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ASYMMETRIC AND STRUCTURAL EFFECTS OF EXCHANGE RATE, INFLATION AND FUNDING COSTS ON CBRT RESERVES

TCMB Rezervleri Üzerinde Döviz Kuru, Enflasyon ve Fonlama Maliyetlerinin Asimetrik ve Yapısal Etkileri

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ABSTRACT

The reserves of the Central Bank of the Republic of Turkey (CBRT) showed a marked downward trend between 2013 and 2020 due to economic, political, and global developments. In particular, reserves fell to historic lows in 2020, but showed signs of partial recovery in the following periods. These developments attracted the attention of both the public and academic circles, and debates over reserves intensified. In this study, using monthly data for the period January 2015–May 2025, the asymmetric effects of the producer price index, weighted average funding cost, and exchange rate on CBRT reserves were examined. The stationarity levels of the variables were tested using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, as well as Zivot-Andrews unit root tests while accounting for structural breaks. After ensuring stationarity conditions, the NARDL cointegration method was applied to identify asymmetric long-term relationships. The findings indicate that the macroeconomic variables examined have statistically significant and asymmetric effects on CBRT reserves in both the short and long term. It was found that positive and negative shocks have different effects on reserves in the short term, while in the long term, increases in the exchange rate and inflation reduce reserves, whereas decreases increase them. Furthermore, while increases in funding costs have a negative and statistically significant effect on reserves, decreases in funding costs do not have a statistically significant effect. Overall, the results suggest that CBRT reserves are shaped not only by responses to short-term shocks but also by long-term structural factors.

Keywords: Central Bank Reserves, Exchange Rate, Structural Break, NARDL Bound Test.

ÖZ

Türkiye Cumhuriyet Merkez Bankası (TCMB) rezervleri, 2013-2020 döneminde ekonomik, siyasi ve küresel gelişmelerin etkisiyle belirgin bir azalma eğilimi göstermiştir. Özellikle 2020 yılında rezervler tarihi dip seviyelere inmiş, ancak takip eden dönemlerde kısmi bir toparlanma eğilimine girmiştir. Bu gelişmeler hem kamuoyunun hem de akademik çevrelerin dikkatini çekmiş ve rezervler üzerinde tartışmalar yoğunlaşmıştır. Bu çalışmada, 2015 Ocak–2025 Mayıs dönemine ait aylık veriler kullanılarak, üretici fiyat endeksi, ağırlıklı ortalama fonlama maliyeti ve döviz kurunun, TCMB rezervleri üzerindeki asimetrik etkileri incelenmiştir. Analizde değişkenlerin durağanlık düzeyleri Augmented Dickey-Fuller (ADF) ve Phillips-Perron (PP) birim kök testleri ve yapısal kırılmalar dikkate alınarak Zivot-Andrews birim kök testleri kullanılarak sınamıştır. Durağanlık koşullarının sağlanmasının ardından, asimetrik uzun dönem ilişkileri tespit etmek amacıyla NARDL eşbütünleşme yöntemi uygulanmıştır. Elde edilen bulgular, incelenen makroekonomik değişkenlerin TCMB rezervleri üzerinde hem kısa hem de uzun vadede istatistiksel olarak anlamlı ve asimetrik etkiler yarattığını göstermektedir. Kısa dönemde pozitif ve negatif şokların rezervleri üzerinde farklı yönlü etkiler oluşturduğu belirlenirken; uzun dönem döviz kuru ve enflasyondaki artışların rezerv düzeyinde azalmaya yol açtığı, azalışların ise rezervleri artırdığı saptanmıştır. Ayrıca, fonlama maliyetindeki artışların rezervler üzerinde negatif ve istatistiksel anlamlı bir etkisi bulunmakla birlikte, fonlama maliyetindeki azalışların rezervlere etkisi istatistiksel açıdan anlamlı çıkmamıştır. Elde edilen bulgular, rezervlerin sürdürülebilirliğinin yalnızca kısa vadeli şoklara verilen tepkilerle değil aynı zamanda uzun vadeli yapısal faktörlerle de şekillendiğini ortaya koymaktadır.

Anahtar Kelimeler: Merkez Bankası Rezervleri, Döviz Kuru, Yapısal Kırılmalar, NARDL Sınır Testi

INTRODUCTION

International reserves are assets held by countries' monetary authorities that can be liquidated quickly, easily converted into other currencies, and are globally accepted (CBRT, 2011). In other words, they are an important source for maintaining exchange rate stability and financing the external trade balance (Johnson and Fung, 2014). These resources consist of convertible foreign exchange assets, international standard gold, special drawing rights and International Monetary Fund (IMF) reserve positions (CBRT, 2011). The primary reason for central banks to hold reserves is to meet the country's foreign exchange needs. However, in addition to this purpose, the other factors presented in Figure 1 are also among the main reasons for holding reserves.

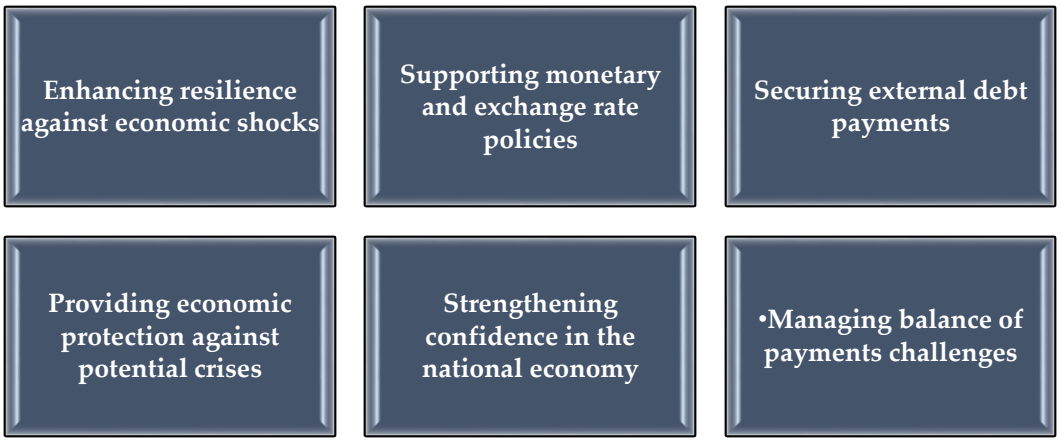


Figure 1. Why Countries Accumulate International Reserves

Source: CBRT, 2022**.**

Periods when macroeconomic indicators are stable and financial volatility is low in the global economic environment are defined as “normal times” when central bank reserves are not widely discussed in public. However, when this balance is disrupted and uncertainty increases, especially on a global scale, the level and adequacy of reserves become a topic of debate once again (Kılcı, 2021). This has transformed reserves from a mere technical instrument into a key element of economic confidence and crisis management. The appropriate level of reserves that central banks should maintain is discussed in the literature from different perspectives. For

instance, the International Monetary Fund (IMF) has suggested that, for countries with closed capital accounts, reserves should be sufficient to cover at least three months of imports. The Guidotti-Greenspan rule, on the other hand, argues that reserves should be maintained at a level that fully covers countries' short-term external debt (Aydoğuş and Öztürkler, 2006). On the other hand, the cost-benefit-based model developed by Jeanne and Rancière (2006) emphasizes that the amount of reserves that central banks should hold should be determined by balancing the opportunity cost of reserves with the benefits they provide against sudden shocks that may occur in the economy. In this model, the level of reserves that central banks should hold is formulated as follows:

$$\max_{\{R\}} U = B(R) - C(R)$$

In the formula above, R represents the amount of reserves held; B(R) represents the benefits provided by reserves (e.g., providing liquidity in times of crisis, increasing market confidence); and C(R) represents the opportunity cost of reserves. In the model, the benefit level is treated as having diminishing marginal returns, while costs are treated as having increasing marginal costs. In this case, the optimal reserve amount R* is determined by the equation B ′(R*) = C ′(R*) (Jeanne and Rancière, 2011). The “Reserve Adequacy Assessment (ARA)” metric, developed by the IMF and considered a more comprehensive method, takes into account countries' dollarization levels, capital mobility, and export and import structures, and recommends that reserve levels vary between 100% and 150% depending on the country's risk profile (Arslan and Cantu, 2019; Cinel and Yamak, 2014). Another important aspect of reserve measurement is that, when assessing a country's reserve adequacy against its external liabilities, not only official reserve assets but also the foreign currency assets of the banking sector and real sector firms should be taken into account. This approach allows for a more accurate analysis of an economy's total external vulnerabilities (CBRT, 2019).

According to IMF's COFER data, approximately 71% of central banks' global foreign exchange reserves were held in US dollars in 2001, whereas this ratio declined to 58.9% as of 2024. Despite this decrease, the US dollar largely retains its dominance as the global reserve currency. The process of the dollar becoming the international reserve currency accelerated after World War II and became even more pronounced especially from the 1980s onward with the widespread adoption of neoliberal economic policies globally (Daldal, 2006). Today, the dollar not only holds the largest share of central banks' foreign exchange reserves but also remains the most actively traded currency in global foreign exchange markets (Yaman et al.,, 2003). The dollar's central role has directly influenced central banks' reserve holding behavior. These global trends also directly affect reserve strategies in developing countries. Turkey provides a notable example in this context. While countries pursue different reserve strategies in response to global fluctuations, these strategies have come to the fore in Turkey in recent years. Discussions about reserves in Turkey have particularly increased after 2020 and deepened alongside economic and political developments. The sanctions imposed during the Pastor Brunson crisis (Ünlü and Yıldız, 2021), the global economic effects of the COVID-19 pandemic beginning in 2020 (Kılınç, 2022), the low-interest rate policy applied during the 2021–June 2023 period, and rising geopolitical risks have increased the pressure on the Central Bank of the Republic of Turkey's reserve management and made the level and quality of reserves one of the foremost issues in the public agenda.

The factors causing fluctuations in CBRT reserves and the macroeconomic problems arising from declining reserves are a complex reflection of a multidimensional process. In this study, monthly data from (January) 2015 and (May) 2025 will be used to analyze the relationship between the Turkish Central Bank's (CBRT) official reserve assets and the exchange rate, inflation, and funding costs from a macroeconomic perspective. The main hypotheses of the study are as follows:

H_{01}: The depreciation of the domestic currency has no statistically significant long-term impact on the Central Bank's reserve assets.

H_{11}: The depreciation of the domestic currency leads to a statistically significant increase in the Central Bank's reserve assets in the long run.

H_{02}: Rising inflation does not exert a statistically significant long-term effect on the Central Bank's reserves.

H_{12}: Rising inflation causes a statistically significant decline in the Central Bank's reserves over the long term.

H_{03}: An increase in the policy interest rate has no statistically significant long-term impact on the reserve assets of the Central Bank.

H_{13}: An increase in the policy interest rate results in a statistically significant decrease in the Central Bank's reserve assets in the long run.

This study consists of six sections. The second section presents an overview of the CBRT's reserve policies; the third section provides an empirical literature review; the fourth section explains the data set and methods in detail; the fifth section presents the findings obtained from the analysis; and the sixth section discusses and evaluates the findings.

CBRT RESERVE MANAGEMENT

The phrase "to manage the country's gold and foreign exchange reserves" in Article 4 of Law No. 1211 on the CBRT forms the legal basis for the CBRT 's management of foreign exchange reserves. In the reports it shares with the public on reserve management, the CBRT explains the factors that shape the policies to be followed in reserve management as follows: the monetary and exchange rate regime applied, the CBRT's assets and liabilities, the Treasury's borrowing policies, foreign currency debt repayments to be made on behalf of the Treasury, and internal and external economic conditions. These reports also emphasize the importance of transparency and accountability in reserve management, noting that data is shared with

international organizations and accounting records are prepared in accordance with international standards (CBRT, 2018).

In 2001, the exchange rate system in the Turkish economy changed, and a transition was made from a fixed exchange rate system to a flexible exchange rate system. This situation enabled structural changes in the CBRT's reserve management, and the bank began to perform its sterilization function in cases of volatility in the foreign exchange market under this system. In addition, the flexible exchange rate system provided flexibility in terms of liquidity and maturity in the policies pursued by the CBRT compared to the fixed exchange rate system. Following the financial crisis in 2008, the CBRT began implementing the "Reserve Option Mechanism" to prevent an increase in the liquidity gap. Through this method, the CBRT has enabled banks to hold Turkish lira deposits required under the reserve requirement framework in foreign currency and standard gold (CBRT, 2018).

The CBRT's reports on international reserves and FX liquidity developments summarize the policies and developments for the 2014-2024 period below;

Table 1. Summary of CBRT Reserve Management Policies and Development between 2014-2025

2014	2015	2017	2018
Foreign exchange sales were conducted to support exchange rate stability.	While the effects of the global crisis persisted, the CBRT maintained a conservative reserve management strategy.	External debt payments and foreign exchange sales to public institutions led to a decline in reserves, which was offset by rediscount credits.	TL swap transactions against FX were initiated, but their utilization remained limited due to low interest rates.
2019	2020	2021	2022
Liquidity support was provided by increasing swap limits following the depreciation in TL	During the pandemic, reserves were supported by swaps, foreign exchange sales and rediscount credits, and the share of gold increased	In order to stabilize the foreign exchange market and limit exchange rate volatility, the CBRT sold a total of USD 7.3 billion worth of foreign exchange.	Due to high geopolitical risks and global inflation, reserve resources were diversified within the scope of the Monetization Strategy, and currency-protected deposits (FX-protected deposits) and FX-convertible products were integrated into the system.

2023	2024	2025&06
With the monetary tightening, reserves rose to USD 141.1 billion, with gold accounting for 34.2%.	Amid global interest rate cut expectations, local elections and geopolitical developments, CBRT prioritized safety, liquidity and return in reserve management. While reserves rose to USD 155.1 billion, the share of gold reserves was 41.5%. Moreover, the capacity to cover pre-determined and contingent liabilities had weakened in the March 2024 period, but the balance was largely restored by May 2024.	In order to stabilize the foreign exchange market and limit exchange rate volatility, the CBRT sold a total of USD 1.1 billion worth of foreign exchange

Source: CBRT, 2014-2025.

In the last decade, rising geopolitical risks and global crises have led to a structural transformation in the composition of the CBRT international reserves. In response to these risks, the CBRT has increased its gold reserves with the aim of reducing its dependence on foreign exchange reserves. During periods of heightened exchange rate volatility, the Bank sought to alleviate pressure on foreign exchange demand through various instruments, including swap agreements, FX sales, and the FX-protected deposit scheme (KKM). Between 2021 and June 2023, policy interest rates were kept at low levels, resulting in relatively low funding costs. While this weakened the effectiveness of monetary policy, it simultaneously contributed to increased demand for foreign currency. The CBRT's strategy of increasing gold reserves as a substitute for the U.S. dollar in its reserve composition appears to serve as an economic shield against potential future risks. However, the implementation of this prudent policy was undermined by policy inconsistencies regarding funding costs, thereby creating the impression of a lack of coordination in the policy framework. Following the shift in economic management after June 2023, there was a transition toward rational policy practices, accompanied by a notable increase in funding costs. This development helped suppress both domestic and foreign exchange demand through the credit interest rate channel, enabling a relatively more stable outlook in terms of reserve management.

Chart 1. summarizes the change in the CBRT's official reserve assets from 2009 to March 2025. The graph shows that FX assets reached their highest level in 2013 and have been on a downward trend since then, albeit fluctuating over time. Especially in 2020, the lowest level of

FX assets triggered a significant transformation in the composition of central bank reserves after 2021, with gold reserves steadily increasing and becoming an important component. A similar trend is observed in other central banks at the global level. Indeed, as of May 2025, countries such as Kazakhstan, Turkey and Poland have significantly increased their gold purchases. According to the World Gold Council's Gold Reserves of Central Banks Survey for 2025, 95% of central banks expect their gold reserves to increase in the coming period, while 43% expect to increase the share of gold in their reserves. In addition, a structural shift is expected to take place in reserve portfolios, with an increase in the weight of gold and a decrease in the share of the dollar. All these developments reveal that the CBRT and other central banks continue to embrace gold as a strategically important and secure reserve asset (www.gold.org, 2025).

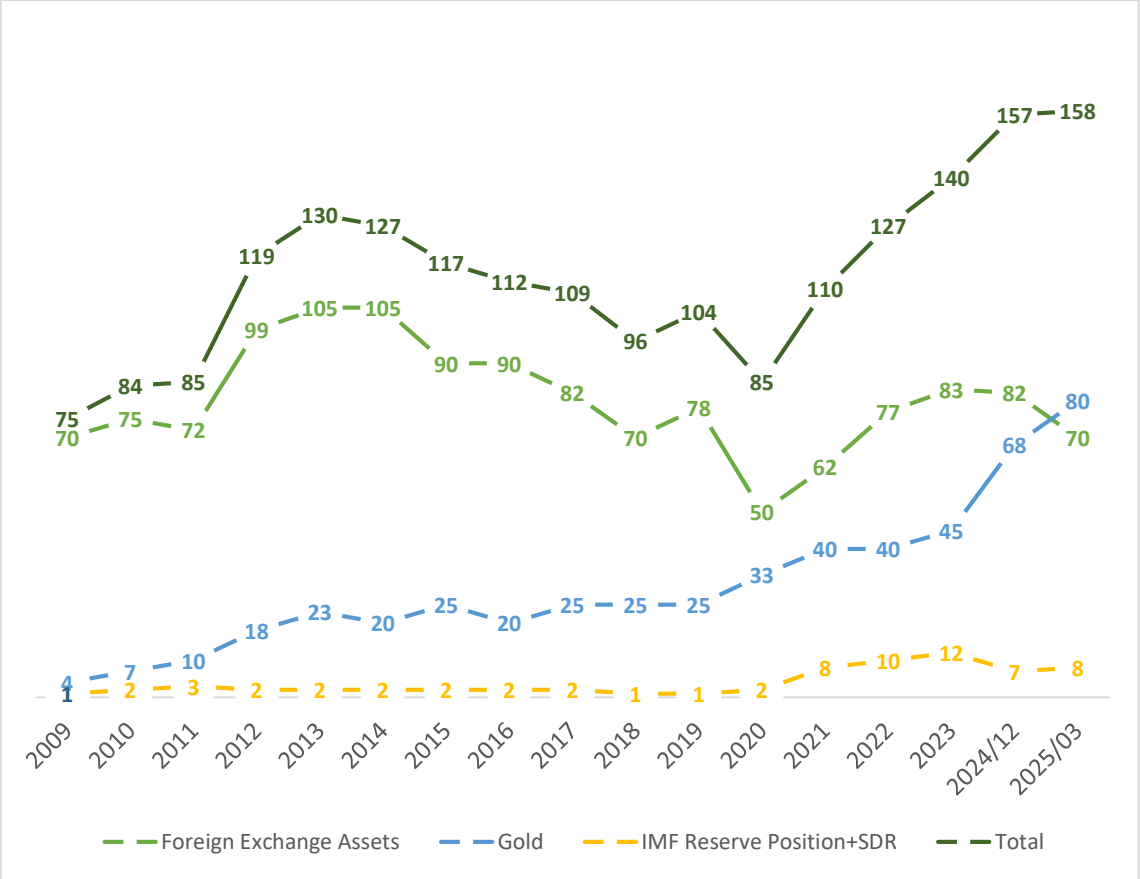


Chart 1. Trends in CBRT Official Reserves in the 2009-2025/03 Period

Source: CBRT, 2025

EMPIRICAL LITERATURE REVIEW

Foreign exchange reserves are one of the fundamental economic indicators that enhance countries' resilience to external economic shocks, strengthen the effectiveness of monetary policy, and support financial stability. Therefore, identifying the factors affecting foreign exchange reserves is of great importance for economic policymakers. In the literature, the relationship between central bank reserves and the exchange rate has been examined using various empirical methods for different country examples and periods; these studies show that foreign exchange reserves are affected by both internal and external economic variables. In this context, the relationship between foreign exchange reserves and the exchange rate and other macroeconomic indicators is summarized in the literature review below.

Kim et al. (2000) examined the relationship between international reserves and exchange rates for the Reserve Bank of Australia between 1983 and 1997 using time series methods and found that changes in exchange rates caused fluctuations in central bank reserves. Cinel and Yamak (2014) examined the factors affecting foreign exchange reserves in Turkey for the period 2000-2013 using time series methods and found that the exchange rate, money supply, and short-term debt stock had a positive effect on reserves. Memiş et al. (2014) analyzed the macroeconomic factors affecting the foreign exchange reserves of the Central Bank of the Republic of Turkey (CBRT) for the period 1989-2013 and determined that there is a causal relationship between total reserves and the exchange rate and GDP in both the short and long term. Bayat et al. (2014) analyzed the asymmetric relationship between the nominal and real exchange rates and the CBRT's foreign exchange reserves in Turkey for the period 2003-2014 using a nonlinear Granger causality test. According to the research findings, while foreign exchange reserves have no significant effect on exchange rates, they identified a one-way causality relationship from exchange rates to reserves. Daude et al. (2016) analyzed 18 developing countries using panel data methods for the period 2003-2011 and found that changes

in exchange rate levels have a decisive effect on central bank reserves. Pina (2017) examined the effect of global interest rates on national reserves using panel data in a study covering 75 countries between 2000 and 2013 and found that increases in interest rates play a decisive role in reserve transfers. Yüksel and Özsarı (2017) analyzed the factors affecting the CBRT's foreign exchange reserves between 1988 and 2015 using the MARS method and found that the current account deficit and the US dollar interest rate had a negative impact on foreign exchange reserves when they exceeded a certain threshold value. Acci (2018) examined the relationship between the Turkish Central Bank's nominal exchange rate and gross foreign exchange reserves for the period 2005-2018 using the Bootstrap Rolling Window Causality test. The study found that positive exchange rate shocks lead to an increase in reserves, while increases in reserves lead to a decline in the exchange rate, indicating a bidirectional causality relationship between these variables. Kalu et al. (2019) analyzed the relationship between the Central Bank of Nigeria's foreign exchange reserves and the exchange rate using the ARDL method for the period 1996-2016 and found that the nominal exchange rate had no effect on reserves, but there was a positive relationship between the real exchange rate and reserves.

Cengiz (2024) examined the relationship between foreign exchange reserves, exchange rates, and current account deficits in Turkey between 2000 and 2019 using time series methods and found that changes in exchange rates had a causal effect on reserves. Jena and Sethi (2021) analyzed the determinants of foreign exchange reserves in Brazil between 1960 and 2018 using the ARDL method and found long-term and significant relationships between foreign exchange reserves and the current account balance, debt level, private sector loans, exchange rate, inflation, per capita GDP, and real interest rate. Akdoğan (2020) examined the relationship between central bank reserves and the exchange rate in developed and developing countries between 2008 and 2017 using panel data methods and found that changes in the exchange rate level had a strong impact on reserves. Öztürk and Özkul (2021) analyzed the relationship

between central bank reserves and exchange rates in Turkey between January 2002 and June 2021 using time series methods and found a two-way causal relationship between exchange rate volatility and central bank net reserves, and a one-way causal relationship from central bank gross reserves to the exchange rate. Gereziher et al. (2021) conducted a study on Ethiopia for the period 1981-2017 and determined that inflation and the exchange rate had a negative effect on reserves in the short term, while inflation and external debt had a positive effect on reserves in the long term. Viorica and Tatiana (2022) identified a long-term relationship between the exchange rate and foreign exchange reserves in their analysis of Moldova for the period 2015-2021. Bayat and Çolak (2024) examined the effect of international reserves on the nominal exchange rate in Turkey between January 2006 and April 2024 using the ARDL method and found that the nominal exchange rate had a negative effect on international reserves. Gilal and Ismail (2025) analyzed the effect of macroeconomic indicators on central bank reserves in BRIC countries for the period 2003-2023 using the ARDL method and found that uncertainty in economic policies, GDP growth, and trade openness reduce reserves, while direct foreign investment and currency depreciation increase reserves.

To summarize the studies in the literature; Kim et al. (2000), Daude et al. (2016), Cinel and Yamak (2014), Memiş et al. (2014), Jena and Sethi (2021), Acci (2018), Öztürk and Özkul (2021), and Gilal and Ismail (2025) indicate that reserve increases have a positive effect on the exchange rate, while Bayat and Çolak (2024) and Yüksel and Özsarı (2017) identify a negative relationship. Furthermore, the direction of the relationship varies depending on the conditions; Bayat et al. (2014) found no statistically significant causality from reserves to the exchange rate, while Acci (2018) found that reserve increases lower the exchange rate and positive shocks in the exchange rate increase reserves, Öztürk and Özkul (2021) found bidirectional causality, and Yüksel and Özsarı (2017) emphasized a negative effect after a certain threshold.

DATA SET and METHOD

This study aims to examine the effects of selected macroeconomic indicators on CBRT reserves using monthly data from January 2015 to May 2025 in Turkey. In this context, the dependent variable is the CBRT's official reserve assets, while the independent variables are the nominal US dollar exchange rate, the domestic producer price index, and the weighted average funding cost. Table 2 presents the data set and sources used in the study.

Table 2. Data Set and Sources

Variables	Description	Period	Source
RES	CBRT Official Reserve Assets	2015M(1)-2025(M(5) (Monthly)	CBRT
FC	Weighted Average Funding Cost	2015M(1)-2025(M(5) (Monthly)	CBRT
ER	Nominal USD Exchange Rate	2015M(1)-2025(M(5) (Monthly)	CBRT
INF	Domestic Producer Price Index	2015M(1)-2025(M(5) (Monthly)	CBRT

Descriptive statistics for the pretests conducted to assess the consistency and accuracy of the model are presented in Table 3.

Table 3. Descriptive Statistics of Variables

Variables	Mean	S.Deviation	Max	Min	Skewness	Kurtosis	Observation
RES	11.624	0.159	12.020	11.290	0.316	2.919	125
FC	18.940	13.469	52.790	7.6200	1.450	3.746	125
ER	11.940	10.978	38.760	2.330	1.136	2.845	125
INF	6.563	0.969	8.3500	5.470	0.591	1.816	125

Chart 2 shows the trend changes of the variables included in the study for the 2015-2025 period. In this framework, CBRT reserves are at their lowest level in 2018 and 2020, with an unstable upward trend after 2020. Funding costs (FC), which were at their lowest level in 2020, have a sharp upward trend in the second period of 2023. Inflation (INF) and exchange rate (ER) variables generally exhibit an upward trend in the 2015-2025 period.

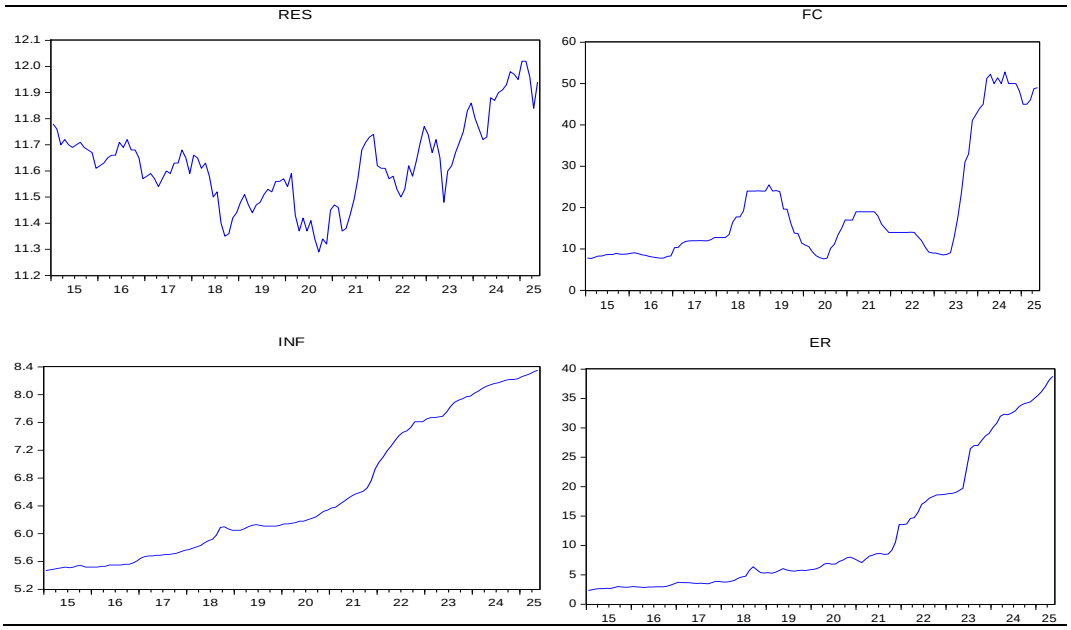


Chart 2. Trend of Variables in the Period 2015-2025

FINDINGS

In the empirical findings section of the study: first, the correlation structure of the RES, FC, and ER INF variables will be examined; then, Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Zivot-Andrews structural break unit root tests will be performed to determine the level of stationarity of the series; subsequently, the NARDL boundary test will be applied to determine whether there is a long-term relationship between the variables, and an asymmetric effect analysis will be performed using the long-term coefficients obtained from this test.

In the correlation analysis, the coefficients range between -1 and +1, and this analysis provides partial information about the direction and strength of the relationship between the variables. The absolute value of the coefficient being close to 1 provides information about the strength of the relationship, while a negative or positive value provides information about the direction of the relationship. Positive and significant correlations were found between the dependent variable RES and other variables. In this context, it was found that the highest correlation coefficient was in the ER variable (0.636), followed by the FC (0.552) and INF (0.508) variables.

Table 4. Correlation Analysis Findings

Variables	RES	FC	ER	INF
RES	1			
FC	0.552	1		
ER	0.636	0.827	1	
INF	0.508	0.727	0.965	1

Findings Related to Unit Root Tests

One of the most basic requirements for analyzing the relationship between variables is determining the level of stationarity of the series. In this regard, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied to determine whether the time series were stationary. Additionally, the Zivot-Andrews structural break unit root test was applied to the series to identify structural breaks in the series within the relevant time period. The Augmented Dickey-Fuller (ADF) test developed by Dickey-Fuller (1981) and the Phillips and Perron (1988) test are the main methods used to determine the stationarity properties of time series. The hypotheses presented in these tests are as follows (Yavuzaslan et al., 2017):

H_0: The series contains a unit root, it is non-stationary.

H_1: The series does not contain a unit root, the series is stationary.

In this context, the results of the ADF-PP unit root test are presented in Table 5.

Table 5. ADF-PP Unit Root Test Results

			Variables	ADF	PP		ADF	PP
Level	Level		RES	-1.50(0.52)	-1.33(0.61)	First Difference	-10.51(0.00)*	-10.28(0.00) *
			FC	-1.02(0.74)	-0.64 (0.85)		-4.01 (0.00)*	-7.67(0.00) *
			ER	3.20 (1.00)	3.75(1.00)		-6.32(0.00) *	-6.22(0.00) *
			INF	1.30(0.99)	1.51(0.99)		-4.75(0.00)*	-4.87 (0.00)*
	Level +	Trend	RES	-2.05(0.56)	-2.07(0.55)		-10.62(0.00) *	-10.40(0.00) *
			FC	-2.08(0.55)	-1.65 (0.76)		-4.08(0.00) *	-7.750.00) *
			ER	-0.03(0.99)	-0.02(0.99)		-7.91(0.00) *	-6.79(0.00) *
			INF	-1.84(0.67)	-1.69(0.75)		-5.06(0.00) *	-5.21 (0.00) *

Note: Values in parentheses indicate probability values. *,**,*** and values indicate stationarity of the series at 1%, 5% and 10% levels of significance, respectively.

When Table 5 is examined, it is determined that, according to the ADF unit root test results, none of the series are stationary at the level, but they become stationary when their first differences are taken. The PP unit root test, which was conducted to support the reliability of the ADF test findings, shows similar results in terms of the stationarity properties of the series.

The fundamental limitation of the Zivot-Andrews (1992) test is that it assumes the absence of structural breaks under the unit root hypothesis and determines critical values based on this assumption. Therefore, the alternative hypothesis of the test is that structural breaks are present in the series. In this test, the break time is determined internally, and only a single break point is considered (Zivot and Andrews, 1992). The basic assumptions of the test are as follows:

H_0: The series contains a unit root without a structural break.
H_1: The series is stationary with a structural break.

Table 6. Zivot- Andrews Unit Root Test with Structural Break

Variables	Model	Break Date	Test Statistic	Critical Values		
				%1	%5	%10
RES	Constant (A)	2023M06	-3.60	-5.34	-4.93	-4.58
	Constant + Trend (C)	2020M03	-4.65	-5.57	-5.08	-4.82
FC	Constant (A)	2023M06	-5.71	-5.34	-4.93	-4.58
	Constant + Trend (C)	2022M07	-4.65	-5.57	-5.08	-4.82
INF	Constant (A)	2021M11	-6.18	-5.34	-4.93	-4.58
	Constant + Trend (C)	2021M11	-4.60	-5.57	-5.08	-4.82
ER	Constant (A)	2023M06	-3.13	-5.34	-4.93	-4.58
	Constant + Trend (C)	2020M12	-4.43	-5.57	-5.08	-4.82
Δ RES	Constant (A)	2020M10	-10.77	-5.34	-4.93	-4.58
	Constant + Trend (C)	2023M06	-10.82	-5.57	-5.08	-4.82
Δ FC	Constant (A)	2023M05	-4.62	-5.34	-4.93	-4.58
	Constant + Trend (C)	2023M06	-6.16	-5.57	-5.08	-4.82
Δ INF	Constant (A)	2022M11	-4.66	-5.34	-4.93	-4.58
	Constant + Trend (C)	2021M10	-5.86	-5.57	-5.08	-4.82
Δ ER	Constant (A)	2021M10	-6.88	-5.34	-4.93	-4.58
	Constant + Trend (C)	2023M06	-7.63	-5.57	-5.08	-4.82

When Table 6 is examined, in the fixed (A) model, the FC variable has a test statistic of -5.71 and the INF variable has a test statistic of -6.18, and these values are above all critical

values in absolute terms, indicating that the variables reject the unit root hypothesis and are stationary at the level. In contrast, the test statistics for the RES and ER variables are below all critical values in absolute terms under both Model A and Model C. In this case, the null hypothesis cannot be rejected, and it is observed that these variables are not stationary at the level, i.e., they contain a unit root despite structural breaks. When the first differences of the series are taken, the test statistic results are above the critical values in absolute terms, rejecting the null hypothesis and accepting the alternative hypothesis. The structural break dates determined by the test results are parallel to important economic developments in the relevant periods.For instance, in the 2023M06 period, following the post-election change in Turkey's eceonomic administration and restructuring of reserve policies, the CBRT shifted its focus toward orthodox economic policies to restore the disrupted links among macroeconomic indicators.In this context, the Bank raised the policy interest rate from 9% in 2022 to 42.5 by the end of 2023 to reestablish price stability (Bagir et al., 2024: Akçay, 2024).

NARDL Bound Test

The NARDL (Nonlinear Autoregressive Distributed Lag) method was developed by Shin et al. (2014) to examine short- and long-term relationships between variables and reveal asymmetric effects in these relationships. This method enables the analysis of the dynamic structure between variables in terms of asymmetric effects in both the short and long term (Altıntaş, 2024). In line with the nonlinear/asymmetric model developed by Shin et al. (2014), the functional expression for the variables included in the study is as follows:

$$\begin{aligned}\Delta lnRES_t = {} & \beta_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta lnRES_{t-i} + \sum_{i=0}^{q1} \beta_{2i}\, \Delta FC_{t-i}^{+} + \sum_{i=0}^{q2} \beta_{3i}\, \Delta FC_{t-i}^{-} + \sum_{i=0}^{q3} \beta_{4i}\, \Delta ER_{t-i}^{+} \\ & + \sum_{i=0}^{q4} \beta_{5i}\, \Delta ER_{t-i}^{-} + \sum_{i=0}^{q5} \beta_{6i}\, \Delta lnINF_{t-i}^{+} + \sum_{i=0}^{q6} \beta_{7i}\, \Delta lnINF_{t-i}^{-} + \alpha_1\, lnRES_{t-1} \\ & + \alpha_2\, FC_{t-1}^{+} + \alpha_3\, FC_{t-1}^{-} + \alpha_4\, ER_{t-1}^{+} + \alpha_5\, ER_{t-1}^{-} + \alpha_6\, lnINF_{t-1}^{+} \\ & + \alpha_7\, lnINF_{t-1}^{-} + \mu\end{aligned}$$

In the equation above, the short-term effects of positive and negative shocks of independent variables on the lagged values of the dependent variable are taken into account; in addition, the lagged level values of the positive and negative components of each independent variable are included in the model, enabling the analysis of long-term asymmetric relationships.

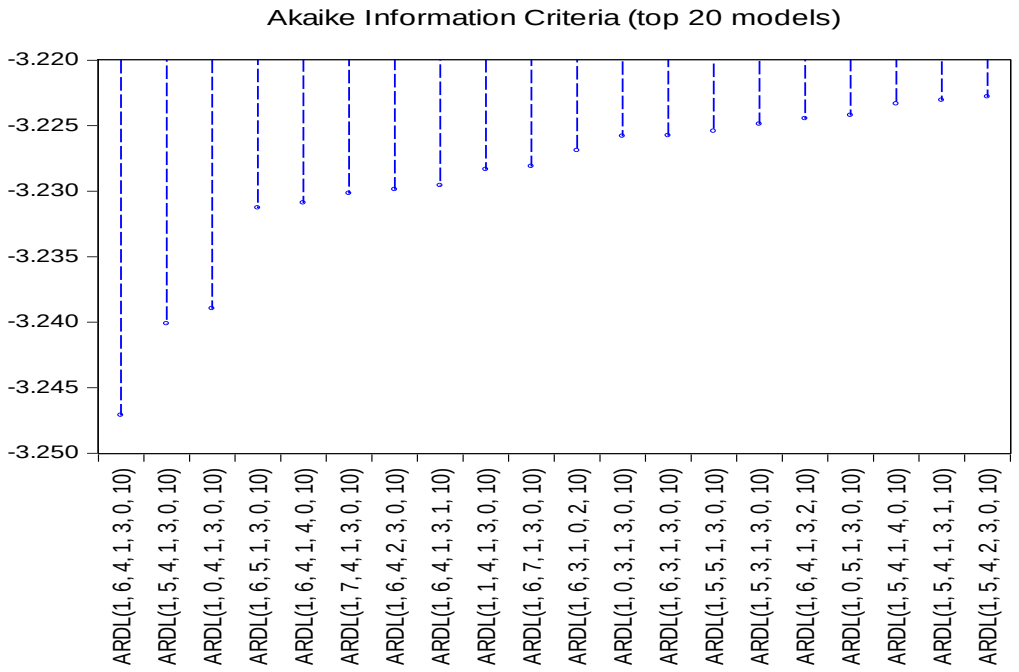
In the cointegration analysis conducted in Table 7 for the Central Bank of the Republic of Turkey's Official Reserve Assets, Weighted Average Funding Cost, Nominal USD Exchange Rate, and Domestic Producer Price Index, the fact that the f statistic (5.63) has a value above all critical values indicates the existence of a cointegration relationship between these variables.

Table 7. Results of Asymmetric ARDL Cointegration Analysis

Model		**F-stat**	**k**
		5.63	**6**
Critical Values	***I(O)***	***I(1)***	
%10	2.12	3.23	
%5	2.45	3.61	
%2.5	2.75	3.99	
%1	3.15	4.43	

The Akaike Information Criterion (AIC) values used to determine the appropriateness of the model established within the scope of the NARDL bounds test are presented in Graph 2.

Graph 2. Akaike Information Criterion ARDL (4.4 Model)



After determining the cointegration relationship for the variables, the findings of the coefficient estimation analysis are presented in table 8 and table 9.

Table 8. Asymmetric ARDL Model Estimation Results

Variable (Dependent Variable RES)	Coefficient	t-statistic	Probability
C	5.09	5.17	0.00*
D(ER_POS)	0.026	2.28	0.02**
D(ER_POS(-1))	-0.018	-1.30	0.30
D(ER_POS(-2))	0.018	0.98	0.32
D(ER_POS(-3))	-0.029	-1.60	0.11
D(ER_POS(-4))	0.0002	0.01	0.98
D(ER_POS(-5))	0.013	1.42	0.15
D(ER_NEG)	-0.108	-1.50	0.13
D(ER_NEG(-1))	0.125	-0.83	0.40
D(ER_NEG(-2))	0.063	0.48	0.62
D(ER_NEG(-3))	0.152	1.80	0.07***
D(INF_POS)	-1.126	-3.83	0.00*
D(INF_NEG)	1.727	0.75	0.45
D(INF_NEG(-1))	1.501	0.60	0.54
D(INF_NEG(-2))	-3.759	-2.26	0.02**
D(FC_POS)	-0.006	-3.10	0.00*
D(FC_NEG)	-0.014	-2.17	0.03**
D(FC_NEG(-1))	-0.019	-2.24	0.02**
D(FC_NEG(-2))	-0.011	-1.32	0.18
D(FC_NEG(-3))	0.018	2.09	0.03**
D(FC_NEG(-4))	0.00008	0.008	0.99
D(FC_NEG(-5))	-0.019	-1.99	0.04
D(FC_NEG(-6))	0.001	0.17	0.85
D(FC_NEG(-7))	-0.004	-0.40	0.68
D(FC_NEG(-8))	-0.004	-0.45	0.65
D(FC_NEG(-9))	0.019	2.27	0.02**
ECM	-0.42	-5.15	0.00*
Diagnostic Test Results			
R-squared	0.95	F-statistic	52.18
Adjusted R-squared	0.93	Prob.	0.00

Breusch/Pagan Heteroskedasticity Test	21.2(0.90)	Breusch-Godfrey Serial Correlation LM Test	0.10(0.89)
Jarque-Bera Test	3.96(0.13)	Ramsey RESET Test	1.15(0.24)

Note: *, **, *** denote statistical significance at the 1%, 5% and 10% levels, respectively. Values in square brackets are t-statistics

When examining the short-term findings of the NARDL method in Table xx, it is seen that positive and negative shocks in the exchange rate, inflation, and funding costs have asymmetric effects on CBRT reserves. In this context: positive shocks in the exchange rate increase reserves, while negative shocks have a statistically significant effect; positive shocks in the inflation variable reduce reserves, while negative shocks only reduce reserves after a certain lag; positive shocks in funding costs have a reducing effect on reserves, while negative shocks increase reserves in the fourth and ninth lagged periods. The error correction coefficient is expected to be negative, statistically significant, and between 0 and-1. In the analysis, this coefficient was found to be-0.21 and statistically significant at the 1% significance level. This finding indicates that imbalances occurring in the short term tend to cycle over a period of |1/-0.42|=2.3. Diagnostic test results indicate that the model does not exhibit autocorrelation, heteroskedasticity, or normality issues, and that it is structurally consistent.

Table 9. Long Run Coefficient Results

Variable	Coefficient	t-statistic	Probability
INF^+	-1.0188	-5.04	0.00*
INF^-	8.0753	4.19	0.00*
FC^+	-0.0155	-3.70	0.00*
FC^-	0.0004	0.07	0.94
ER^+	0.0981	4.54	0.00*
ER^-	-0.4152	-4.42	0.00*
Fixed Term	11.846	252.4	0.00*

Note: *, **, *** denote statistical significance at the 1%, 5% and 10% levels, respectively. Values in square brackets are t-statistics

The long-run analysis presented in Table 9 reveals that a 1-unit increase in the exchange rate increases CBRT reserves by 0.098 units, while a 1-unit decrease decreases reserves by-0.41 units; a 1-unit increase in inflation decreases reserves by-1.01 units, while a 1-unit decrease

increases reserves by 8.07 units; a 1-unit increase in funding costs decreases reserves by-0.015 units, while a 1-unit decrease is not statistically significant.

CONCLUSION

In recent years, central bank reserves have gained strategic importance not only for providing foreign exchange liquidity but also for enhancing resilience against external shocks, establishing confidence in financial markets, and supporting the effectiveness of monetary policy. The economic fluctuations and uncertainties experienced in the Turkish economy after 2013 have led to changes in both the level and qualitative structure of reserves. Factors such as economic crises, natural disasters, global pandemics, and geopolitical risks have increased pressure on the reserve accumulation process and led to reserves being viewed not only as a monetary policy indicator but also as an indicator of economic resilience.

The findings of the NARDL analysis reveal that positive and negative shocks in the exchange rate, inflation, and funding costs have asymmetric and significant effects on CBRT reserves. It has been determined that positive exchange rate shocks increase the reserve level in the long term, while negative shocks decrease it, confirming hypothesis H_{11}. Positive shocks in inflation reduce reserves, while negative shocks increase them, supporting hypothesis H_{12}. Positive shocks in funding costs reduce reserves, while negative shocks do not create a statistically significant effect, and hypothesis H_{13} remains valid.

Empirical findings are generally consistent with the results reported by Kim et al. (2000), Cinel and Yamak (2014), Daude et al. (2016), and Akdoğan (2020), but show a clear difference from Kalu et al. (2019). This difference may stem from variations in the data set, period, and model specifications used in Kalu et al.'s study; it is also thought that Turkey's specific economic and political conditions may have caused a deviation from Kalu et al.'s findings. This comparison demonstrates that findings in the literature may vary by country and period.

The asymmetric response of CBRT reserves to exchange rate, inflation, and funding costs underscores the need for a carefully calibrated monetary policy framework. As rising inflation and exchange rate depreciation reduce reserve levels, policies that prioritize price stability and limit exchange rate volatility need to be strengthened. In addition, the negative effects of funding costs on reserves point to the need to prioritize measures that will increase predictability in liquidity management and simplify policy instruments. For example, coordinated use of foreign exchange interventions, interest rate policy, and short-term liquidity tools can be effective in preserving reserve levels. Continuing the policies implemented since June 2023 in line with macroeconomic dynamics and supporting them with long-term institutional reforms is critical to increasing the CBRT's resilience to economic shocks.

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