework. To model this behavior, quadratic (second-degree) regression models are employed, providing a nonlinear explanation of the relationship between LDR and other financial variables.

The model includes a linear time trend variable (t) and its square (t^2) to capture the phases of increase and decrease over time. The general form of the regression model is specified as:

$$\mathrm{LDR}_t = \beta_{0i} + \beta_{1i} t + \beta_{2i} t^2 + \beta_{3i} X_{it} + \varepsilon_{it}$$

where $i = dep_t, com_t, con_t, auto_t, mort_t$.

In this equation, the time trend (t) and its square (t^2) are used to examine the effects on the Loan-to-Deposit Ratio (LDR). In addition, the independent variables X_i — representing the deposit interest rate, commercial loan interest rate, consumer loan interest rate, auto loan interest rate, and mortgage loan interest rate — are included in the model one by one, and the individual effects of each variable on LDR are analyzed separately. The main reason for adopting this approach is the strong patterns observed among the interest rate series, as illustrated in Figure 2, and the high correlations among these variables.

Furthermore, to examine the long-term relationship between LDR and other variables, cointegration analysis is conducted. This analysis tests whether there is a long-run equilibrium relationship among the variables. Cointegration analysis is performed by testing the stationarity of the residuals obtained from the regression models. To test the stationarity of the residuals, the Kapetanios, Shin, and Snell (KSS) nonlinear unit root test is employed. This test allows for the analysis of stationarity while taking into account the nonlinear dynamics of the series.

The stationarity properties of time series data are crucial when modeling financial variables. Traditional unit root tests, such as the Augmented Dickey-Fuller (ADF) test, assume linear adjustments toward equilibrium. However, many economic and financial series exhibit nonlinear behavior, particularly in the presence of threshold effects or asymmetric adjustments.

To account for potential nonlinearity, this study applies the Kapetanios, Shin, and Snell (KSS; 2003) nonlinear unit root test. The KSS test extends the ADF framework by incorporating a nonlinear exponential smooth transition autoregressive (ESTAR) structure. It tests the null hypothesis of a unit root against the alternative hypothesis of a globally stationary ESTAR process.

The auxiliary regression used in the KSS test is specified as follows:

$$\Delta y_t = \delta y_{t-1}^3 + \sum_{j=1}^{p} \phi_j \Delta y_{t-j} + \epsilon_t \quad (1)$$

where:

- y_t is the time series under investigation,
- Δ denotes the first difference operator,
- p is the number of lagged differences included to correct for serial correlation,
- ϵ_t represents the error term.

The null hypothesis $H_0: \delta = 0$ implies the presence of a unit root (nonstationarity), while the alternative hypothesis $H_1: \delta < 0$ suggests stationarity under a nonlinear adjustment process.

Since the distribution of the KSS test statistic is non-standard, critical values are obtained through Monte Carlo simulations. Lag lengths are determined based on information criteria such as the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC).

This modeling approach provides a suitable framework for explaining the inverted U-shaped behavior of the Loan-to-Deposit Ratio (LDR) and for analyzing the relationships among financial variables in a nonlinear manner. By drawing inspiration from the Environmental Kuznets Curve, modeling the dynamic behavior of the LDR over time in a similar way offers an important perspective for financial policy analysis.

4. Findings

This section presents the results of the regression models estimated to examine the effects on the Loan-to-Deposit Ratio (LDR). In each model, the time trend variable (TTT) and its square (T2T^2T2) are included alongside different independent variables: deposit interest rate, commercial loan interest rate, consumer loan interest rate, auto loan interest rate, and mortgage loan interest rate. These models are designed to explain the inverted U-shaped behavior of LDR over time and to analyze the individual effects of each interest rate on LDR.

The table below summarizes the coefficients of each regression model, their statistical significance, and key model performance indicators (such as R2R^2R2, F-statistics, AIC, SIC, etc.). This table can be used to compare the effects of different independent variables on LDR and to evaluate the models' overall performance.

Table 2. Summary of Regression Results

Variable	Model 1 (DEP)	Model 2 (COM)	Model 3 (CON)	Model 4 (AUTO)	Model 5 (MORT)
Constant	77.4883*	78.4708*	76.0761*	76.9581*	76.9248*
t	1.0163*	0.9995*	1.0346*	1.0022*	1.0168*
t^2	-0.0067*	-0.0064*	-0.0068*	-0.0066*	-0.0066*
DEP	0.3376*	-	-	-	-
COM	-	0.2019*	-	-	-
CON	-	-	0.2593*	-	-
AUTO	-	-	-	0.3068*	-
MORT	-	-	-	-	0.2980*
R^2	0.9687	0.9641	0.9696	0.9656	0.9653
Adj. R^2	0.9682	0.9634	0.9691	0.9650	0.9646
F-Stat	1663.4520	1440.3760	1713.6620	1508.4430	1491.1910
Prob(F)	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
AIC	4.5997	4.7389	4.5709	4.6944	4.7055
SIC	4.6750	4.8142	4.6462	4.7696	4.7808
HQC	4.6303	4.7695	4.6015	4.7249	4.7360

Note: $*$ indicates statistical significance at the 1% confidence level.

The regression results presented in Table 2 show the findings from five different models estimated to examine the effects on the Loan-to-Deposit Ratio (LDR). In each model, the time trend variable (t) and its square (t^2) are included along with a different independent variable deposit interest rate, commercial loan interest rate, consumer loan interest rate, auto loan interest rate, and mortgage loan interest rate.

In all models, the coefficient of the time trend (t) is positive and statistically significant, while the coefficient of the squared trend term (t^2) is negative and statistically significant. This finding supports the hypothesis that LDR follows an inverted U-shaped curve over time. That is, after increasing during a certain period, the LDR reaches a peak point and then begins to decline. This dynamic is consistent with the structure described by the Environmental Kuznets Curve (EKC).

In terms of the independent variables, all of the interest rate variables deposit interest rate (DEP), commercial

loan interest rate (COM), consumer loan interest rate (CON), auto loan interest rate (AUTO), and mortgage loan interest rate (MORT) have positive and statistically significant coefficients. These results indicate that increases in interest rates have a positive effect on the Loan-to-Deposit Ratio (LDR). Particularly, the consumer loan interest rate (CON) and the deposit interest rate (DEP) exhibit higher coefficients compared to the other interest rates. This suggests that increases in consumer loan and deposit interest rates have a more pronounced impact on the LDR.

Regarding model performance, all models demonstrate high R^2 values (ranging between 0.964 and 0.970), indicating that the models have a strong explanatory power in capturing the variation in LDR. Moreover, the F-statistics are significant across all models ($p < 0.01$), supporting the overall statistical significance of the estimated models. In terms of model selection criteria (AIC, SIC, HQC), the model including the consumer loan interest rate (CON) has the lowest AIC and SIC values, while the model with the deposit interest rate (DEP) also exhibits similarly strong performance. These findings suggest that these two models provide a better fit compared to the others.

In conclusion, the regression findings confirm that the LDR follows an inverted U-shaped curve over time and that increases in interest rates have a significant impact on the LDR. These results offer important insights for financial policymakers and contribute valuable understanding regarding the effects of interest rate movements on the banking sector.

Figure 3. Model 1-Regression Outcomes: Residual, Actual and Fitted Values

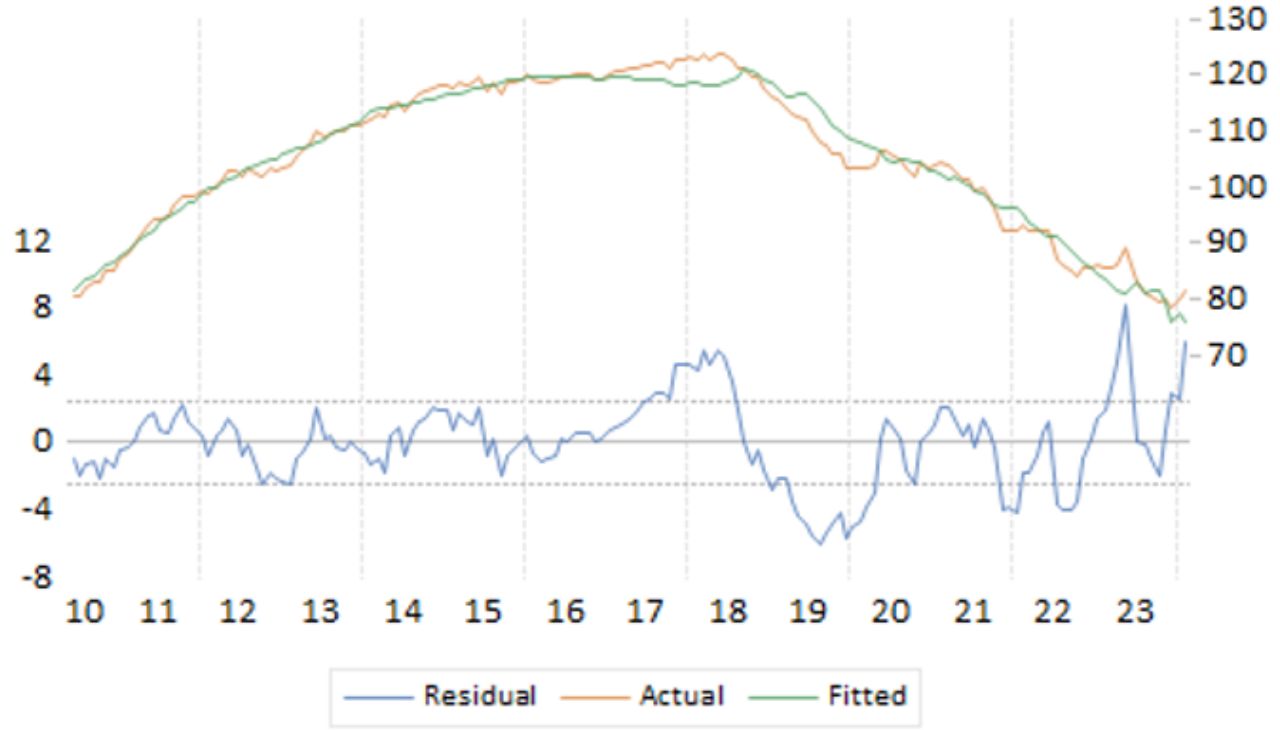

Figure 4. Model 2-Regression Outcomes: Residual, Actual and Fitted Values

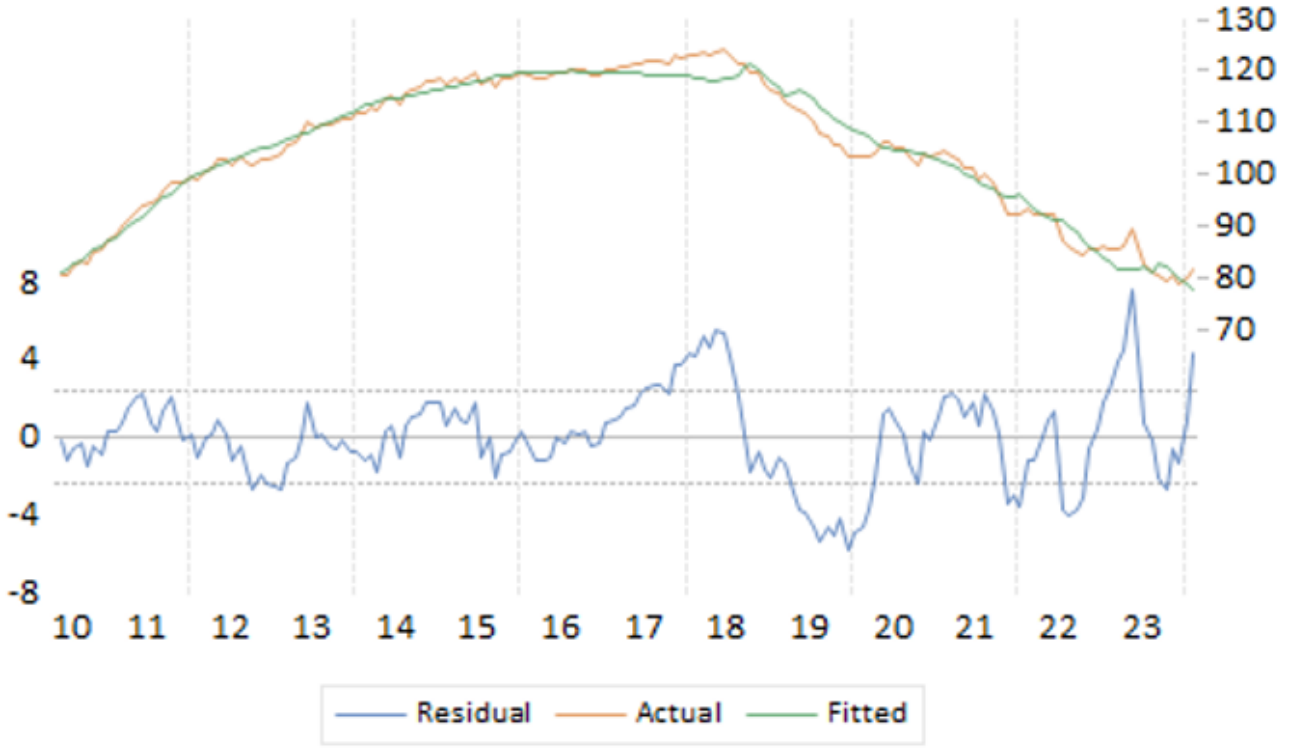

Figure 5. Model 3-Regression Outcomes: Residual, Actual and Fitted Values

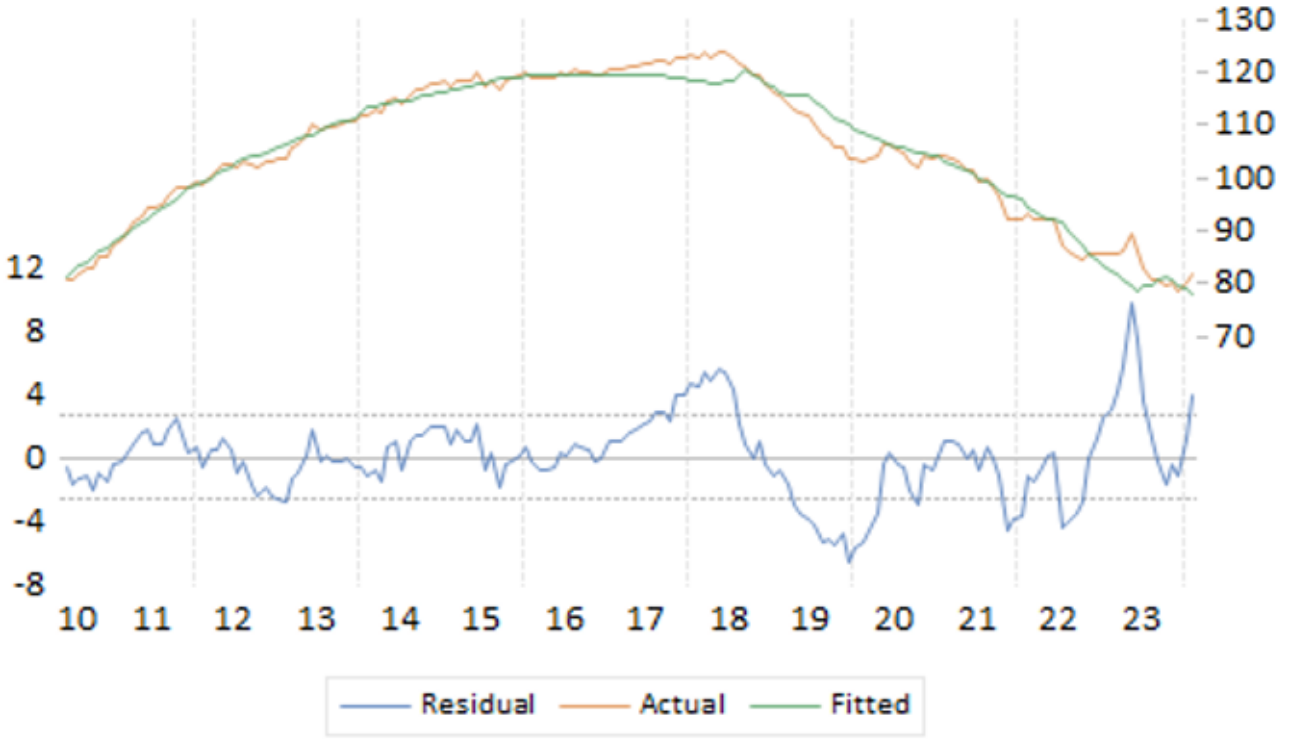

Figure 6. Model 4-Regression Outcomes: Residual, Actual and Fitted Values

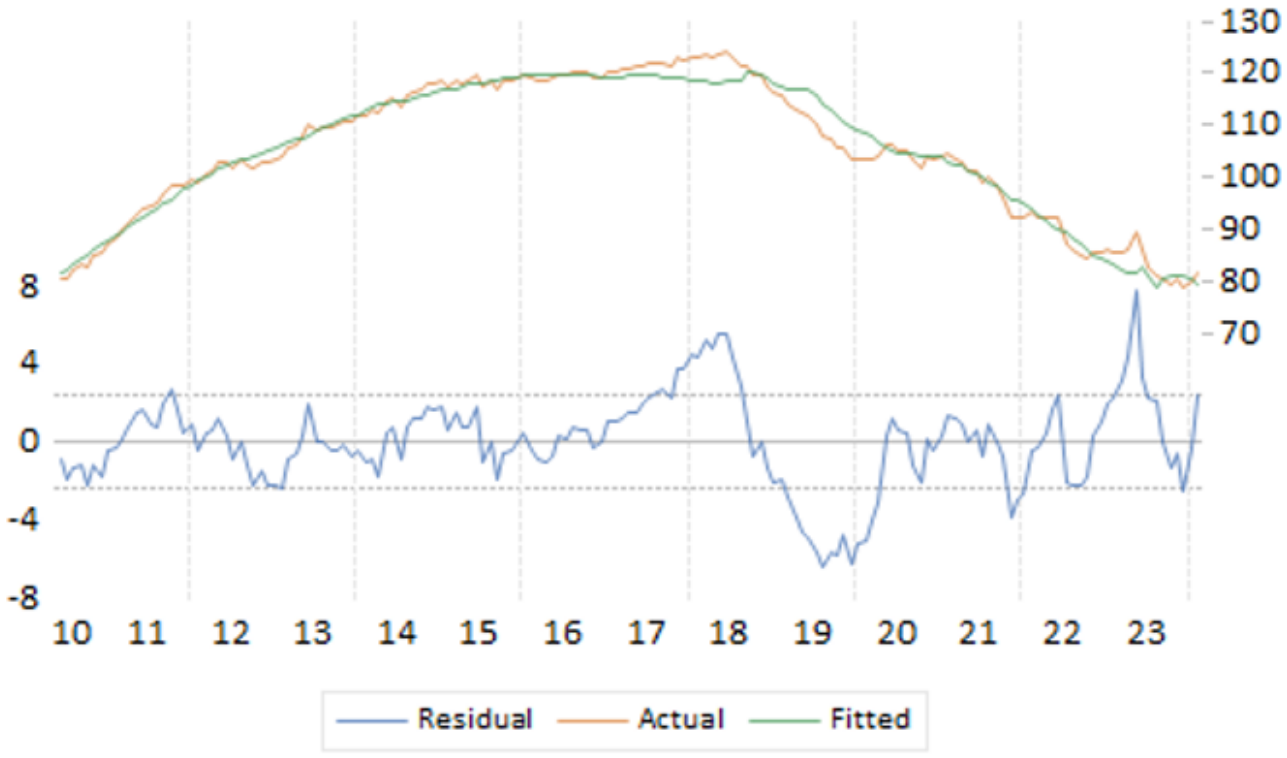

Figure 7. Model 5-Regression Outcomes: Residual, Actual and Fitted Values

The graphs displaying the relationship between the residuals obtained from the regression models, actual values, and fitted values provide visual support for the inverted U-shaped relationship between the Loan-to-Deposit Ratio (LDR) and interest rates. In the graphs, the Actual (observed values) and Fitted (predicted values) series illustrate the evolution of the LDR over time and the extent to which the model captures this pattern. The Residuals represent the differences between the actual and fitted values.

The graphs clearly show that the LDR initially increases over time, reaches a certain peak point, and then begins to decline. This dynamic resembles an inverted U-shaped curve and aligns with the structure described by the Environmental Kuznets Curve (EKC). Particularly, the close alignment between the Fitted and Actual values demonstrates that the model successfully captures the behavior of the LDR. The fact that residuals are generally symmetrically distributed around zero further indicates a good model fit. However, during certain periods, larger residuals are observed, suggesting that the model does not fully capture the actual values during those times. This is especially evident during periods of heightened economic uncertainty, such as after 2018.

Each graph is presented separately for a different interest rate (deposit interest rate, commercial loan interest rate, consumer loan interest rate, auto loan interest rate, and mortgage loan interest rate). These graphs can also be used to compare the effects of different interest rates on the LDR. Notably, in the models for the consumer loan interest rate (CON) and deposit interest rate (DEP), the Fitted values align more closely with the Actual values. This indicates that these two interest rates have a more pronounced effect on the LDR.

In conclusion, the relationship between residuals, actual values, and fitted values supports the finding that the LDR follows an inverted U-shaped curve over time, and that the regression models successfully capture this dynamic structure. These results provide significant insights into the nonlinear nature of the relationship between the LDR and interest rates.

The findings from the regression models offer valuable information for explaining the relationship between the LDR and interest rates. However, to test whether this relationship holds within a long-term equilibrium framework, the Kapetanios, Shin, and Snell (KSS) nonlinear unit root test was applied to the residuals obtained from the regression models. This test analyzes the stationarity of the series while accounting for nonlinear dynamics and assesses the existence of a long-term equilibrium relationship. The KSS test results, calculated based on the regression residuals presented in Table 2, were used to evaluate the long-term relationships among the variables.

The results of the Kapetanios, Shin, and Snell (KSS) nonlinear unit root test applied to the residuals from the regression models are presented in the table below. This test is employed to assess whether a long-term equilibrium relationship exists between the LDR and interest rates. Table 3 reports the KSS test statistics, p-values, and critical values calculated under different lag selection criteria (FIXED, AIC, SIC, GTS05, GTS10) for each model.

Table 3. Kapetanios, Shin & Snell (KSS) Nonlinear Unit Root Test Results

Variable	Criteria	KSS Statistics	p-value	Critical values (1%, 5%, 10%)
Consumer Loan Interest Rate	FIXED	-3.02	0.015	-3.150, -2.573, -2.286
	AIC	-2.583	0.071	-3.333, -2.733, -2.441
	SIC	-2.858	0.031	-3.233, -2.677, -2.408
	GTS05	-3.164	0.018	-3.366, -2.808, -2.530
	GTS10	-3.164	0.017	-3.339, -2.780, -2.499
Mortgage Loan Interest Rate	FIXED	-3.254	0.007	-3.150, -2.573, -2.286
	AIC	-3.944	0.001	-3.333, -2.733, -2.441
	SIC	-3.212	0.011	-3.233, -2.677, -2.408
	GTS05	-3.38	0.01	-3.366, -2.808, -2.530
	GTS10	-3.38	0.009	-3.339, -2.780, -2.499
Deposit Interest Rate	FIXED	-2.965	0.017	-3.150, -2.573, -2.286
	AIC	-2.935	0.03	-3.333, -2.733, -2.441
	SIC	-2.935	0.025	-3.233, -2.677, -2.408
	GTS05	-3.342	0.011	-3.366, -2.808, -2.530

	GTS10	-3.342	0.01	-3.339, -2.780, -2.499
Auto Loan Interest Rate	FIXED	-3.797	0.001	-3.150, -2.573, -2.286
	AIC	-4.092	0.001	-3.333, -2.733, -2.441
	SIC	-2.972	0.022	-3.233, -2.677, -2.408
	GTS05	-4.092	0.001	-3.366, -2.808, -2.530
	GTS10	-4.092	0.001	-3.339, -2.780, -2.499
Commercial Loan Interest Rate	FIXED	-3.268	0.007	-3.150, -2.573, -2.286
	AIC	-3.544	0.005	-3.333, -2.733, -2.441
	SIC	-2.79	0.037	-3.233, -2.677, -2.408
	GTS05	-3.343	0.011	-3.366, -2.808, -2.530
	GTS10	-3.343	0.01	-3.339, -2.780, -2.499

The KSS test results presented in Table 3 include the KSS test statistics, p-values, and critical values calculated under different lag selection criteria (FIXED, AIC, SIC, GTS05, GTS10) for each model's independent variable (IHT: Consumer Loan Interest Rate, KON: Mortgage Loan Interest Rate, MEV: Deposit Interest Rate, TAS: Auto Loan Interest Rate, TIC: Commercial Loan Interest Rate). The KSS test statistics are compared against critical values at the 1%, 5%, and 10% significance levels to assess the stationarity of the residuals. When the test statistics are smaller than the critical values and the p-values are low, it indicates that the residuals are stationary and that a long-term equilibrium relationship exists between the LDR and the respective interest rates. These findings suggest that the variables move together over time within a stable long-term relationship and that the regression models successfully capture this dynamic.

5. Discussion and Conclusion

This study examined the relationship between the Loan-to-Deposit Ratio (LDR) and various interest rates (deposit interest rate, commercial loan interest rate, consumer loan interest rate, auto loan interest rate, and mortgage loan interest rate) using nonlinear time series analysis. The results indicate that the LDR follows an inverted U-shaped curve over time, initially increasing to a peak point before subsequently declining. This dynamic structure mirrors the Environmental Kuznets Curve (EKC) and helps explain the relationship between credit expansion within the financial system and deposit mobilization strategies.

The findings from the regression models reveal that increases in interest rates significantly affect the LDR, with consumer loan interest rates and deposit interest rates exerting a particularly strong influence. Furthermore, the results of the Kapetanios, Shin, and Snell (KSS) nonlinear unit root test support the stationarity of the residuals, confirming the existence of a long-term equilibrium relationship between the LDR and the interest rates.

These findings offer important implications for financial policymakers. Firstly, it is evident that changes in interest rates have significant effects on the banking sector. In particular, the stronger impact of consumer loan interest rates on the LDR suggests that policies targeting consumer credit should be carefully considered. Additionally, the positive effect of deposit interest rates on the LDR implies that policies encouraging savings could support banks' credit expansion. Therefore, central banks and other financial regulatory institutions should manage credit and deposit policies in a balanced manner, taking into account the effects of interest rate fluctuations on the banking sector.

For future research, the findings of this study could be extended and tested across different countries and time periods. Moreover, investigating the relationship between the LDR and other macroeconomic variables (such as inflation, exchange rates, and economic growth) would further enhance understanding of financial system dynamics. Such studies would provide valuable contributions for developing more effective recommendations for policymakers.

In addition to the direct policy implications, the findings emphasize the importance of adopting a dynamic and forward-looking regulatory approach in managing financial sector risks. Since the Loan-to-Deposit Ratio (LDR) exhibits nonlinear behavior over time, static or purely linear policy measures may not sufficiently address emerging vulnerabilities or growth opportunities. Policymakers should integrate early warning indicators and flexible regulatory tools that recognize threshold effects in LDR dynamics, allowing for timely intervention during phases of rapid credit expansion or contraction. In particular, a macroprudential regulatory framework

that employs countercyclical instruments such as dynamic provisioning and capital buffers could significantly enhance financial system resilience. Aligning monetary policy adjustments with sector-specific prudential measures would ensure that credit supply to the real economy is maintained without exacerbating systemic risks. These considerations are particularly critical for emerging economies like Turkey, where fluctuations in interest rates and credit activity can intensify the transmission of macroeconomic shocks. Thus, a holistic and nonlinear-aware regulatory strategy would contribute to both financial stability and sustainable economic growth.

In conclusion, by revealing the nonlinear nature of the relationship between the LDR and interest rates, this study offers a new perspective for financial policy analysis and highlights the importance of flexible and dynamic regulatory approaches for sustaining economic and financial system resilience.

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