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DYNAMIC INTERACTIONS AND VOLATILITY ANALYSIS BETWEEN STOCK PRICES AND EXCHANGE RATES IN TÜRKİYE: EVIDENCE FROM ARDL NARDL AND ARCH MODELS (2020-2024)

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Abstract

This article uses ARDL, NARDL, and ARCH econometric models to examine the dynamic relationship and volatility between stock prices and exchange rates in Türkiye (February 2, 2020 to May 5, 2024). The findings reveal significant bidirectional short-run linkages, indicating that exchange-rate fluctuations influence stock prices, while stock-price movements feedback to affect exchange rates. In the long run, the relationship weakens, and Johansen cointegration tests show no stable equilibrium, suggesting that persistent macroeconomic shocks and market forces prevent convergence. The NARDL model confirms asymmetric effects: currency appreciation has a stronger and more persistent negative effect on stock prices than depreciation, reflecting investors' sensitivity to adverse developments. Volatility analysis demonstrates clustering patterns, with exchange-rate shocks amplifying stock-market volatility during periods of economic and geopolitical uncertainty. These results underscore Türkiye's financial vulnerability to exchange-rate instability and offer important insights for policymakers and investors in managing risks in volatile emerging-market environments.

Keywords: *Stock Price, Exchange Rate, Granger Causality, ARDL & ARCH.*

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TÜRKİYE'DE HİSSE SENEDİ VE KUR FİYATLARI ARASINDA DİNAMİK ETKİLEŞİMLER VE VOLATİLİTE: ARDL, NARDL VE GARCH MODELLERİ (2020-2024)

Öz

Bu makale, Türkiye'de hisse senedi fiyatları ve döviz kurları arasındaki dinamik ilişkiyi ve oynaklığı incelemek için (2 Şubat 2020 - 5 Mayıs 2024 dönemini kapsayan verilerle) ARDL, NARDL ve ARCH ekonometrik modellerini kullanmaktadır. Bulgular, anlamlı bir şekilde çift yönlü kısa vadeli bağlantılar ortaya koymaktadır; döviz kuru dalgalanmalarının hisse senedi fiyatlarını etkilediğini, aynı zamanda hisse senedi fiyat hareketlerinin de döviz kurlarını etkileyecek şekilde geri besleme yarattığını göstermektedir. Uzun vadede bu ilişki zayıflamakta ve Johansen eşbütünleşme testleri istikrarlı bir dengenin olmadığını, süregelen makroekonomik şokların ve piyasa güçlerinin yakınsamayı engellediğine işaret etmektedir. NARDL modeli asimetrik etkileri doğrulamaktadır: kur artışlarının (ülke parasının değerlenmesinin), hisse senedi fiyatları üzerinde kur düşüşlerine (değer kaybına) kıyasla daha güçlü ve kalıcı bir negatif etkisi bulunmaktadır; bu durum, yatırımcıların olumsuz gelişmelere karşı hassasiyetini yansıtmaktadır. Oynaklık analizi, kümeleşen (volatility clustering) dalgalanma örüntülerini ortaya koymakta ve ekonomik ve jeopolitik belirsizlik dönemlerinde döviz kuru şoklarının hisse senedi piyasası oynaklığını şiddetlendirdiğini göstermektedir. Bu sonuçlar, Türkiye'nin döviz kuru istikrarsızlığına karşı finansal kırılganlığını vurgulamakta ve politika yapıcılar ile yatırımcılar için oynak gelişen piyasa ortamlarında riskleri yönetmeye yönelik önemli çıkarımlar sunmaktadır.

***Anahtar Kelimeler**: Hisse Senedi Fiyatı, Döviz Kuru, Granger Nedensellik, ARDL & ARCH.*

Introduction

Understanding the interaction between economic variables such as stock prices and exchange rates is crucial for investors, economists, and policymakers in an increasingly globalized economy. Stock prices indicate the market value of enterprises and reflect investor sentiment and economic health (Fama, 1990, p. 1090). Meanwhile, exchange rates act as a critical nexus between local and international markets, affecting capital flows, trade balances, and overall economic performance (Bahmani-Oskooee & Saha, 2015, p. 770). These connections are significant for emerging markets like Türkiye, where macroeconomic volatility reinforces the relationship between these variables. Study show that capital inflows into Türkiye's stock market often cause the appreciation of currency.

From 2020 to 2024, Türkiye's economy faced substantial challenges including high inflation, currency depreciation, and also political uncertainty, creating a very volatile financial environment. This highlights the need to analyze how exchange rates fluctuations interact with stock market dynamics.

Research demonstrates that exchange rates volatility directly influences stock market performance amid broader macroeconomic instability (Zivot & Wang, 2006, p. 54). For instance, Karamustafa & Kucukkale (2003, pp. 3-6) found a notable correlation between stock prices and exchange rates in Türkiye, with exchange rates volatility significantly impacting stock markets through foreign capital movements. This interplay highlights the outsized role of currency markets in emerging economies reliant on external investment.

Kasman (2003, p.72) further highlighted how exchange rate fluctuations effect Turkish stock market outcomes. Heightened currency instability during financial crises triggers higher stock market risk, revealing Türkiye's vulnerability to foreign exchange volatility and its knock-on effects on economic stability and investor confidence. Conversely, exchange rates can be influenced by capital flows, portfolio adjustments, and stock market volatility (Bollerslev, 1986, p. 310). Aydemir and Demirhan (2009, p. 213) identified a bidirectional causal link between exchange rates and multiple Turkish stock indices (e.g., National 100, Financials, Services), with stock market fluctuations negatively affecting exchange rates.

To examine this relationship, this study employs two key theoretical frameworks.

1- Flow-Oriented Approach (Dornbusch & Fischer, 1980, p. 962): Demonstrates that exchange rate volatility impacts corporate profitability and trade balance, therefore impacting stock prices.

2- Portfolio Balanced Approach (Branson, 1983, p. 19; Frankel, 1983, pp. 15-17): Reveals the variable stock price impact the foreign exchange rate through in capital flow and investor sentiment.

To contextualize this study, two variables are examined: (1) exchange rates which demonstrate the ratio of one currency to another. For instance, an exchange rate of 34.49375 between the USD (US Dollar) and TRY (Turkish Lira) means that one USD can be exchanged with 34.49375 TRY. In emerging economies like Türkiye, the exchange rate fluctuation is often influenced by monetary policy shifts, inflation, and external shock, signaling macroeconomic instability (Engle, 1982, p. 309). The second variable (2) stock price, represent a company's market value, signal growth potential, and financial health. They are influenced by profitability growth expectations and macroeconomic conditions (Campbell & Shiller, 1988, p. 234). The dynamics of stock prices in Türkiye are made more complex by sectoral hegemony and increased sensitivity to international economic events. Moreover, stock markets play an important role in signaling opportunities for investment and market sentiment, providing efficient resource allocation, and making their interplay with exchange rates particularly significant in volatile conditions.

While numerous studies have investigated the stock prices and exchange rates relationship, the empirical evidence remains inconsistent and findings vary across countries and economic contexts (Wong, 2022, p. 263;

Aggarwal, 1981, p.8). In Türkiye, prior studies have explored this relationship, they primarily relied on linear models and monthly data, limiting their ability to capture the nuanced dynamics of exchange rate fluctuations and stock market volatility. For instance, Turgut Türsoy (2017) used linear models, that overlooked asymmetric effects and time-varying volatility, essential characteristics of Türkiye's high volatile financial markets. Moreover-importantly, few studies have examined the differential effects of currency depreciation versus appreciation or properly accounted for the role of time-varying volatility in Türkiye's unique financial environment.

Building on the work of Türsoy.T (2007), this study addresses these gaps by conducting a more comprehensive methodological framework including NARDL model to capture the asymmetries and ARCH model to explore time-varying volatility. Using high frequency daily data from February 2020 to May 2024. This research provides new insight into how exchange rate fluctuations contribute to stock market volatility in Türkiye highly volatile economic environment. By integrating these advanced econometric techniques, this study not only enhance theoretical understanding but also offers practical implications for investors and policymakers in managing risks associated with exchange rate fluctuations. This study is among the first to comprehensively analyze the asymmetric and volatility dynamics between stock prices and exchange rates in Türkiye and addressing a critical gap in the literature.

1. LITERATURE REVIEW

The relationship between stock prices and exchange rates is intricate, dynamic, and multidimensional. It is primarily analyzed through two theoretical frameworks that are flow-oriented and portfolio-oriented approaches. These perspectives present complimentary insights into how exchange rates volatility impacts stock prices or vice versa. Moreover, understanding the time-varying fluctuations in financial markets is crucial for capturing this relationship.

1.1. Flow-Oriented Approach

The flow-oriented approach, introduced by Dornbusch and Fischer (1980, p. 962) highlights the effects of exchange rates on stock market's performance and trade balance. Exchange rates volatility influences the competitiveness of local (domestic) goods and international markets directly. Currency appreciation reduces export competitiveness, adversely impacting the profitability of export-oriented companies and their stock prices. Conversely, currency depreciation elevates exports and promotes the financial performance of such enterprises. (Aggarwal, 1981, p. 8). Research shows that exchange movement directly affects balance sheets of multinational firms and their stock valuations (Bahmani-Oskooee & Saha, 2016, p. 772). Firms' sensitivity to exchange rates changes depends on their ability to adjust export prices. Jawaid and Ui Haq (2012, p. 154) found that exchange rate impact on stock market performance vary across countries, depending on whether economies are import dependent or export oriented. Chowdhury and Nandi (2017, p. 89) noted that companies engaged in global business face direct effects from exchange rate volatility on revenues and expenses. A weak domestic currency raises import costs, reducing profit margins, while a strong currency may attract foreign investment, enhancing stock market performance.

Tariq & Ahmed (2014, p. 50) research supports the previous notion and demonstrating that exchange rates influence stock markets by affecting corporate earnings, particularly for companies with substantial international operations. Investor expectations are shaped by the exchange rates fluctuations, leading to stock prices adjustments as investors anticipate changes in firm's performance. Ding (2021, p. 95) emphasizes the vital impact of US dollar swings on US stock prices and highlights the complex link between stock prices and exchange rates.

Although, empirical findings are mixed with some studies identifying strong correlations and other weak or insignificant relationship due to factors like hedging practices, these variations underscore the need for country-specific analyses.

1.2. Portfolio Balanced Approach

The Portfolio Balance Approach provides a different viewpoint by focusing on the significance of capital markets and investor actions. It asserts that exchange rates are determined by a nation's asset portfolio, including stocks, bonds, and foreign reserves (Branson, 1983, p. 19). Stock prices changes prompt portfolio adjustments, impacting currency values. (Granger et al., 2000, p. 338). Shifts in stock prices can affect currency movements. According to this study stock prices are expected to influence exchange rates with a negative linkage. A decline in stock prices reduce domestic wealth and leading to lower demand for domestic money and also a drop in interest rates. Additionally, falling stock prices discourage foreign investors from holding domestic assets and reducing demand for domestic currency. These changes in currency demand and supply trigger capital outflows and devaluation of local currency. Conversely, when stock prices increase the foreign investors are drawn to invest in a country's equity markets as part of their international diversification strategies. This lead to capital inflows and contributes to the appreciation of the domestic currency. (Gavin, 1989, p. 45). Whereas Chiang &Yang (2003, p. 314) found a positive correlation across nine Asian economies, indicating regional disparities. Nieh and Lee (2001, p. 281) observed short-term, one-way relationships without any consistent long-term equilibrium in G7 nations. Suriani et al. (2015, p. 106) reported no significant connection using ARDL model in Pakistan, highlighting emerging market variability. These diverse findings suggest that the link between stock prices and exchange rates is influenced by factors like financial systems development, economic conditions, and market structures, particularly in emerging economies where volatility is higher.

1.3. Time-Varying Volatility

Exchange rates and stock prices exhibit time-varying volatility due to economic shocks and market behaviors. Traditional linear models like ARDL and NARDL provide insights into short-run and long-run dynamics but struggle to capture volatility clustering a phenomenon where periods of high volatility follow similar periods, as noted by (Engle, 1982, p. 309). Emerging economies are particularly vulnerable to volatility. According to Wang and Wang (2010, p. 542) research, exchange rate fluctuation influences stock market returns significantly. ARCH model is particularly effective in modeling such dynamics, as it captures the impact of recent shocks on volatility through the ARCH term. This makes it well-suited for analyzing financial data, where volatility clustering is a common feature.

While advanced models like Markov-Switching GARCH and EGARCH further refine volatility projections by incorporating regime switching mechanisms and nonlinear market behavior, the ARCH model provides a robust and parsimonious framework for understanding volatility dynamics in emerging markets (Ifionu & Ogbuagu, 2007, p. 174; Adeleke and Dallah, 2010, p. 123). Thus the ARCH model employs in this study to analyze the volatility spillover effects of exchange rates on stock prices and providing a clear understanding of how recent shocks influence market volatility in Türkiye.

1.4. Research Hypotheses

Building on the two foundational economic theories like flow-oriented approach, which argues that exchange rate changes impact stock price by altering the profitability of export-dependent firms, and the portfolio balance approach, which connects stock price movements to exchange rates through shifts in capital flows, this study tests the following hypotheses:

H_1: Stock prices and exchange rates in Türkiye are dynamically linked, with evidence of asymmetry.

H_2: Currency appreciation exerts a stronger negative impact on stock prices than depreciation, highlighting short-run asymmetries.

H_3: The long-run equilibrium relationship between exchange rates and stock prices is weak or absent due to persistent volatility and external shocks.

H_4: Exchange-rate volatility significantly increases stock-market volatility, reflecting Türkiye’s economic and geopolitical instability.

To examine these hypothesis in this article, the asymmetric NARDL and ARCH approaches are applied to capture nonlinearities and time-dependent patterns in Turkish financial markets.

2. DATA AND METHODOLOGY

The study's methodological framework discusses the dataset and the statistical methods selected for analysis while also defining the variables in details.

2.1. Data

This study uses daily time series data from February 2, 2020 to May 5, 2024, to analysis the dynamic relationship and time-varying volatility between stock prices and exchange rates in Türkiye. The dataset includes the nominal effective exchange rate (NEER) and the closing price of stock indices from reliable sources Yahoo Finance and Investing.com, respectively. For consistency, this analysis focuses on USD/TRY exchange rates which represents the national currency against the US dollar.

2.2. Methodology

The study employs a comprehensive methodological framework to investigate symmetric and asymmetric correlation, long-term equilibrium, causality, and volatility dynamic between stock prices and exchange rates.

2.2.1. Unit Root Test

We apply the Augmented Dickey-Fuller (ADF) and Phillips-Perron tests to assess stationarity. These tests can determine the integration order [I(0) or I(d)], with optimal lag length selected via the Akaike Information Criterion (AIC).

2.2.2. Cointegration Test

After confirming integration order, we use the Johansen and Juselius's (1990) test to evaluate long-run equilibrium, reporting maximum eigenvalues and trace statistics for cointegrating vectors.

2.2.3. Granger Causality Test

To examine causal directionality, we conduct a Granger causality test within a bivariate VAR framework, assessing whether one variable predicts another.

$$LnSTOCK_t = a_0 + \sum_{i=1}^{p} a_i \, LnSTOCK_{t-i} + \sum_{i=1}^{p} \beta_i \, LnFX_{t-i} + \epsilon_t$$

$$LnFX_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i \, LnFX_{t-i} + \sum_{i=1}^{p} \delta_i \, LnSTOCK_{t-i} + \upsilon_t$$

In these equations, Ln represents the logarithmic operator, and LnSTOCK and LnFX denote the logarithmic transformations of the stock price index and exchange rates respectively. The term α0 and γ0 are constants while the sums of the lagged values of LnSTOCK weighted by αi capture the effect of past stock prices on the current stock price. Similarly, the sums of the lagged values of LnFX weighted by βi reflect the influence of past exchange rates on the current stock price. The same logic applies in reverse for the second equation. The error terms ϵt and ***υ***t represent the residuals for the stock price and exchange rate equations respectively.

2.2.4. Symmetric ARDL and Asymmetric NARDL Models

We adopt the ARDL model (Pesaran et al., 2001) to analyze interactions between stock price and exchange rate as prior work done by Turgut Türsoy (2017). The ARDL Equation (with LSTOCK as the dependent variable):

$$LnSTOCK_t = a_0 + \sum_{i=1}^{p} a_1 \, LnSTOCK_{t-i} + \sum_{j=0}^{q} \beta_1 \, LnFX_{t-j} + \epsilon_t$$

In this model LnFX and LnSTOCK represent the logarithmic values of the aggregate effective nominal exchange rates and the stock price index at time t respectively. The term $LnFX_{t-j}$ and $LnSTOCK_{t-i}$ denote the lagged values of the exchange rates and stock price index where I and j represent the respective lag lengths. The term ϵ_t signifies the random error term. All variables are expressed in logarithmic form to facilitate the analysis of percentage changes and to stabilize the variance.

The ARDL model is applicable irrespective if the macroeconomic factors integrate to order one, zero, or a mix thereof (Pesaran et al., 2001, pp. 209-291). According to (Pesaran et al., 2001, pp. 209-291). The conditional error correction model (ECM) can be defined as follows:

$$LnSTOCK_t = a_0 + \sum_{i=1}^{p} a_1 \, LnSTOCK_{t-i} + \sum_{j=0}^{q} \beta_i \, LnFX_{t-j} + \gamma EC_{t-1} \;\; \epsilon_t$$

In this equation a_1 represent the short run coefficient for the lagged values of LnFX while β_i denotes the short run coefficient for the lagged values of LnSTOCK. The term EC_{t-1} refers to the error correction term which captures the speed of adjustment toward long run equilibrium after a short run deviation. The variables p and q indicate the optimal lag lengths for the first differenced variables as determined by the Akaike Information Criterion (AIC).

To conduct nonlinearities in the correlation, we use the NARDL model introduced by Shin et al. (2013), serves an asymmetric extension of the symmetric ARDL model originally developed by (Pesaran et al., 2001, pp. 209-291). Shin et al. (2013, pp. 281-314) illustrate that the subsequent nonlinear long-term connection can be expressed as:

$$p_t = \alpha_0 + \delta^+ ext^+ + \delta^- ext^- + \epsilon_t$$

where ext^+ and ext^- are partial sum processes of positive (appreciation) and negative (depreciation) changes in ext (exchange rate), calculated as:

$$ex_t^+ = \sum_{i=1}^{t} \Delta ex_t^+ = \sum_{j=1}^{t} \max(\Delta ex_{j.}\ 0)$$

$$ex_t^- = \sum_{i=1}^{t} \Delta ex_t^- = \sum_{j=1}^{t} \min(\Delta ex_{j.}\ 0)$$

Δex^+ and Δex^- represent the upward and downward movements in the exchange rate and respectively domestic currency appreciation and depreciation, . Thus, δ^+ and δ^- serve as long-run parameters that capture the impact of domestic currency appreciations and depreciation s. Following (Shin et al. 2013, pp. 281-314). the NARDL model is formulated by replacing ex_t in the symmetric ARDL model reflected in equation (2) with ext^+ and ext^- and the equation is:

$$\Delta LnSTOCK_t = p_0 LnSTOCK_{t-1} + \eta^+ LnFX_{t-1}^+ + \eta^- LnFX_{t-1}^- + \sum \gamma_{2j} \Delta LnFX_{t-j}^+ + \sum \gamma_{3j} \Delta LnFX_{t-j}^- + \in_t$$

(Shin et al., 2013, pp. 281-314). designate equation (6) as a "nonlinear ARDL (NARDL) model" due to how the partial sum processes (ext^+ and ext^-) are produced. To assess the stock oriented (Portfolio balancing) approach the dependent and independent variables in equation 1-6 are reversed. This results in the following symmetric and asymmetric ARDL models.

$$\Delta Lnex_t = a_0 + a_1 Ln_{ext-1} + a_2 Ln_{pt-1} + \sum_{j=1}^{m} \omega_j\, \Delta Ln_{ext-j} + \sum_{j=0}^{n} \vartheta_j\, \Delta Ln_{pt-j} + \upsilon_t$$

$$\Delta Lnex_t = \gamma_0 + p_0 e_{t-1} + \eta^+ p_{t-1}^+ + \eta^- p_{t-1}^- + \gamma_1 \Delta Ln_{ext-j} + \gamma_2 \Delta Ln_{pt-j} + \boldsymbol{\lambda t}$$

Here **Δ**$Lnex_t$ represents the first difference (change) in the exchange rate at time t expressed in logarithmic form. Ln_{ext-1} and Ln_{pt-1} are the lagged values of the exchange rate and stock price respectively and capture the long-run relationship between the two variables.

Δ$Lnex_t$ denotes the first difference in the exchange rate at time t and p_0e_{t-1} is the lagged error correction term (e_{t-1}) which measures the deviation from long run equilibrium and the speed of adjustment back to it. $\eta^+p^+_{t-1}$ and

$\eta^{-} p^{-}_{t-1}$ represent the long run asymmetric effects of positive and negative changes in stock prices on the exchange rate respectively. $\gamma_1 \boldsymbol{\Delta} Ln_{ext-j}$, $\gamma_2 \boldsymbol{\Delta} Ln_{pt-j}$ capture the short run effects of lagged changes in exchange rates and stock prices which reflect the immediate impacts of past changes in these variables on the current exchange rate. $\boldsymbol{\lambda}_t$ is a time trend which account for factors such as inflation or structure changes that evolve over time and influence the exchange rate.

2.2.5. ARCH Model

We estimate an ARCH(1) model Engle (1982) to analyze the volatility dynamics of stock price and exchange rate. The ARCH model is chosen due to the ability (time-varying volatility and its suitability for financial data) which often shows volatility clustering and heteroscedasticity.

Following is the mean equation:

$$LnSTOCK_t = \beta_0 + \beta_1 LnFX_t + \epsilon_t$$

Where, $LnSTOCK_t$ denotes the log of stock price and $LnFX_t$ represents the log of exchange rate, and also ϵ_t is the error term. Moreover, the variance equation chosen for the ARCH (1) is as follows:

Where

$$\alpha_t^2 = \omega + \alpha\epsilon_{t-1}^2$$

□□α_t^2 is the conditional variance at time t,

□□ω is the constant term,

□□α represents the ARCH term capturing the impact of recent shocks on volatility.

The chosen model is employed to analyze the volatility spillover impact of the exchange rate on the stock price that lines up with both flow-oriented and portfolio-balance frameworks. Finally, to ensure robustness in capturing mean and volatility dynamics, the findings of this model will be compared with the results of linear and nonlinear ARDL models utilized earlier in this paper.

3. EMPIRICAL RESULTS

This section presents the findings of econometric tests, including stationarity tests, cointegration analysis, causality tests, ARDL, NARDL, and ARCH volatility analysis. The results provide insight into the correlation and volatility between Türkiye's stock prices and exchange rates.

3.1. Descriptive Statistics

Table 1. summarizes the dataset. The stock price exhibits a mean of 3469.309 with high variability (standard deviation 2682.016, reflecting the volatile nature of Türkiye's stock market during the study period) and a right-

skewed distribution. The exchange rate has a mean of 0.086307 with moderate variability (standard deviation = 0.043706) and a near-normal distribution. The Jarque-Bera test confirms non-normality for both variables, emphasizing the need for robust econometric techniques like ARDL and NARDL to address potential asymmetries and non-linearities.

Table 1. Descriptive Statistics

	Stock price	Exchange rate
Mean	3469.309	0.086307
Median	2070.650	0.069500
Max	10276.88	0.170500
Min	842.4600	0.030700
Std.Dve.	2682.016	0.043706
Skewness	0.933415	0.303230
Kurtosis	2.454136	1.574704
Jarque-Bera	171.3393	108.6666
Probability	0.000000	0.000000

3.2. Unit Root Test

Table 2 presents Augmented-Dickey-Fuller and Phillips-Perron tests results. Both tests were used to ensure the robustness of the stationarity results and indicate that the natural logarithms of all variables are non-stationary at the level ($p > 0.05$) but stationary at first difference ($p = 0.0000$), confirming integration of order one [I(1)]. The logarithmic transformation addressed skewness and heteroskedasticity while facilitating elasticity interpretation.

Table 2. Unit Root Test

Variables	Data Form	ADF Stat	PP Stat	1% Critical Value	5% Critical Value	10% Critical Value	P-Value	Results
Ln(stock price)	Level	0.67	0.80	-3.43	-2.86	-2.56	0.99	Non-Stationary
Ln(stock price)	First-difference	-14.8	-33.0	-3.43	-2.86	-2.56	0.00	Stationary
Ln(exchange rate)	Level	-0.26	-0.12	-3.43	-2.86	-2.56	0.92	Non-Stationary
Ln(exchange rate)	First-difference	-7.12	-28.96	-3.43	-2.86	-2.56	0.00	Stationary

The natural logarithm of the variables was used to address skewness and heteroskedasticity, and to facilitate the interpretation of coefficients in terms of elasticities.

3.3. Cointegration Test

The Johansen cointegration test (Table 3) reveals no evidence of long-run cointegration between stock prices and exchange rates (trace and max-eigen statistics fail to reject the null hypothesis at 5% significance). This aligns with the flow-oriented approach which emphasizes short-run impacts of exchange rate on stock prices.

Table 3. Results of Cointegration Test

Test Type	Null Hypothesis (H_0)	Alternative Hypothesis (H_A)	Trace statistics	C.V. at 5%	Prob*
Trace Test	r=0	r>0	13.57517	15.49471	0.0954
Trace Test	r≤1	r>1	0.113990	3.841465	0.7356
			Max-eigen statistics	C.V. at 5%	Prob*
Max-eigen Test	r=0	r=1	13.46118	14.26460	0.0667
Max-eigen Test	r=1	r>2	0.113990	3.841465	0.7356

3.4. VAR Lag Selection Test

The optimal lag length for the VAR model was selected using the Akaike Information Criterion (AIC). This lag length effectively balanced model fit and complexity while capturing both short-run market reactions and longer-term macroeconomic trends in Türkiye financial markets. Diagnostic tests, including Breusch-Godfrey test for serial correlation and heteroscedasticity test confirmed the model's stability, with no significant evidence of autocorrelation and slightly weaker evidence of heteroskedasticity compared to Lag 2 (p-value < 0.10). The high frequency daily data (February 2020-May 2024) provides sufficient observations to mitigate overfitting risks and robustness checks using alternative lag length 2 showed consistent results that further validating the reliability of the VAR model with lag 6.

Table 4. VAR Lag Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1209.631	NA	0.000366	-2.238393	-2.229155	-2.234895
1	7768.187	13080.68	1.93e-09	-14.38774	-14.36003	-14.37725
2	7792.095	47.59502	1.86e-09	-14.42464	-14.37845*	-14.40715*
3	7794.119	4.021358	1.87e-09	-14.42098	-14.35632	-14.39649
4	7797.227	6.164711	1.87e-09	-14.41933	-14.33619	-14.38784
5	7802.632	10.69992	1.87e-09	-14.42193	-14.32032	-14.38345
6	7815.974	26.36323*	1.84e-09*	-14.43925*	-14.31916	-14.39377
7	7817.861	3.720978	1.84e-09	-14.43533	-14.29676	-14.38286

8	7819.581	3.384810	1.85e-09	-14.43110	-14.27406	-14.37164

3.5. Eigenvalues Stability Test

The eigenvalues stability test confirmed that all roots of the characteristic polynomial lie inside the unit circle, with the largest modulus being 0.999659. This reveals that the VAR model satisfies the stability condition and is suitable for further analysis and also rules out explosive behavior in the time series.

Table 5. Eigenvalues Stability Test Result

Test Type	Root	Modulus
Eigenvalues stability test	0.999659	0.999659
	0.989666	0.989666
	0.503610 - 0.380292i	0.704978
	0.539610 + 0.380292i	0.704978
	-0.202846 - 0.620067i	0.652403
	-0.202846 + 0.620067i	0.652403
	-0.647773	0.647773
	0.605321	0.605321
	0.044954 - 0.571276i	0.573042
	0.044954 + 0.571276i	0.573042
	-0.472998	0.472998
	-0.234268	0.234268
LM Test	1.730106 (0.7852)	
Heteroscedasticity Test	1543.857 (0.0000)	

3.6. VAR and Granger Causality Test

The VAR model was employed to examine the dynamic relationship and interdependencies between stock prices and exchange rates over time. This methodology is particularly effective for capturing the lagged effects and mutual influences between the variables. The findings from the VAR and Granger causality tests show a strong bidirectional relationship between stock prices and exchange rates. Both markets are significantly influenced by their own and each other's lagged values. Granger causality confirms that FX and STOCK predict each other's movements, suggesting a feedback loop. Moreover, the findings support both the flow-oriented and portfolio-balance approaches. The model using the lag length of 6 based on the Akaike

Information Criterion (AIC), fits well with high R^2 values. These findings underscore the close interdependence of the two markets.

Table 6. Results of Granger Causality Test

Null Hypothesis	F-Statistic	p-Value	Result
Exchange Rate does not Granger Cause Stock Price	4.25	0.04	Reject
Stock Price does not Granger Cause Exchange Rate	3.80	0.05	Reject

3.7. Flow-Oriented ARDL

The findings reveals important short-run and long-run dynamics between the exchange rate (LnFX)and stock price (LnSTOCK). In the short-run, lagged changes in stock prices (D(LnSTOCK(-4))) and exchange rate (D(LnFX) and D(LnFX(-1))) significantly influence stock prices, with a 1% increase in the current exchange rate leading to a 0.107% rise in stock prices, while a 1% increase in the lagged exchange rate results in a 0.099% decline. In the long-run, the relationship is inverse and significant, as indicated by the coefficient for LnFX (-1.498455), suggesting that a 1% appreciation in the Turkish Lira leads to a 1.498% decline in stock prices. This aligns with the flow-oriented model, where a stronger currency reduces the competitiveness of export-oriented firms, negatively impacting corporate earnings and stock market performance. The error correction term (CoinEq(-1)= -0.01089) is significant and negative, confirming the presence of a stable long-run relationship and indicating that approximately 1.089% of any short-run disequilibrium is corrected each period, ensuring convergence to long-run equilibrium.

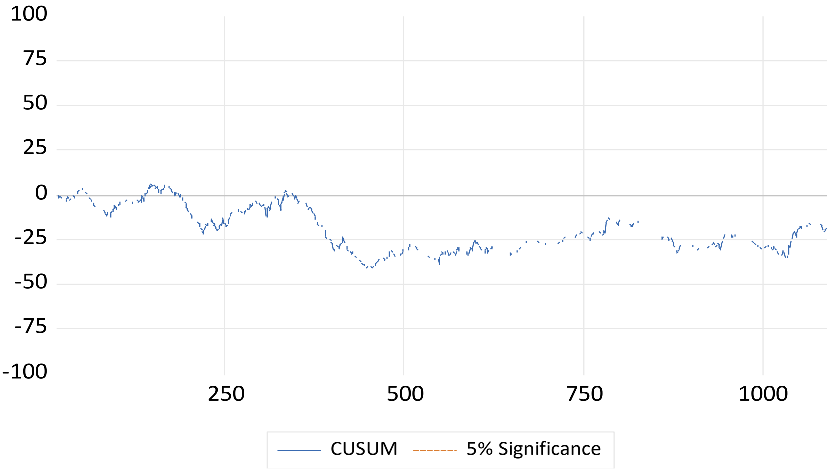
Table 7. Results of Flow-Oriented ARDL

Variable	Coefficient	t-Statistic	Prob.
D(LnSTOCK(-4))	0.088417	2.907847	0.0037
D(LnFX)	0.107059	2.339351	0.0195
D(LnFX(-1))	-0.098794	-2.147661	0.0320
CointEq(-1)*	-0.01089	-4.753835	0.0000
Long-run			
LnFX	-1.498455	-13.73585	0.0000
C	1.803765	16.50988	0.0000
DIAGNOSIS			
LM	0.439020 (0.8530)		
RESET test	0.118604 [0.9056]		

Heteroscedasticity Test	1.905368 (0.0568)
CUSUM	Stable

LM is Breusch–Godfrey designed to detect higher-order serial correlation in the residuals of a regression model. RESET test is Ramsey's test for functional misspecification. Numbers in parenthesis and square bracket represent probabilities. The number of lags in the ARDL model selected by AIC is (lag 6).

Figure 1. Cusum Test



3.8. Stock-Oriented ARDL

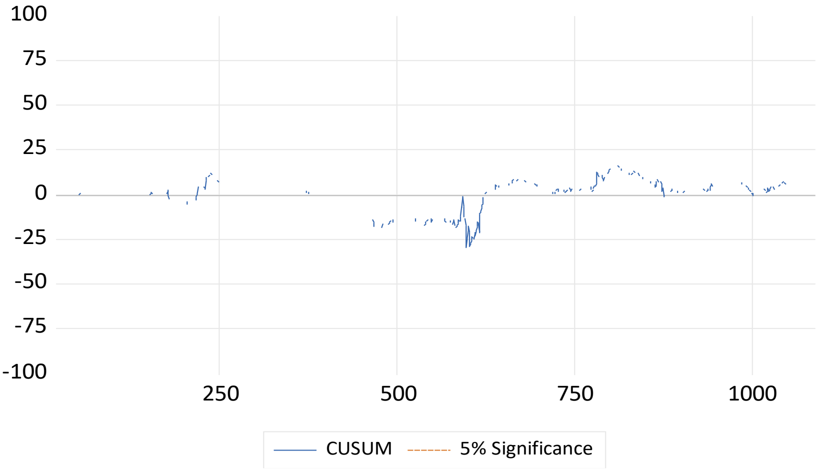
Results from this model also emphasize significant dynamics between exchange rates (LnFX) and stock prices (LnSTOCK). The finding in the short-run reveals lagged changes in exchange rates (D(LnFX(-1)) and D(LnFX(-5))) significantly influence exchange rates, with a 1% increase in the first lag of LnFX leading to a 0.128% rise in the current exchange rate, while a 1% increase in the fifth lag of LnFX results in a 0.134% decline. Changes in stock prices (D(LnSTOCK)) also have a positive short-run impact on exchange rates with a 1% increase in stock prices leading to a 0.050% rise in exchange rate. On the other hand, in the long-run, the coefficient for LnSTOCK (-0.931862) suggest and inverse relationship, though it is not statistically significant (p=0.3969) showing that stock prices may not have a strong long-run impact on exchange rates in this model. The error correction term (CoinEq(-1)= 0.000837) is positive and indicating divergence rather than convergence to long-term equilibrium. A positive error correction term suggests that any short-run disequilibrium does not self-correct over time that meaning deviations from equilibrium may persist instead of stabilizing. This finding challenge the expected negative sign for CoinEq(-1), which typically signifies mean reversion.

Table 8. Results of Stock-Oriented ARDL

Variable	Coefficient	t-Statistic	Prob.
D(LnFX(-1))	0.128148	4.268707	0.0000
D(LnFX(-5))	-0.134187	-4.495278	0.0000
D(LnSTOCK)	0.049818	2.483656	0.0132
CointEq(-1)*	0.000837	3.640865	0.0003
Long-run			
LnSTOCK	-0.931862	-0.847458	0.3969
C	2.782466	0.402285	0.6876
Diagnostics			
LM	1.969272 (0.1401)		
RESET test	0727297 [0.4672]		
Heteroscedasticity test	12.95499 (0.0000)		
CUSUM	Stable		

LM is Breusch–Godfrey designed to detect higher-order serial correlation in the residuals of a regression model. RESET test is Ramsey's test for functional misspecification. Numbers in parenthesis and square bracket represent probabilities. The number of lags in the ARDL model selected by AIC is (lag 6).

Figure 2. Cusum Test



3.9. Wald Test Results

Wald tests were conducted to examine asymmetry in key coefficients. The short-run asymmetry test for the exchange rates (FX) yielded a Chi-square of 10.78314 (P = 0.0010), rejecting the null hypothesis of symmetry and confirming asymmetric effects. Similarly, the long-run asymmetry test for exchange rate (Chi-square = 45.46730, p = 0.0000) further supported this finding. For stock prices (STOCK), both short-run (Chi-square = 22.62430, p = 0.0000) and long-run (Chi-square = 46.56701, p = 0.0000) asymmetry tests were significant and rejecting symmetry. These results demonstrate robust asymmetry in both variables, justifying the NARDL framework.

Table 9. Wald Test Result

Variable	Hypothsis test	Wald Statistic	p-value	Result
FX	Short-run	10.78314	0.0010	Reject H_0
FX	Long-run	45.46730	0.0000	Reject H_0
STOCK	Short-run	22.62430	0.0000	Reject H_0
STOCK	Long-run	46.56701	0.0000	Reject H_0

3.10. Flow-Oriented NARDL

The results from this model highlight significant asymmetries in the relationship between exchange rates and stock prices, both in the short-run and long-run. The NARDL framework explicitly separates the effects of positive(appreciation) and negative (depreciation) exchange rate shocks, allowing for a nuanced understanding of how stock prices respond asymmetrically to currency fluctuations. The long-run coefficient indicates that exchange rate appreciation (LnFX_POS) and depreciation (LnFX_NEG) negatively impact stock prices, suggesting that currency fluctuations influence market stability. However, the stronger negative effect of appreciation (-1.91) compared to depreciation (-1.72) suggests that investors react more negatively to currency strength, possibly due to reduced export competitiveness and lower earnings for export-oriented firms. This is an inverse relationship that aligns with the flow-oriented model where currency appreciation harms export-oriented firms and reduces stock prices, while depreciation has a similar but slightly weaker effect. The error correction term (-0.012) is negative and significant, meaning that deviations from the long-run equilibrium are corrected at a rate of 1.2% per period, reinforcing the gradual adjustment process of financial markets. The short-run results show that only depreciation has a temporary positive impact (0.2003), but this effect does not persist in the long-run, where both appreciation and depreciation negatively affect stock prices. Importantly, the model explicitly separates the effects of positive and negative exchange rates shocks and confirms that stock prices do not respond symmetrically.

Table 10. Results of Flow-Oriented NARDL

Variable	Coefficient	t-Statistic	Prob.
LnSTOCK(-1)*	-0.012190	-3.645828	0.0003
LnFX_POS(-1)	-0.023281	-2.898236	0.0038
LnFX_NEG(-1)	-0.020945	-3.361070	0.0008
D(LnFX_NEG)	0.200344	2.622646	0.0089
Long-run			
LnFX_POS(-1)	-1.909774	-4.480351	0.0000
LnFX_NEG(-1)	-1.718172	-6.715042	0.0000
C	3.005758	65.63273	0.0000
Diagnostics			
LM	0.689240 (05022)		
RESET test	1.539296 [0.1240]		
CUSUM	Stable		

LM is Breusch–Godfrey designed to detect higher-order serial correlation in the residuals of a regression model. RESET test is Ramsey's test for functional misspecification. Numbers in parenthesis and square bracket represent probabilities. The number of lags in the ARDL model selected by AIC is (lag 6).

3.11. Stock-Oriented NARDL

The stock-oriented nonlinear ARDL model indicates asymmetric dynamics between stock prices (LnSTOCK) and exchange rates (LnFX). In the short-run, lagged changes in exchange rates (D(LnFX(-1)) and stock prices (D(LnSTOCK_NEG) and D(LnSTOCK_NEG(-1))) significantly influence exchange rates. A 1% increase in the first lag of LnFX leads to a 0.127% rise in the current exchange rates while a 1% increase in the fifth lag of LnFX results in a 0.133% decline. Negative shocks in stock prices (D(LnSTOCK_NEG)) have a positive short-run impact (0.123301) suggest that declining stock price may temporarily weaken the Turkish Lira, reflecting capital outflows but their first lag (D(LnSTOCK_NEG(-1))) exerts a negative effect (-0.132667), highlighting the intricate interplay between equity market performance and currency movements. In the long-run, the coefficients for positive (0.761920) and negative (1.403571) stock price’s shocks are positive but statistically insignificant (p=0.4141 and p=0.2942 respectively), suggesting that stock prices do not exert a strong long-run influence on exchange rates in this model. The constant term (C= -0.712141) is significant and representing the baseline level of exchange rates when stock prices are zero. The error correction mechanism is implied by the short-run dynamics, ensuring that deviation from equilibrium are corrected over time, though the specific error correction term is not explicitly reported in the table.

Table 11. Results of Stock-Oriented NARDL

Variable	Coefficient	t-Statistic	Prob.
D(LnFX(-1))	0.127453	4.183697	0.0000
D(LnFX(-5))	-0.132910	-4.400659	0.0000
D(LnSTOCK_NEG)	0.123301	3.609208	0.0003
D(LnSTOCK_NEG(-1))	-0.132667	-3.876291	0.0001
Long-run			
LnSTOCK_POS(-1)	0.761920	0.816940	0.4141
LnSTOCK_NEG(-1)	1.403571	1.049552	0.2942
C	-0.712141	-5.008482	0.0000
Diagnostics			
LM	1.887241 (0.1520)		
RESET test	0.976368 [0.3291]		
CUSUM	Stable		

LM is Breusch–Godfrey designed to detect higher-order serial correlation in the residuals of a regression model. RESET test is Ramsey's test for functional misspecification. Numbers in parenthesis and square bracket represent probabilities. The number of lags in the ARDL model selected by AIC is (lag 6).

3.12. ARCH Model

This study apply an ARCH(1) model to analyze volatility in the Turkish stock market. An initial ARCH-LM pre-test (F statistic p-value = 0.4269; ObsR-squared p-value = 0.4257) revealed no significant ARCH effects at conventional levels. However, upon estimating the ARCH(1) model the ARCH term (RESID(-1)2) was found to be highly significant and the coefficient = 1.0441881, p-value = 0.0000 suggesting the presence of volatility clustering despite the pre-test result. To assess model adequacy a post estimation ARCH-LM test was performed on the residuals, yielding non-significant results and F-stat p-value = 0.3048; ObsR-squared p-value 0.3054 confirming that the ARCH model successfully captured the time-varying volatility.

A GARCH(1.1) model was also estimated. However, the GARCH(1) term was statistically insignificant (p-value = 0.2180) supporting the choice of the simpler ARCH(1) model as a more parsimonious specification for the this context.

Table 12. ARCH Model Results

Variable	Coefficient	Std. Error	z-Statistic	Prob.

LnFX	-1.376256	0.002209	-622.9743	0.0000
Constant (C)	1.887561	0.002502	754.5428	0.0000
ARCH Variance Equation (Volatility Dynamics)				
RESID(-1)^2	1.041881	0.092673	11.24258	0.0000
Constant	5.80E-05	1.04E-05	5.605810	0.0000

Conclusion

This study provides robust evidence of a dynamic and asymmetric relationship between stock prices and exchange rates in Türkiye from February 2020 to May 2024. The ARDL analysis demonstrates bidirectional short-run feedback between the two markets, while long-run effects are predominantly driven by exchange-rate movements. Specifically, a 1% appreciation in the Turkish Lira is associated with a 1.498% decline in stock prices, reflecting the negative impact of a stronger currency on export-oriented firms. Stock prices, in turn, exert limited long-term influence on exchange rates, highlighting the market's sensitivity to macroeconomic conditions.

The NARDL results reveal significant asymmetries: currency appreciation negatively affects stock prices more strongly than depreciation (-1.91% vs. -1.72%), indicating heightened investor sensitivity to adverse macroeconomic developments. Short-run adjustments further show that depreciation may temporarily support stock prices, reflecting adaptive market behavior. Stock-oriented NARDL confirms that equity market shocks can influence currency fluctuations, though these effects are largely short-lived.

Volatility analysis via the ARCH model underscores the clustering of shocks, with exchange-rate fluctuations amplifying stock-market volatility (coefficient = 1.042), emphasizing the market's vulnerability during periods of economic and geopolitical uncertainty.

The findings contribute to the literature by explicitly capturing asymmetric, bidirectional, and volatility-driven dynamics in an emerging-market context. For policymakers, stabilizing exchange rates and addressing structural vulnerabilities are crucial to mitigating financial instability. For investors, understanding asymmetric responses and volatility clustering enables more effective risk management, hedging, and portfolio strategies. Finally, future research could extend this analysis by incorporating high-frequency trading data or exploring sector-specific responses to exchange-rate shocks, further enriching understanding of Türkiye's evolving financial landscape.

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Yazar Katkısı: Nazir Ahmad MUJADDADI: %100

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Etik Onay: Bu çalışma etik onay gerektiren herhangi bir insan veya hayvan araştırması içermemektedir.

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