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DYNAMICS OF STOCK PRICES AND EXCHANGE RATE WITH STRUCTURAL BREAKS AND ASYMMETRY: EVIDENCE FROM TÜRKİYE[*]

Hisse Senedi ve Döviz Kuru Dinamiklerinin Yapısal Kırılmalı ve Asimetrik İncelemesi: Türkiye'den Kanıtlar

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JEL Codes:
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Abstract

This study investigates the impacts of the nominal exchange rate on Turkish stock prices using a structural break cointegration test with endogenously determined multiple structural breaks and an asymmetric cointegration test for the period of 2002-2021. The study differs from previous research on this relation in two respects. First, it takes into account structural breaks in relation to both regimes and trends (C/S/T). Second, it extends the asymmetric cointegration with multiple structural breaks. The findings of structural break cointegration capture the break dates in line with the Turkish economics dynamics and reveal the negative effects of the exchange rates on stocks, with their significance and magnitude differing in regimes. Similarly, NARDL results indicate that negative and positive exchange rate shocks exhibit asymmetric effects on stocks for both the whole period and regimes. The overall findings demonstrate that exchange rate variations have distinctive impacts on stock prices when considering structural break and asymmetrical dynamics. In this background, policymakers and foreign investors need to take into account these dynamics when dealing with Turkish financial markets.

Anahtar Kelimeler:
Hisse Senedi Fiyatları,
Döviz Kuru,
Çoklu Yapısal Kırılmalı Eşbütünleşme,
NARDL.

JEL Kodları:
E44, F31, G11

Öz

Bu çalışma, nominal döviz kurunun Türkiye hisse senedi fiyatları üzerindeki etkisini içsel belirlenen çoklu yapısal kırılmalı eşbütünleşme ve asimetrik eşbütünleşme testlerini kullanarak 2002-2021 dönemi için incelemektedir. Çalışma, Türkiye ekonomisinde iki değişken arasındaki ilişkiyi ele alan literatürden iki açıdan farklılaşmaktadır. İlk olarak, rejim ve trenddeki (C/S/T) çoklu yapısal kırılmaları dikkate almaktadır. İkincisi, asimetrik eşbütünleşme testini rejim ve trenddeki çoklu yapısal kırılmalarla genişletmektedir. Çoklu yapısal kırılmalı eşbütünleşme testi bulguları, Türkiye ekonomisi dinamikleriyle uyumlu kırılma tarihlerini yakalamakta ve döviz kurunun hisse senetleri üzerinde negatif etkilere sahip olduğunu göstermektedir. Etkinin büyüklüğü ve anlamlılık derecesi rejimlere göre farklılık sergilemektedir. Asimetrik eşbütünleşme test sonuçları hem tüm dönem hem de yapısal kırılmaların dikkate alındığı alt rejimler için negatif ve pozitif kur şoklarının hisse senedi üzerinde asimetrik ve genellikle negatif etkilere sahip olduğunu göstermektedir. Genel bulgular, döviz kurunun hisse senedi fiyatları üzerindeki etkisinin, yapısal kırılma ve asimetrik dinamikler dikkate alındığında hem yön hem de anlamlılık açısından farklı olabileceğine işaret etmektedir. Bu bağlamda, politika yapıcılar ve yabancı yatırımcıların Türk finansal piyasalarıyla ilgilenirken bu dinamikleri dikkate almalarının önem arz ettiği düşünülmektedir.

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1. Introduction

The ongoing liberalizations on trade and financial markets have led many countries worldwide to reduce capital restrictions and exchange rate market interventions (Phylaktis and Ravazzolo, 2005). Similarly, a significant and strategic interdependence between stock and foreign exchange markets has received great attention due to decrease in financial autarky and the adoption of floating exchange rate regimes (Adekoya, 2020). Determining the characteristics of this relation between these two markets is crucial for policy making process since shocks transmit their spillover effects to other markets (Mishra, 2004; Chkili and Nguyen, 2014). Consequently, financial markets cannot be considered independent of exchange rate movements (Fasanya and Akinwale, 2022).

Exchange rates and stock prices matter due to the information they carry about resource allocation through price mechanisms in open market economies. While the former affects resource allocation through the terms of trade, competitiveness and the purchasing power of the country's currency, the latter plays a significant role in the allocation of resources as they represent sources of funds and firm values. After all, currency flows have impact on stock prices through international competitiveness and the balance of trade, and stock prices have impact on exchange rates through asset returns and domestic currency demand. Therefore, there is a vast empirical literature attempting to reveal the dynamics of relationship between stock prices and exchange rates (e.g., Bahmani-Oskooee Sohrabian, 1992; Ajayi, Friedman, and Mehdian, 1998; Stavárek, 2005; Rahman and Uddin, 2009; Lean, Narayan, and Smyth, 2011). Most of these empirical studies are conducted using standard time series techniques based on the assumptions that imply negative and positive changes of the one variable affect other in a similar vein (symmetric).

However, the asymmetrical features of this relation have been discussed in the literature for many years within the framework of approaches such as asymmetrical hedging (Miller and Reuer, 1998; Griffin and Stulz, 2001), pricing-to-market (Marston, 1990; Knetter, 1994) and hysteresis effect (Baldwin, 1988; Ljungqvist, 1994; Christophe, 1997). These approaches emphasize at micro level by cash flows, default risks, currency of liability and asset holdings, exporting/importing characteristics of firms as the source of the asymmetry. Similarly, Bahmani-Oskooee and Saha, (2015, 2016a, 2016b, 2018) point out that the effects of the appreciation or depreciation of the domestic currency on stock prices may vary depending on the country's sectoral distribution and whether it exhibits characteristics of being an exporter or importer at macro level. The standard time series techniques neglect this asymmetrical feature which may cause biased results. In order to preclude biased estimation, methods such as non-linear autoregressive distributed lag (NARDL) has become current issue (e.g., Bahmani-Oskooee and Saha, 2015, 2016a, 2016b, 2018, Bhottu and Chang, 2019; Adekoya, 2020; Nusair and Olson, 2020; Nusair and Al Khasawneh 2022; Kassouri and Altintas, 2020).

Moreover, the financial crises that occurred in the 1997 and 2008 led to increase in discussion the effects of the crises and structural changes such as huge amount capital flows, financial liberalization, deregulations, the transition from fixed exchange rate to flexible exchange rate regime and their spillover effect on the economies especially in emerging markets (Diamandis and Drakos, 2011; Lin, 2012; Fowowe, 2015; Nguyen, 2019; Adekoya, 2020). Hence, the empirical literature on this subject also suggests that the estimation processes need to take into account structural breaks. For example, Moore and Wang (2014) recommend determining the break dates endogenously by structural break methods in order to explain the nature of financial markets. Similarly, Fawowe (2015) proposes the econometric models with structural breaks by stating that models that do not take into account the structural breaks caused by the impact of the recent global financial crisis on financial markets may yield misleading results in financial market analysis. Correspondingly, studies such as Adekoya (2020), Fasanya and Akinwale (2022), Nusair and Al-khasawneh (2022) and Nusair and Olson (2022) determine the break dates endogenously by Bai-Perron (1998, 2003) structural break tests in their asymmetric analysis.

Türkiye as an emerging economy provides a suitable case for examining the effects of exchange rate on stock prices based on the asymmetry and structural breaks. The focus on exchange rate in the analyzing stock prices using such a modelling is rooted from several reasons attributed to the economic dynamics and empirical literature. First, a severe financial crisis in 2001 led to structural changes in the Turkish economy such as the abolition of the fixed exchange rate system and the promotion of financial liberalization (Alkan and Çiçek, 2020). These structural changes, combined with favorable global financial conditions, have increased the foreign portfolio investments towards the Turkish financial markets. Although the Turkish lira maintained a stable image between 2002 and 2014 by ranging around 1.40–2.10 USD/TRY, it suffered from depreciation and its volatility has shown an increasing trend after 2015 (Tarakçı et al., 2022), even more severe after 2018. Similarly, the BIST 100 index has been in an upward trend in the long-run ranging from about 100 to 1400 between 2001 and 2021, but it incurred enormous losses during the great recession and has become highly volatile during the COVID-19 pandemic. Furthermore, Başçı and Kara (2011) and Özatay (2011, 2012) also indicate that the nontraditional policies are implemented by the CBRT (Central Bank of the Republic of Türkiye) after the 2008 financial crisis to prevent capital flow and currency-induced financial instability are important as they point to a new policy understanding. This observed volatility of the exchange rate and BIST 100 index implies that some notable incidents may have led to structural breaks and asymmetrical feature within the covered period.

Second, most of the empirical studies implemented for the Turkish economy fail to incorporate asymmetric dynamics within the structural break framework. These studies do not determine potential breaks endogenously and do not consider the asymmetry within the regimes in the presence of structural breaks (e.g., Yıldırım and Adalı, 2018; Tiryaki et al., 2019; Kassouri and Altıntaş, 2020; Genç and Öztürk, 2021). The study extends this literature by including these features and incorporates the endogenously determined multiple structural breaks and asymmetrical dynamics within regimes.

The contribution of this study to the existing body of knowledge is evident in its distinct approaches, as outlined below. Firstly, the study examines the long-run impact of the exchange rate on stock prices for Turkish economy using the version of Kejriwal (2008) cointegration test with endogenously determined multiple structural breaks augmented with a deterministic trend (C/S/T) by Lopcu et al. (2013), departing from the existing empirical literature. Secondly, this study employs the nonlinear autoregressive distributed lag (NARDL) cointegration test proposed by Shin et al. (2014) and NARDL with structural breaks following studies such as Adekoya (2020), Fasanya and Akinwale (2022), Nusair and Al-khasawneh (2022) and Nusair and Olson (2022). Furthermore, the study distinguishes from these studies by augmenting the NARDL model to account structural breaks in regime and trends (C/S/T). Considering the characteristics of the Turkish economy, the use of methods that allow to identify breaks in regime and trends, which have not been presented in previous literature, is expected to yield more effective results.

The remaining sections are organized as follows. Section 2 discusses the relevant literature, Section 3 clarifies the data and the methodology, Section 4 presents the empirical results and Section 5 concludes the study.

2. Literature Review

The relationship between stock prices and exchange rate is one of the most studied topics in finance literature. In the following, this comprehensive literature is classified according the assumptions/methods such as micro or micro level, asymmetric or structural breaks, they based on[1].

First group of studies deal with the asymmetric relationship between stock prices and exchange rate at micro level. Since the asymmetrical literature has advanced in the beginning of 1990s, studies such as Goldberg (1995), Miller and Reuer (1998), Apergis and Rezitis (2001) Koutmos and Martin (2003), and Hsu, Yau and Wu (2009) analyzed the asymmetrical relationship between exchange rates and stock prices based on asymmetrical hedging, pricing-to-market and hysteresis effect on a micro level. Goldberg (1995) referred to pricing-to-market behaviors and revealed that the American automobile industry to be less effected by the strengthening the domestic currency than German and Japanese cars. Similarly, Miller and Reuer (1998) analyzed the asymmetric reactions of stock prices of the US manufacturer firms on exchange rates. They indicated that if the firms used real options to hedge their economic exposures to exchange rate movements, then different exposure coefficients were to be expected for periods of currency appreciations and depreciations. Apergis and Rezitis (2001) revealed asymmetric volatility spillovers from exchange rate deviations to stock markets for New York and London foreign exchange and equity market. Koutmos and Martin (2003) discovered widespread asymmetric exposures within the financial sector due to asymmetrical hedging and within the consumer non-cyclical sector due to asymmetric pricing-to-markets and/or hysteretic behaviors for the advanced economies. Hsu, Yau and Wu (2009) analyzed the effects of exchange rates on stock returns for 33 Japanese sectoral stocks and discovered significant asymmetric responses in the pharmaceutical, real estate, and air transportation industries

Second group of studies focus on the asymmetric relationship between stock prices and exchange rate at macro level. Bahmani-Oskooee (2015 and 2016b) investigated the possible symmetric and asymmetric effects of exchange rate changes on stock prices for the US economy. While Bahmani-Oskooee (2015) reported no significant long-run cointegration relationship between the variables, in their sectoral analysis Bahmani-Oskooee and Saha (2016a) reached statistically significant asymmetric effects for ten sectors in the short-run and for six sectors in the long-run. Their findings showed that dollar depreciation has a positive impact on stock prices and dollar appreciation does not have any impact in the long-run. Bahmani-Oskooee and Saha (2016b) investigated the relationship for several countries and showed that exchange rates have asymmetric effects on stock prices, though effects were mostly in the short-run. Additionally, Bahmani-Oskooee and Saha (2018) reexamined the asymmetric relationship for different countries and revealed short-run asymmetry for six countries and long-run asymmetry for two countries. The negative coefficients for positive and negative shocks indicate that the depreciation

[1] Readers may view some of these empirical studies and their implications in Table C in Appendix III.

of the domestic currency (negative shocks) to have higher pressure on stock prices. Supporting these findings, Bhutto and Chang (2019) reveal that the exchange rate has an asymmetric effect on stock prices, and the financial crisis influences asymmetric relations for China. For four Asian countries, Sheikh at. al (2020) report the asymmetric exchange rate effect on stock indices indicating that depreciation have harmful effect on the firm relying on the imported products. Siew-pong et al. (2021) conclude that only appreciation has a significant effect on the stock prices for ASEAN-5 countries.

Third group of studies analyze the effect of structural breaks or changes on this relation. Pan, Fok and Liu (2007) assert some mixed results for Hong Kong, Japan, Malaysia, Thailand, Korea and Singapore. They report that dynamic relationship changes depending on the exchange rate regime, the degree of financial liberalization and the size of the equity market. Lin (2012) reports the importance of financial crises on the relation for 6 emerging Asian countries. The relation gets stronger during a period of crisis depending on the contagion or spillover between asset prices. Similarly, Moore and Wang (2014) find a dynamic negative relationship between some advanced economies and emerging Asian countries. Driving forces are the trade balances for the emerging countries and the interest rate differences for the advanced countries. Fowowe (2015) points out the mixed results indicating that international stock markets are driving both the Nigeria and South African stock market. Sui and Sun (2016) reach similar results for BRICS countries. Zeren and Koç (2016) report two-way causality indicating significant effects of the global and local crises for Japan, England and Türkiye. Both studies conclude that the relationship gets stronger during the period of crisis depending on the contagion, spillover between asset prices or volatility. Nguyen (2019), supporting these findings, indicates the mixed results for emerging and advanced countries for the whole period and during the crises. The exchange rate has a positive effect on the domestic stock prices for all countries after the crisis except the United Kingdom. Similarly, Gokmenoglu et al. (2021) show the significant effects of the exchange rate flexibility on the stock market depending on the bearish or bullish conditions for ten emerging countries including Türkiye.

Some studies also focus on the asymmetric relation in the presence of structural breaks, this study also based on. Nusair and Olson (2022) find that change in exchange rates has short run effect on the stock in G7 countries except for Italy while stock price has long run and short run effects on exchange rate. Correspondingly, Fasanya and Akinwale (2022) conclude that changes in the exchange rate effect sectoral stock prices in case of asymmetry and structural breaks for Nigeria. Similarly, based on the asymmetry with structural breaks analyzes Adekoya (2020) and Nusair and Alkasawneh (2022) report the asymmetric findings for Nigeria and ASEAN-9 countries, respectively.

There are various empirical studies on the relationship between stock prices and exchange rate for the Turkish economy. First group of studies investigates the asymmetric or structural break causality between stock prices and exchange rates. For example, Ürkmez and Karataş (2017) point out the effect of global crisis in the long-run and conclude that there is causality from exchange rate to stock price. Based on the nonlinear causality test, Karadağ and Sekmen (2021), Kılıç and Naimoğlu (2022) and Sertkaya and Songur (2021) conclude that there exists two-way asymmetric causality between different signs of shocks, while Yıldırım and Adalı (2018) report one-way causality from stock prices to exchange rate. Durgun and Temurlenk (2021), Kılıç and Naimoğlu (2022) and Sertkaya and Songur (2021) also highlight the effects of domestic and international developments on stock prices and exchange rates via the financial market volatilities.

Second group of studies investigates the long-run asymmetric relation using the NARDL model. For example, Tiryaki et al. (2019) find the asymmetric long-run effects of the exchange rate on stock returns, which are larger after the 2002 period compared to full period of 1994-2017. The findings indicate that appreciation of Turkish Lira increases stock prices. Kaya and Soybilgen (2019) determined asymmetric relation both in the short and long-run, which the decreases (increases) of the stock prices in case of depreciation (appreciation) of Turkish Lira. Benli et al. (2019) reports asymmetric effects of exchange rate on stock prices in ten (six) sectors in the short (long) run. Supporting this findings, Ürkmez and Bölükbaşı (2021) find that the asymmetric effects of exchange rate on all stock indices in the short-run and on the technology sector in the long-run. In another study, Kassouri and Altıntaş (2020) report a long-run asymmetric relation. Although the effects of appreciation on stock prices are negative, the effects of appreciation are insignificant, which is implying the evidence of incomplete exchange rate pass-through in Türkiye. Differently, the findings of Genç and Öztürk (2021) report that the increase in the stock market in the pre-2013 period affected the exchange rate negatively. In the Hatemi j causality results, it is observed that there is only causality from the positive shocks in the exchange rate to the positive shocks in the BIST100 index.

3. Model, Data and Methodology

3.1. Model and Data

To analyze the effects of the exchange rate changes on stock prices in the presence of asymmetric dynamics and structural breaks for the Turkish economy, the functional form of the bivariate model is formed following Bahmani-Oskooee and Saha (2018), Nusair and Al-khasawneh (2022), Nusair and Olson (2022).

$$sp_t = \mu_1 + \delta_i trend + \beta_i exc_t + e_t \qquad (1)$$

The variables are in natural log forms and seasonally adjusted. The *sp* and *exc* denote stock prices and nominal exchange rates, respectively. The notations *t* and *i* represent the time and the regime denominator. The stock prices (sp) are expressed BIST 100 index which contains the stocks of the most successful 100 firms in the Borsa Istanbul. The exchange rate (exc) represents the value of one unit of the US dollar in terms of Turkish lira that implying an increase in the exchange rate indicates a depreciation of the TL and a decrease in the exchange rate indicates an appreciation of the TL. The data of both series are acquired from the Electronic Data Delivery System of the CBRT. The analysis period captures from January 2002 to February 2021. The available data after the 2021:02 are excluded to avoid drastic changes caused by exchange rate turbulence during COVID-19 pandemic.

3.2. Methodology

The analysis part of the study consists of three stages. In the first stage, to test whether the effect of the exchange rate on stocks changes across regimes, it is applied the Lopcu et al. (2013) cointegration test, which allows for the investigation of long-term relationships in the presence of multiple structural breaks in trend and regime (C/S/T). In the second stage, NARDL model, which allows for an asymmetric long-term relationship, is estimated to test whether the effects of the depreciation and appreciation of the local currency on stocks differ. In the third stage, it is analyzed whether the asymmetric relationship differs across regimes in the presence of breaks in trend and regime (C/S/T). For this purpose, the NARDL model is augmented and estimated using the trend and regime break dates obtained from the first stage. It is thought that modeling both breaks and asymmetry together provide clues about the robustness of both the structural break and the asymmetric relationship.

A cointegration model with multiple structural breaks

As discussed in the previous sections, determining the structural breaks endogenously is important for estimating the nature of financial markets accurately (Moore and Wang, 2014; Fowowe, 2015; Fasanya and Akinwale, 2022; Nusair and Al-khasawneh, 2022; and Nusair and Olson, 2022). While Kejriwal's (2008) cointegration test is based on Gregory-Hansen's (1996a) regime shift (C/S) model for identifying structural change stability, Lopcu et al. (2013) allow shifts in the trend (C/S/T) as well. Therefore, in the first stage, the Kejriwal (2008) cointegration test with endogenously determined multiple structural breaks augmented with a deterministic trend by Lopcu et al. (2013) is used to analyze whether the effects of exchange rates changes in regimes. The cointegration equation based on the regime and trend shift model (C/S/T) is defined as;

$$sp_t = \mu_j + \delta_j trend + \beta_j exc_t + e_t \quad (2)$$

$$if\ T_{j-1} < t \leq T_j \qquad for \quad j = 1, 2, \dots, k+1$$

where, k is the number of breaks, μ is the constant term, δ are the trend coefficients, and β are the slope coefficients, t shows the time period, and T is the sample size by convention, $T_0 = 0$ and $T_{k+1} = T$.

To maintain the stability of the relation and the selection of the number of break, three types of test statistics is considered following Kejriwal and Perron (2010). The first is $SubF$ of the null hypothesis of no structural break against the alternative hypothesis of k breaks. The second is UD_{max} test statistics. The null hypothesis in the UD_{max} test statistic denotes the absence of a structural break, while the alternative hypothesis denotes the presence of an unknown number of breaks. The third involves a sequential procedure (SEQ) that analyzes the null hypothesis of k breaks against the alternative hypothesis of $k+1$ breaks.

Two information criteria are used to determine the number of breaks. The first of these information criteria is the Bayesian Information Criterion (BIC) developed by Yao (1988), the second is the LWZ criterion developed by Liu et al. (1997) and is a modified version of the Schwarz information criterion.

The test statistic with *k* breaks is given by:

$$\tilde{V}_k(\hat{\lambda}) = \frac{T^{-2} \sum_{t=1}^{T} S_k(\hat{\lambda})^2}{\Omega_{11}} \quad (3)$$

where Ω_{11} is a consistent estimation of the long-run variance of u_t^*, $\hat{\lambda} = (\hat{T}_1/T, \dots, \hat{T}_k/T)$ and $\hat{T}_1, \dots \hat{T}_k$ are obtained by minimizing the sum of the squared residuals. The null hypothesis of the test is cointegration with the structural breaks between series against the alternative hypothesis of no cointegration.

To obtain long run coefficients in the presence break in regime and trend, it is used dynamic OLS regression (DOLS), where the leads and lags of the first differences of the regressors deal with the simultaneity bias, as stated by Kejriwal and Perron (2008, 2010). The leads and lags are equal to one.

$$sp_t = \mu_j + \delta_j trend + \beta_j exc_t + \sum_{j=-l_T}^{l_T} \Delta exc_{t-j}\psi_j + e_t \tag{4}$$

A non-linear cointegration model without and with structural breaks

In the second stage, it is estimated the NARDL technique proposed by Shin et al. (2014) to obtain the asymmetric effects of exchange rate on stock prices. The estimated NARDL model;

$$\begin{aligned}\Delta sp_t = \mu + \beta_1\, sp_{t-1} + \beta_2 exc_{t-1}^{+} + \beta_3\, exc_{t-1}^{-} + \sum_{i=1}^{m} \beta_{4,i} \Delta sp_{t-i} \\ + \sum_{i=0}^{n} \beta_{5,i} \Delta exc_{t-i}^{+} + \sum_{i=0}^{q} \beta_{6,i} \Delta exc_{t-i}^{-} + e_t\end{aligned} \tag{5}$$

where, $exc_i^{+} = \sum_i^t \max(\Delta\, exc_i^{+}, 0)$ and $exc_i^{-} = \sum_i^t \max(\Delta\, exc_i^{-}, 0)$ are the cumulative positive (appreciations) and negative (depreciations) in domestic currency, respectively. β_1, β_2 and β_3 are the long-run coefficients; β_4, β_5 and β_6 are the short-run coefficients, and m, n and q are the optimal lags selected by AIC.

The long-run cointegration is established rejecting the null of no-cointegration $(\beta_1 = \beta_2 = \beta_3 = 0)$. Decision to reject the null hypothesis of no cointegration is taken on the basis of upper and lower bounds as already considered in the case of the ARDL model. Then, long-run $-{}^{\beta_2}/_{\beta_1} = -{}^{\beta_3}/_{\beta_1}$ and short-run $\left(\sum_{i=0}^{n} \beta_{5,i} = \sum_{i=i}^{q} \beta_{6,i}\right)$ asymmetry are tested by standard Wald test statistics. In a similar way, long-run $-{}^{\beta_2}/_{\beta_1} = 0, -{}^{\beta_3}/_{\beta_1} = 0$ and short-run $\sum_{i=0}^{n} \beta_{5,i} = 0,\ \sum_{i=i}^{q} \beta_{6,i} = 0$ asymmetric coefficients are obtained.

In the third stage, the NARDL model is augmented with structural breaks both in regime and trend (C/S/T) using the endogenous break dates obtained from the first stage following Fasanya and Akinwale (2022), Nusair and Al-khasawneh (2022), and Nusair and Olson (2022). The model in this study differs from these studies by taking into account breaks in regimes and trend. The NARDL model with structural breaks is shown in Equation (6).

$$\begin{aligned}\Delta sp_t = \mu_j + \delta_j trend + \beta_1 sp_{t-1} + \beta_{2,j}\, exc_{j,t-1}^{+} + \beta_{3,j}\, exc_{j,t-1}^{-} + \sum_{i=1}^{m} \beta_{4,i} \Delta sp_{t-i} \\ + \sum_{i=0}^{n} \beta_{5,ji}\, \Delta exc_{j,t-i}^{+} + \sum_{i=0}^{q} \beta_{6,ji}\, \Delta exc_{j,t-i}^{-} + e_t\end{aligned} \tag{6}$$

where μ and δ are the constant and trend coefficients, respectively. j is the number of regimes, $j = 1, 2, \ldots, k+1$. Accordingly, $\beta_{2,j}$ and $\beta_{3,j}$ represent the long-run dynamics of exc^{+} and exc^{-} for each regimes. The definitions of the parameters follow the NARDL without structural breaks model.

4. Estimation Results

In this section, the bivariate model demonstrated in Equation (1) is used to determine the relationship between stock prices and exchange rate that depend on the structural breaks and asymmetry.

4.1. Unit Root Test Results

In the first stage, linear, structural break, and nonlinear unit root tests that consider the different structures of the variables were conducted. According to NG-Perron (2001) results, given in Table 1, the SP and EXC series has a unit root at all significance levels.

Table 1. NG-Perron (2001) Unit Root Test

		Constant and Trend		
Variables	**MZ_a**	**MZ_t**	**MSB**	**MPT**
EXC	-0.97	-0.46	0.47***	48.84***
SP	-7.40	-1.90	0.25***	12.34***
1%	-23.80	-3.42	0.14	4.03
5%	-17.30	-2.91	0.16	5.48
10%	-14.20	-2.62	0.18	6.67

Note: Critique values are obtained from Ng-Perron (2001). Significance levels: (*), (**) and (***) denote 10%, 5% and 1% level, respectively.

The presence of structural breaks effects the results of traditional unit root tests; therefore, a unit root test that accounts for structural breaks was also applied. As can be seen from Table 2, Zivot-Andrews test indicates that both series are non-stationary in the presence of a structural break.

Table 2. Zivot- Andrews (1992) Unit Root Test with Structural Breaks

Variables	**k**	**TB**	**δ**
EXC	2	2010:07	-3.55 (0.16)
SP	1	2005:05	-2.98 (0.25)

Note: k, TB and δ denotes optimal lag length, break date and ZA test statistics, respectively. Critical values are obtained from Zivot – Andrews (1992). Critical values for 1%, 5% and 10% significant levels are -5.57, -5.08 and -4.82 respectively.

Economic time series may exhibit nonlinear characteristics in certain cases. Traditional and structural break unit root tests do not consider for nonlinearity. Table 3 indicates that KSS and Kruse tests, which consider nonlinear components, also suggest that the series have unit roots.

Table 3. KSS (2003) and KRUSE (2011) Nonlinear Unit Root Test

Variables	**KSS (2003)**		**Kruse (2011)**	
	k	**KSS_t**	**k**	**$KRUSE_t$**
SP	12	-2.80	12	7.80
EXC	6	-2.46	6	6.69

Note: KSS (2003) test critical values are -3.93, -3.40 and -3.13 for 1%, 5%, and 10%, respectively. KRUSE (2011) test critical values are 17.10, 12.82 and 11.10 for 1%, 5% and 10%, respectively.

4.2. A Cointegration with Multiple Structural Breaks Results

In the first stage, the structural change test proposed by Kejriwal and Perron (2010) is used to identify the number of breaks. Table 4 shows the results of $SubF$, UD_{max}, the sequential procedure and information criteria, BIC and LWZ. Based on the $SubF$ and UD_{max} results, at least one provides evidence against the stability of the long-term relation. Sequential procedure selects no break while BIC and LWZ select four and three breaks, respectively.

Table 4. Structural Break Tests Results

(C/S/T)	**SubF(1)**	**SubF(2)**	**SubF(3)**	**SubF(4)**	**SubF(5)**	UD_{max}	**SEQ**	**BIC**	**LWZ**
model	9.33*	6.52	6.04	5.65	4.17	9.33	0	4	3

Note: Critical values are from Kejriwal and Perron (2010) ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

The results of Lopcu et al. (2013) cointegration test with multiple structural breaks in regime and trend, taking into account the number of breaks determined by BIC and LWZ criteria, are reported in Table 5. Critical values are obtained by simulations for break fractions using 100 steps and 2500 replications. According to three and four breaks cointegration tests, the null of cointegration rejects it only at the 10% level. To briefly state, the findings reveal the existence of long-run relationship between exchange rate and stock prices by this result.

The structural break dates endogenously determined are also given in Table 5. These dates can be linked to certain economic conditions in Türkiye and may explain the reasons behind the structural breaks. 2005 was an important year for both Türkiye and European Union as negotiations for Türkiye's full membership were started on 3 October 2005. This progress led extensive foreign portfolio investments to flow on Borsa Istanbul. It is supposed that these foreign investment movements are the reason behind the structural break of 2005:11. It is presumed that the Great Recession of 2008-2009 is the driving force for the second structural break of 2009:02. The Great Recession that harmed the Turkish economy is supposedly caused a structural break. The 3rd structural break dates differ as whether the cointegration test results attribute total of 3 (2015:01) or 4 (2014:03) structural break points. The economy of Türkiye regained its recovery after the Great Recession of 2008-2009 until the 2014-2015 political instability. After the 3rd structural break, the Turkish lira experienced enormous depreciation while BIST 100 index held steady. After the 4th structural break of 2017:01, the deprecation of Turkish lira has continued even further. The July 2016 coup attempt's lagged effect is considered to be the main reason behind this structural break.

Table 5. Cointegration with Multiple Structural Breaks Results

	3 Structural Breaks				**4 Structural Breaks**				
(C/S/T)	$\tilde{V}_3(\tilde{\lambda})$	**T_1**	**T_2**	**T_3**	$\tilde{V}_4$	**T_1**	**T_2**	**T_3**	**T_4**
	0.022**	2005:11	2009:02	2015:01	0.023**	2005:11	2009:02	2014:03	2017:01
***1%	0.033				0.031				
**5%	0.024				0.024				
*10%	0.021				0.018				

Note: T_1, $T_{2,...,}$ T_4 are break dates. ** denote significance levels at 5%.

The long run coefficients for each regime are estimated by the dynamic OLS and the results are shown in Table 6. Three different regression results are reported, with 3 structural breaks (4 regimes based on the LWZ criteria), with 4 structural breaks (5 regimes based on the BIC criteria) and with dummy variable covering March 2020 (the first wave of Covid pandemic) within 4th structural breaks. For the first regression with 3 structural breaks, every constant, trend and slope coefficients are estimated to be statistically significant at 1% level. The results show that the slope coefficients of exchange rate on stock prices in every regime are negative; chronologically -1.09 (1st regime), -1.70 (2nd regime), -2.43 (3rd regime) and -0.59 (4th regime). For the second regression with 4 structural breaks, the constant terms in every regime are statistically significant, and the trend and the slope coefficients give statistically significant results except for the 4th regime. Every statistically significant slope provides negative coefficients; chronologically -1.11 (1st regime), -1.71 (2nd regime), -2.58 (3rd regime) and -0.76 (5th regime). And for the third regression, results only slightly differ from the second regression with structural breaks. According to the results, the dummy variable that covers the COVID-19 shutdown in March 2020 for Türkiye is statistically significant at %10 level and has a negative coefficient of -0.22. The shutdown in Türkiye due to the COVID-19 pandemic has negatively affected the stock performance of BIST.

Table 6. Dynamic OLS Results

$sp = \mathrm{f}(\mathrm{exc})$										
$y_t = \{sp_t\}$	μ_1	μ_2	μ_3	μ_4	μ_5	δ_1	δ_2	δ_3	δ_4	δ_5
$\hat{T}_{1,4}$	4.85 (0.00)	7.13 (0.00)	4.78 (0.00)	4.63 (0.00)	–	0.02 (0.00)	-0.00 (0.00)	0.02 (0.00)	0.01 (0.00)	–
$\hat{T}_{1,5}$	4.86 (0.00)	7.14 (0.00)	4.84 (0.00)	6.50 (0.00)	4.73 (0.00)	0.03 (0.00)	0.03 (0.00)	0.02 (0.00)	0.01 (0.54)	0.00 (0.00)
$\hat{T}_{1,5}^{D}$	5.01 (0.00)	7.33 (0.00)	4.82 (0.00)	6.41 (0.00)	4.74 (0.00)	0.02 (0.00)	-0.01 (0.00)	0.02 (0.00)	-0.01 (0.54)	0.01 (0.00)
$y_t = \{sp_t\}$	β_1	β_2	β_3	β_4	β_5	$D_{2020:03}$				
$\hat{T}_{1,4}$	-1.09 (0.00)	-1.70 (0.00)	-2.43 (0.00)	-0.59 (0.00)	–	–				
$\hat{T}_{1,5}$	-1.11 (0.00)	-1.71 (0.00)	-2.58 (0.00)	-0.27 (0.34)	-0.76 (0.00)	–				
$\hat{T}_{1,5}^{D}$	-1.47 (0.00)	-1.93 (0.00)	-2.70 (0.00)	-0.44 (0.33)	-0.73 (0.00)	-0.22 (0.06)				

The findings obtained from the cointegration test with multiple structural breaks generally indicate that the appreciations of TL lead to a decrease in the BIST 100 index by varying its magnitude and significance in regimes. Considering the break dates (and regimes), results point out that some factors such as internal and external developments (shocks), political (in)stability, capital inflows, and currency volatility may lead to changes in the effects of the exchange rates on stock prices. The findings are also parallel with Zeren and Koç (2016) and Gökmenoglu et al. (2021) that the effect of exchange rate on stock prices differs due to crises, structural changes, or economic cycles in Türkiye.

4.3. A Non-linear Cointegration Test Results

In the second stage, the NARDL model in Equation (5) is estimated to see whether the effects of positive and negative changes in exchange rate differ on stock prices and report the results in Table 7 (NARDL without structural break). The critique value of F-statistics of estimation strongly provides evidence in support of the long-run relationship between stock prices and exchange rate[2]. LM and White tests show that residuals within the model do not possess autocorrelation and heteroscedasticity. In appendix II, graph A shows that the CUSUM lies within the critical bounds which mean that the coefficients of the model are stable. DW_{LR} and DW_{SR} statistics provide results in favor of the long-run and short-run asymmetry, respectively. It should be noted that the coefficient of positive (negative) changes in the exchange rate is positive (positive) indicating that stock prices are influenced in the same direction when the Turkish lira depreciates (appreciates). The interpretations of the coefficients should be made in line with this.

As the results show that DW_{LR} and DW_{SR} statistics are significant and there is a short-run and long-run asymmetric relationship between stock prices and exchange rates. Thus, positive and negative changes in exchange rate have different effects on the stock price in both the short and long-run for the Turkish economy. In the long run, positive changes in exchange rate (L_{exc}^{+}) has a statistically significant positive effect on stock price (0.38). This indicates that one percentage depreciation of Turkish lira increases the stock price by 0.38%. However, negative changes in exchange rate (L_{exc}^{-}) is insignificant which indicates that the appreciation of Turkish lira does not have any significant effect on stock prices. In the short-run, on the other hand, negative changes in exchange rate (S_{exc}^{-}) has statistically significant effects which show that one percentage appreciation of Turkish lira increases stock prices by 1.38%. Findings set out that the appreciation of Turkish lira leads stock prices to increase in the short-run, which contrasts with the long-run results. Additionally, as seen in Table A in Appendix I, the COVID-19 pandemic dummy variable is statistically significant and has negative effects on stock prices in parallel with DOLS results (shown in Table 6). The findings are consistent with the results in Tiryaki et al (2019), Kaya and Soybilgen (2019), and Kassouri and Altıntaş (2020), and indicate the presence of asymmetric effects of the exchange rate on stocks.

Table 7. NARDL Results

Long-Run Coefficients	**Short-Run Coefficients**
L_{exc}^{+} =0.38 (0.08)	S_{exc}^{+} =0.02 (0.94)
L_{exc}^{-} =-0.41(0.35)	S_{exc}^{-} = -1.38 (0.00)
DW_{LR} = 11.66 (0.00)	DW_{SR} = 9.23 (0.00)
F statistics: 7.26 (0.00)	LM Test: 16.24 (0.18)
Error Correction: -0.21[-2.89] (0.00)	White Test: 31.19 (0.30)

Note: The critical values are taken from Pesaran et al. (2001) Table CI, Case III p. 300. Critical values for 1%, 5% and 10% significant levels are 6.84-7.84, 4.94-5.73 and 4.04-4.78, respectively. Values in parentheses are p-values. Short-run and long-run dynamics are given in the Appendix 1, Table A.

In the third stage, the NARDL model is augmented with structural breaks (five regimes, given in equation 6) using four endogenously determined breaks obtained from the first stage to

[2] Long-run and short-run dynamics of NARDL estimation procedure is shown at Table-A in the appendix I.

see whether the possible asymmetric effect of exchange rate on stock prices varies within regimes. The results of NARDL with structural breaks estimation are presented in Table 8 (NARDL with multiple structural breaks)[3]. According to the critique value of F-statistics of NARDL estimation, there is a long-run relationship between the variables. LM and White tests show that residuals within the model do not possess autocorrelation and heteroscedasticity. In Appendix II, graph B shows that the CUSUM lies within the critical bounds which means that the coefficients of the model are stable.

The long-run asymmetry test statistics of DW_{LR} indicate that every regime displays an asymmetrical feature. However, DW_{SR} tests statistics show that asymmetric dynamics occur only in the first two regimes. For the last three regimes, because statistically significant short run dynamics could not be estimated, DW_{SR} tests statistics are inestimable.

Table 8. NARDL with Structural Breaks Results

Regimes	Long-Run Coefficients	Short-Run Coefficients
2002:01–2005:11	DW_{LR} =35.98 (0.00) L^{+}_{exc} =-1.51 (0.00) L^{-}_{exc} = 0.33 (0.24)	DW_{SR} =12.25 (0.00) S^{+}_{exc} =1.93 (0.02) S^{-}_{exc} = -1.12 (0.01)
2005:12–2009:02	DW_{LR} =32.35 (0.00) L^{+}_{exc} =-0.51 (0.06) L^{-}_{exc} =1.33 (0.00)	DW_{SR} =18.46 (0.00) S^{+}_{exc} =-5.35 (0.00) S^{-}_{exc} =-12.31 (0.00)
2009:03–2014:03	DW_{LR} =19.56(0.00) L^{+}_{exc} =-1.97 (0.00) L^{-}_{exc} =-0.67 (0.05)	DW_{SR} = Inestimable* S^{+}_{exc} =-2.24 (0.00) S^{-}_{exc} = ----
2014:04–2017:01	DW_{LR} =26.76 (0.00) L^{+}_{exc} =-0.25 (0.41) L^{-}_{exc} =1.48 (0.00)	DW_{SR} = Inestimable S^{+}_{exc} =-0.03 (0.00) S^{-}_{exc} = ----
2017:02–2021:02	DW_{LR} =31.50 (0.00) L^{+}_{exc} =-0.05 (0.81) L^{-}_{exc} =1.75 (0.00)	DW_{SR} = Inestimable S^{+}_{exc} =-1.26 (0.00) S^{-}_{exc} =----
F statistics:	13.41 (0.00)	LM Test: 10.32 (0.24)
Error Correction:	-0.98 [-10.45] (0.00)	White Test: 33.61 (0.91)

Note: The critical values are taken from Pesaran et al. (2001) Table CI, Case V p. 301. Critical values for 1%, 5% and 10% significant levels are 3.93-5.23, 3.12-4.25 and 2.75-3.79, respectively. Values in parentheses are p-values. *Since there is no found short-run significant lags for negative shocks within 3rd, 4th and 5th regimes, the short-run asymmetry tests cannot be applied, and therefore coefficients for negative shocks are not demonstrated. Short-run and long-run dynamics are given in the Appendix I, Table B.

In the first regime (2002:01–2005:11), positive changes in exchange rate are statistically significant at 1% level and have a negative coefficient sign (–1.51), but the negative changes in exchange rate appear to be statistically insignificant. This indicates that one percentage depreciation of Turkish lira decreases the stock prices in the long-run. In the short run, positive and negative changes in exchange rates appear to be statistically significant, and depreciation and appreciation increase stock prices.

[3] Long-run and short-run dynamics of NARDL with structural breaks estimation procedure is shown at Table-B in the appendix I.

For the second regime (2005:12–2009:02), the long-run asymmetric effects of exchange rate on stock prices are statistically significant for both positive and negative changes in exchange rate. One percentage depreciation and appreciation of TL decreases the stock prices by 0.51% and 1.33 %, respectively. In the short run depreciation (appreciation) of TL decreases (increases) stock prices.

For the third regime (2009:03–2014:03), the positive and negative changes in the exchange rate are statistically significant and have negative signs. The long-run impact of the lira's depreciation (appreciation) on stock prices is estimated to be -1.97 (-0.67). These results indicate that a currency depreciation (appreciation) decreases (increases) the stock prices in the third regime. The positive changes in the exchange rate in the first three regimes accommodate compatible results that are all statistically significant at 1% level and have negative coefficients. Therefore, the long-run coefficients for the first three regimes indicate that BIST 100 index is more sensitive to the currency depreciation.

The positive changes in exchange rate provide no statistically significant effect for the fourth and fifth regimes (2014:04–2017:01 and 2017:02–2021:02). However, the negative changes in exchange rate are statistically significant at 1% level with positive signs by 1.48 % and 1.75% in two regimes, respectively. The results indicate that appreciation of TL decreases the stock prices in the last two regimes (2014:04–2021:02). Hence, findings highlight that stock prices have become more sensitive to the appreciation of the domestic currency in last two regimes.

To sum up the outcomes listed above, the effects of the positive exchange rate shocks are statistically significant in the first 3 regimes and statistically insignificant in the last 2 regimes. The effects of the negative changes in exchange rate are statistically significant in every regime except for the first one. The depreciations of TL are correlated with stock price declines in the first three regimes. During the appreciations, on the other hand, stock prices increase in the 3rd regime and stock prices decrease in the 2nd, 4th (at 10% level) and 5th regimes. Findings obtained from NARDL without and with multiple structural breaks are in line with studies by Tiryaki et al. (2019), Benli et al. (2019), Kassouri and Altıntaş (2020) and Ürkmez and Bölükbaşı (2021) in terms of achieving results such as asymmetry for the Turkish economy.

Overall findings from the model with multiple structural breaks are crucial in highlighting the potential variations in the sign and magnitude of asymmetric effects within regimes. For instance, contrary to the model without breaks that suggest that the appreciation of the domestic currency has no significant impact on stock prices, the model with structural breaks shows statistically significant effects for all regimes except for the first one. Similarly, unlike the model without breaks, the model with breaks indicates that the impact of the domestic currency on stocks is significant in the first three periods. Moreover, the coefficients obtained from the model with structural breaks demonstrate greater significance and magnitude. All these results emphasize the importance of considering structural breaks and asymmetry in stock price-exchange rate relation.

5. Conclusion

This paper examines the effects of exchange rate changes on stock prices in the presence of structural breaks and asymmetrical dynamics for Türkiye over the period of 2002:01-2021:02. Such an experiment is applicable and possesses critical implications due to Türkiye's own dynamics such as liberalization movement after the 2001 Turkish financial crisis, new policy approaches following the 2008 global financial crisis and increasing volatility of Turkish financial markets after 2015, encompassing the first wave Covid pandemic. For this purpose, it is estimated Kejriwal (2008) cointegration test with endogenously determined multiple structural breaks model augmented with a deterministic trend by Lopcu et al. (2013), and the NARDL asymmetric cointegration test without and with structural breaks.

The evidences based on the Lopcu et al. (2013) structural break cointegration test suggest that these two series are cointegrated in the presence of structural breaks that are in line with the Turkish economic dynamics. According to the results with three and four structural breaks (with or without dummy variable of 2020:03), every slope coefficient of sub-periods except for the 4th (2014:04–2017:01) sub-periods is negative and statistically significant at 1% level. The results also show that Covid pandemic has negative impact on stock prices. These findings are important in terms of indicating that the depreciation of the domestic currency leads to decrease the stock prices, and the magnitude and significance of the relation may differ in regimes. Similarly, both the NARDL with and without of structural breaks estimations reveal the short-run and the long-run asymmetric relationship between stock prices and exchange rate. Although depreciation of TL leads to increase in stock prices, the effects of appreciation of TL is statistically insignificant in the NARDL without structural breaks. According to cointegration with structural breaks results, the depreciation of the TL has a negative effect and leads to decrease in stock stocks prices in the first three regimes. On the other hand, the appreciation of the TL has statistically significant positive effects on stock prices in the 2nd, 4th and 5th regimes and negative effects only in the 3rd regime. In other words, the appreciation of TL leads to decrease in stock prices in the 2nd, 4th and 5th regimes and increase in 3rd regime. Thus, general findings imply that negative and positive changes in exchange rate have different effect on stock prices and the magnitude and significance of the relation may differ in each regime.

Overall findings demonstrate that exchange rate variations have distinctive impacts on stock prices when considering structural break and asymmetrical dynamics. Policymakers and foreign investors need to take into account these dynamics when dealing with Turkish financial markets. Additionally, the findings obtained regarding the Turkish economy, which is part of the group of emerging countries, may also be applicable to other countries with similar dynamics. As discussed in the introduction and literature review sections, the sensitive nature of these country groups to external factors such as capital flows, oil price or financial distortions, indicate that the relationship in question may exhibit structural changes and asymmetric characteristics. Finally, it should be noted that results given in this study depend on the structural breaks that are determined endogenously.

Declaration of Research and Publication Ethics
This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement
The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest
There is no potential conflicts of interest in this study.

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Appendix I

Table A. Long-Run and Short-Run Dynamics of NARDL

Variables	Long-Run Dynamics	Variables	Short-Run Dynamics
Constant	0.43 [4.19]***	Δsp_{t-1}	-0.22 [-3.42]***
$D_{2020:03}$	-0.17 [-2.76]***	Δsp_{t-5}	0.17 [3.17]***
sp_{t-1}	-0.08 [-3.63]***	Δsp_{t-6}	0.11 [2.01]**
exc^{-}	-0.03 [-0.80]	Δsp_{t-12}	-0.12 [-2.13]**
exc^{+}	0.03 [2.15]**	Δexc^{-}	-0.78 [-2.41]***
		$\Delta {exc^{-}}_{t-1}$	0.81 [2.83]***
		Δexc^{+}	-0.96 [-5.55]***
		$\Delta {exc^{+}}_{t-2}$	-0.42 [0.01]

Note: Values in square brackets are t-statistics. Significance levels: (*), (**) and (***) denote 10%, 5% and 1% level, respectively.

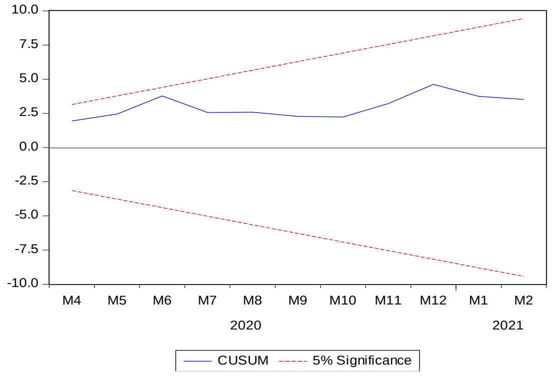
Table B. Long-Run and Short-Run Dynamics of NARDL Model With Structural Breaks

Variables	Long-Run Dynamics	Variables	Short-Run Dynamics
$Constant_1$	2.3597 [9.7136] ***	Δsp_{t-2}	0.2568 [4.6201]***
$Constant_2$	3.5331 [9.8426] ***	Δsp_{t-5}	0.2640 [5.1543]***
$Constant_3$	2.9868 [10.7845] ***	Δsp_{t-6}	0.1600 [3.0947] ***
$Constant_4$	4.6408 [8.2147] ***	Δsp_{t-7}	0.1300 [2.5811]**
$Constant_5$	3.3668 [8.4026] ***	Δsp_{t-12}	−0.0878 [−1.8601]*
$Trend_1$	0.0334 [9.3869] ***	$\Delta exc^{-}_{1,t-6}$	−1.1265 [−2.5098]**
$Trend_2$	0.0084 [3.1202] ***	$\Delta exc^{+}_{1,t}$	−1.4866 [−3.3196] ***
$Trend_3$	0.0154 [6.7952] ***	$\Delta exc^{+}_{1,t-1}$	1.3778 [2.9172]***
$Trend_4$	0.0039 [1.6047]	$\Delta exc^{+}_{1,t-4}$	1.3976 [3.3057]***
$Trend_5$	0.0116 [4.0302] ***	$\Delta exc^{+}_{1,t-7}$	0.6468 [1.8641]*
sp_{t-1}	−0.5588 [−9.9323] ***	Δexc^{-}_{2}	−1.0367 [−1.8960]*
$exc^{-}_{1,t-1}$	0.2852 [1.4895]	$\Delta exc^{-}_{2,t-2}$	−2.2192 [−3.6663]***
$exc^{+}_{1,t-1}$	−0.8447 [−3.6755]***	$\Delta exc^{-}_{2,t-5}$	−1.1195 [−2.3096]**
$exc^{-}_{2,t-1}$	0.7468 [3.3964] ***	$\Delta exc^{-}_{2,t-6}$	−2.7940 [−4.5807]***
$exc^{+}_{2,t-1}$	−0.2866 [−1.6804] *	$\Delta exc^{-}_{2,t-7}$	−1.2411 [−2.3773]**
$exc^{-}_{3,t-1}$	−0.3777 [−1.7773] *	$\Delta exc^{-}_{2,t-9}$	−1.0118 [−1.9142]*
$exc^{+}_{3,t-1}$	−1.1052 [−5.3481]***	$\Delta exc^{-}_{2,t-10}$	−2.8888 [−3.7594]***
$exc^{-}_{4,t-1}$	0.8290 [2.8469] ***	Δexc^{+}_{2}	−1.5179 [−8.6363]***
$exc^{+}_{4,t-1}$	−0.1413 [−0.8131]	$\Delta exc^{+}_{2,t-4}$	−0.8904 [−2.5364]**
$exc^{-}_{5,t-1}$	0.9802 [4.3693] ***	$\Delta exc^{+}_{2,t-8}$	−1.6006 [−5.0871]***
$exc^{+}_{5,t-1}$	−0.0281 [−0.2261]	$\Delta exc^{+}_{2,t-12}$	−1.3297 [−4.3055]***
		Δexc^{+}_{3}	−2.2497 [−4.9217]***
		$\Delta exc^{+}_{4,t-4}$	−0.7960 [−2.1529]**
		$\Delta exc^{+}_{4,t-12}$	0.7577 [−2.1252]**
		Δexc^{+}_{5}	−0.4781 [−2.1258] **
		$\Delta exc^{+}_{5,t-2}$	−0.7881 [−2.7949] ***

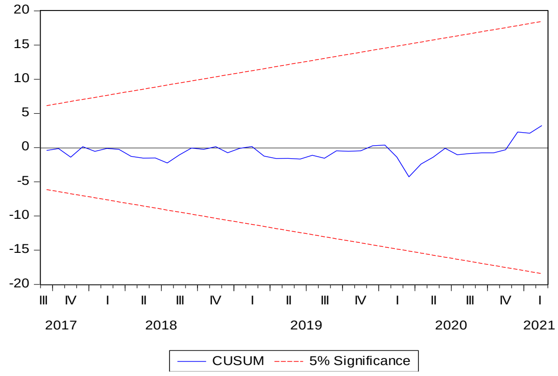
Note: Values in square brackets are t-statistics. Significance levels: (*), (**) and (***) denote 10%, 5% and 1% level, respectively.

Appendix II

Graph A: CUSUM Test



Graph B: CUSUM Test



Appendix III

Table C. The Selected Empirical Studies on the Relationship Between Exchange Rate and stock Price

Authors	Countries	Data	Variables	Methods	Results
Pan et al. (2007)	7 East Asian countries	1988-1998	SP, NER	Johansen cointegration Granger causality	Mixed results
Lin (2012)	6 Asian emerging countries	1986-2010	SP, NER, IR, FR	ARDL cointegration Granger causality	Cointegration Causality
Koseoglu and Cevik (2013)	3 Eastern European countries and Türkiye	2002-2011	SP NER	Hong two step causality	Causality
Fowowe (2015)	South Africa, Nigeria	2003-2013	SP, NER, LSE	Johansen cointegration Gregory- Hansen cointegration Dolado and Lutkepohl (1996) causality	Mixed cointegration results Causality
Sui and Sun (2016)	BRICS countries		SP, NER IRD	ARDL cointegration VAR	Cointegration Causality
Nguyen (2019)	3 advanced and 3 emerging countries	2007-2013	SP, USP NER	Johansen cointegration Granger causality	Cointegration Mixed causality
Ürkmez and Karataş (2017)	Türkiye	2002-2015	BIST 100 NER (USD, EURO)	Gregory-Hansen cointegration Granger causality	No cointegration Mixed causality
Bahmani-Oskooee and Saha (2015)	USA	1973-2014	S & P 500, NEER, IPI, CPI, M2	ARDL cointegration NARDL cointegration	Asymmetric cointegration
Bahmani-Oskooee and Saha (2016a)	USA	1973-2015	SSP (11 sector), NEER, IPI, CPI, M2	ARDL cointegration NARDL cointegration	Asymmetric cointegration
Bahmani-Oskooee and Saha (2016b)	9 countries including emerging and advanced	1994-2014	SSP (11 sector), NEER, IPI, CPI, M2	ARDL cointegration NARDL cointegration	Mixed symmetric cointegration Asymmetric cointegration
Zeren and Koç (2016)	Türkiye, Japan and England	1990-2013	SP, RER	Time varying causality	Causality
Bahmani-Oskooee and Saha (2018)	24 countries including emerging and advanced	1984-2014	SP, NEER	ARDL cointegration NARDL cointegration	Asymmetric cointegration

Table C. Continue

Gokmenoglu et al. (2021)	10 emerging countries	1994-2009	SP REER	Quantile Quantile regression	Asymmetric relation
Bhutto and Chang (2019)	China	1995-2017	SP, REER, CPI, IR	ARDL cointegration NARDL cointegration	Asymmetric cointegration
Adekoya (2020)	Nigeria	1997-2018	SP, NER	Bai and Perron structural break test ARDL cointegration with structural breaks NARDL cointegration with structural breaks	Asymmetric cointegration
Sheikh et al. (2020)	4 South Asian countries	2000-2020	SP, NER	Panel ARDL cointegration Panel NARDL cointegration Hatemi-J panel nonlinear causality	Asymmetric cointegration and causality
Siew-pong et al. (2021)	ASEAN-5 countries	1998-2017	SP, REER, IPI, M2	Panel ARDL cointegration Panel NARDL cointegration	Asymmetric cointegration
Nusair and Al-khasawneh (2022)	9 ASEAN countries including emerging and advanced	1973-2009	SP, NEER	Bai and Perron structural break test ARDL cointegration NARDL cointegration	Symmetric and asymmetric cointegration
Nusair and Olson (2022)	G-7 countries	1973-2020	SP, NEER	Bai and Perron structural break test ARDL cointegration NARDL cointegration Granger causality	Asymmetric cointegration Causality
Fasanya and Akinwale (2022)	Nigeria	2007-2018	SSP, NER, IPI, CPI, M2	ARDL cointegration NARDL cointegration NARDL cointegration with structural breaks	Mixed results
Yıldırım and Adalı (2018)	Türkiye	2005-2017	BIST 100, RER	Granger causality Toda Yamamoto causality Diks and Panchenko nonlinear causality	Symmetric and asymmetric causality

Table C. Continue

Akdağ and Yıldırım (2019)	Türkiye	2000-2018	BIST Industry BIST Finance NER	Granger causality Hatemi-J (2012) asymmetric causality	Symmetric and asymmetric causality
Benli et al. (2019)	Türkiye	2003-2016	BIST 100, BIST 30, SSP, NEER, IPI, CPI. M2	NARDL	Mixed results
Tiryaki et al. (2019)	Türkiye	1994-2017	BIST 100, REER, IPI, M3	NARDL cointegration	Asymmetric cointegration
Kaya and Soybilgen (2019)	Türkiye	2003-2017	BIST 100, NER, IPI, IR	ARDL cointegration NARDL cointegration	Asymmetric cointegration
Kassouri and Altıntaş (2020)	Türkiye	2003-2018	SP, REER, NER, IPI, M3, IR	Threshold cointegration Frequency domain causality NARDL cointegration	Asymmetric cointegration
Durgun and Temurlenk (2021)	Türkiye	2003-2019	BIST 100, NER	Granger causality Diks-Panchenko nonlinear causality MS VAR MS-Granger causality	Nonlinear relation Nonlinear causality
Genç and Öztürk (2021)	Türkiye	2009-2020	BIST 100, REER	Markov Regime Switching Model Hatemi-J (2012) asymmetric causality	Asymmetric relation Asymmetric causality
Karadağ and Sekmen (2021)	Türkiye	2002-2020	BIST 100, SSP, NER, REER	Hacker ve Hatemi-J (2012) causality Hatemi-J (2012) asymmetric causality	Symmetric and asymmetric causality
Sertkaya and Songur (2021)	Türkiye	1996-2018	BIST 100, REER	Hatemi-J ve Irandoust asymmetric cointegration Johansen cointegration Hacker and Hatemi-J causality Hatemi-J asymmetric causality	Asymmetric cointegration Mixed causality results
Kılıç and Naimoğlu (2022)	Türkiye	1990-2021	BIST 100, NER	Hatemi-J asymmetric causality Time-varying asymmetric causality	Asymmetric causality

Note: CPI: Consumer price index, GDP: Gross Domestic Product, IPI: Industrial production ındex, IR: interest rate, NER. Nominal exchange rate, NEER: Nominal effective exchange rate, SP: Stock prices, SSP: Sectoral stock prices, REER: Real effective exchange rate, RER: Real exchange rate.