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Does the Effect of the Real Exchange Rate on Exports of Machinery and Transport Vehicles Change Over Time? Evidence from a Non-linear Panel ARDL Analysis

Reel Döviz Kurunun Makine ve Ulaştırma Araçları İhracatı Üzerindeki Etkisi Zamanla Değişiyor mu? Doğrusal Olmayan Panel ARDL Analizinden Kanıtlar

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Abstract

This study examines the relationship between Türkiye's machinery and transport equipment exports and the real exchange rate using monthly data from January 2013 to August 2023. The long-term relationship was confirmed by the Westerlund (2007) panel cointegration test, and the panel ARDL results were obtained using the CS-ARDL estimator, which accounts for cross-sectional dependence and heterogeneity in slopes. The analysis, including six sub-samples, reveals an asymmetric relationship between exports and the real exchange rate, meaning that depreciation and appreciation of the real exchange rate affect exports with varying significance across time periods. In the early periods of the study, negative shocks to the real exchange rate supported exports. However, after 2020, following the pandemic and global developments, the significance of negative real exchange rate shocks disappeared, while positive shocks began to constrain exports. The study also obtained estimation results at the country level. Overall, the results highlight structural shifts in this relationship over time, suggesting that export policies should be adaptive and targeted based on specific trade partners and periods to account for these asymmetries.

Keywords: Exports, exchange rate, panel data econometrics, nonlinear ARDL

JEL Code: C33, F13, F14

Öz

Bu çalışma, Türkiye'nin makine ve ulaştırma araçları ihracatı ile reel döviz kuru arasındaki ilişkiyi aylık veriler kullanarak 2013 Ocak-2023 Ağustos dönemi için incelemektedir. Westerlund (2007) panel eşbütünleşme testi, değişkenler arasında uzun vadeli bir ilişkinin varlığını ortaya koymuş, kesit bağımlılığı ve eğim heterojenliğini göz önünde bulunduran CS-ARDL yöntemiyle panel ARDL tahmin sonuçlarına ulaşılmıştır. Altı farklı alt örneklem üzerinde yapılan analiz, reel döviz kurundaki dalgalanmaların ihracat üzerinde asimetrik bir etkiye sahip olduğunu göstermektedir. Bu sonuç, reel döviz kurunun değer kaybı ve değer kazanmasının, dönemler arasında değişen öneme sahip olmakla birlikte, ihracatı farklı şekillerde etkilediği anlamına gelmektedir. Çalışmanın erken dönemlerinde, reel döviz kurundaki negatif şoklar ihracatı desteklemiştir. Ancak, 2020'den sonra pandemi ve küresel gelişmelerin etkisiyle, negatif reel döviz kuru şoklarının önemi kaybolmuş ve pozitif şoklar ihracatı sınırlamaya başlamıştır. Ülke bazında tahmin sonuçlarına da yer verilen çalışmada, genel bulgular ihracat politikalarının, reel döviz kuru ile ihracat arasındaki yapısal değişimleri ve asimetrik etkileri göz önünde bulundurarak belirli ticaret ortaklarına ve dönemlere göre uyarlanması gerektiğini işaret etmektedir.

Anahtar Kelimeler: İhracat, döviz kuru, panel veri ekonometrisi, doğrusal olmayan ARDL

JEL Code: C33, F13, F14

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Introduction

The global shift towards financial liberalization following the collapse of Bretton Woods System has strongly influenced international trade. After adopting a floating exchange rate in place of the fixed system, exchange rate fluctuations started influencing trade by changing the cost and profitability of international trade. Production and delivery lags, along with trading in foreign currencies, have intensified these effects, introducing uncertainty and risk for businesses. Currency depreciation can make exports cheaper and more attractive, boosting volumes, while appreciation can have the opposite effect, making exports less competitive. These dynamics are key to understanding how exchange rates shape trade and economic relationships between countries.

Moreover, the acceleration of global trade has led to macroeconomic imbalances in some economies, particularly those reliant on imports. Current account deficits have emerged in these economies, and financing these deficits through foreign debt creates economic fragility. To address these issues, a sustainable external deficit policy that promotes export-driven growth is essential. A thorough understanding of the key determinants of exports and their implications is vital for developing effective export strategies. Besides structural measures to boost production and competitiveness, exchange rate fluctuations also impact exports, highlighting the need to examine their effects. As a result, the relationship between exchange rates and exports has attained significant interest from academics and policymakers, leading to numerous studies on the topic.

Some research revealed an inverse association, implying that as the local currency strengthens and prices of tradable products increase, demand for these products diminishes (Arize, 1995; Cheung & Sengupta, 2013; Wondemu & Pott, 2016; Karamollaoğlu & Yalçın, 2019; Köse & Aslan, 2020). However, other studies have concluded that an appreciation in real exchange rates actually supports exports (Göçer & Elmas, 2013; Hooy et al., 2015). On the other side, Bahmani-Oskooee and Goswami (2004), Oluyemi and Isaac (2017), Catalbas (2016), and Acaravcı and Dağlı (2021) did not detect any statistically meaningful association between real exchange rates and export levels.

Lately, researchers have been emphasizing that the impact of exchange rate fluctuations on international trade varies depending on whether the currency appreciates or depreciates. This asymmetric influence of exchange rates on trade has gained significant attention in academic discussions. For instance, Bahmani-Oskooee and Fariditavana (2016), Arize et al. (2017), Chang et al. (2018), Akpiliç and Yurdakul (2022), and Handoyo et al. (2023) found evidence of an asymmetrical relationship between the exchange rate and foreign trade.

Given the inconsistencies observed across empirical studies, often attributed to variations in methodology, sample selection, scope, and time periods, this research seeks to explore how fluctuations in the real exchange rate influence Türkiye’s exports in the machinery and transport equipment sector. This sector is crucial, accounting for an average 29% of Türkiye's total exports from 2013 to 2023. It includes high-tech products like computers and optical equipment, as well as medium-high technology products such as electrical machinery and motor vehicles. The sector is notable for its significant trade in value added, indicating its importance in driving economic growth, innovation, and technological advancement (Saygili & Turkcan, 2017).

Expanding the export capabilities of this sector could enhance Türkiye's global competitiveness and increase export revenue. Moreover, a stronger export performance in this sector would contribute to Türkiye's economic stability and resilience by diversifying income sources and reducing reliance on external financing. Therefore, prioritizing the development of the machinery and transport equipment sector plays a crucial role in ensuring sustainable economic growth and fostering a more balanced trade relationship.

Furthermore, the sectors such as machinery and transport equipment may exhibit different responses to exchange rate fluctuations due to high fixed costs and long production times. Companies in these sectors may apply varying strategies in response to currency appreciation and depreciation, leading to asymmetric effects. For instance, while currency depreciation may provide a cost advantage, currency appreciation could lead to cost increases that may not be immediately reflected in prices. Additionally, as machinery and transport equipment are often sold in highly competitive international markets, responses to exchange rate changes may vary; while currency depreciation may increase exports, currency appreciation may not necessarily decrease exports to the same extent.

In light of these complexities and uncertainties, it is essential to develop policies that can effectively shape how the real exchange rate influences exports. Such policies must be carefully designed to address the specific needs and characteristics of different sectors. Developing strategies that promote economic stability, enhance exporters' competitiveness in the global market, and mitigate potential negative effects is essential. This includes implementing measures to stabilize the currency, offering support to sectors particularly sensitive to exchange rate fluctuations, and fostering an environment that boosts the overall competitiveness of exporters.

This study examines the impact of foreign demand, real exchange rate, exchange rate volatility, and the Covid-19 pandemic on Türkiye's machinery and transport equipment exports at the country level, emphasizing the highlighting the need for well-designed policies given the complexities of exchange rate effects on exports. The study encompassed 54 of Türkiye's trading partner countries, each of which accounted for an average share of 0.25 percent or more in Türkiye's exports in the machinery and transport equipment sector, based on Standard International Trade Classification (SITC) code 7. These selected countries together account for approximately 93.2% of Türkiye's total exports in the machinery and transport equipment sector.

This study also explores the asymmetrical relationship between machinery and transport equipment exports and the real exchange rate, suspecting different effects during appreciation and depreciation. To analyze the long-term relationship, the Westerlund (2007) panel cointegration test is applied, accounting for cross-sectional dependence and slope heterogeneity across the panel members. Estimation results were obtained using the Non-Linear Panel ARDL method with the CS-ARDL estimator.

To explore whether the relationship between the real exchange rate and exports changes over time, this study divides the entire sample period of 2013-2023 into six sub-samples, allowing for an analysis of how this relationship differs across various periods.

The study is structured into three main parts. Following the introduction, the second section explains the econometric techniques used, including the estimation process and interpretation of model coefficients. The final section discusses the findings and provides suggestions based on the results.

Literature Review

A wide range of studies have examined the effects of exchange rate movements on exports. Arize (1995) found that the relationship between relative prices and exports for the United States was negative and inelastic. Vita and Abbott (2004) discovered a negative association between real exchange rate and exports with ARDL bound test. In their empirical study on Pakistan, Kemal and Qadir (2005) employed the Johansen cointegration technique and observed that the real exchange rate adversely affects exports while positively influencing imports. Cheung and Sengupta (2013) demonstrated that the appreciation of the real exchange rate has a strong and negative impact on the export shares of non-financial sector firms in India.

On the other hand, Hooy et al. (2015) applied the panel DOLS technique to study the effect of the real exchange rate on exports from ASEAN countries to China. They discovered a positive relationship between the real exchange rate and ASEAN's total exports to China. In contrast, Bahmani-Oskooee and Goswami (2004) applied the ARDL bounds test to investigate the exchange rate-export relationship and concluded that there was no statistically meaningful connection between the real exchange rate and exports. Furthermore, the findings by Ahmed et al. (2017), using the ARDL modeling approach, indicated that exchange rate movements do not exert a significant influence on Pakistan's export performance.

Studies focused on Türkiye and investigating the impact of exchange rate on exports hold significant presence in the literature. Acaravcı and Öztürk (2002) found that higher relative prices result in a decline in exports, based on their analysis using the Johansen cointegration method and the error correction model. Investigating the long-run relationships with the Bounds Test, Şimşek and Kadılar (2005) determined that exports are more sensitive to price changes than to foreign income.

Yaman (2018) concluded that when the real exchange rate depreciates, exports tend to increase while imports decrease. In their study, Güneş et al. (2018) applied Panel Causality and Dumitrescu-Hurlin Panel Causality tests to assess the effect of the real exchange rate on exports across 11 key sectors of Denizli's export industry, finding that the impact differs among sectors. Karamollaoğlu and Yalçın's (2019) firm-level analysis, using GMM panel, showed that the depreciation of the Turkish lira generally enhances the competitiveness of firms. Çelgin et al. (2019) studied the impact of relative prices on Türkiye's real exports and imports, concluding that exports are more responsive to external demand than to the real exchange rate. Using panel data analysis, Güngör and Kaplan (2021) studied the impact of the exchange rate on Türkiye's exports to EU-27 countries. They found a significant relationship between the real exchange rate and exports in most sectors, although the direction and magnitude of the relationship varied across sectors. Lastly, Dumrul and Gökalp (2022) applied the ARDL model and found that a depreciation of the domestic currency promotes exports in the long run.

Conversely, several studies have not found a meaningful link between the real exchange rate and export levels. For example, Kızıltan and Ciğerlioğlu (2008), employing time series and cointegration techniques, did not detect a long-term association between the real exchange rate and exports in their analysis. Yazıcı (2012) concluded

that although relative prices in Turkish agricultural exports have a significant effect on export demand in the short run, they are not statistically significant in the long run. Acaravcı and Dağlı (2021) conducted the ARDL bounds test and found no evidence of a long-term relationship between the variables in the export model. With the help of the Fourier ADL cointegration test, Toktaş (2021) demonstrated that the real exchange rate has no effect on either exports or imports. In contrast, Göçer and Elmas (2013) employed cointegration techniques and found that exports are significantly influenced by the real exchange rate, with higher real exchange rates resulting in increased export levels.

Several empirical studies have examined the asymmetric effect of the real exchange rate on foreign trade. For instance, Bahmani-Oskooee and Fariditavana (2016), Arize et al. (2017) and Baek and Nam (2021) have found evidence of an asymmetrical relationship between the exchange rate and foreign trade. Regarding studies specific to Türkiye, using linear and nonlinear ARDL methods, Bahmani-Oskooee and Halıcıoğlu (2017) concluded that the appreciation of the lira had no significant impact on Türkiye's bilateral trade developments. Their findings further revealed that a weaker Turkish Lira relative to the Euro and Sterling positively affected Türkiye's trade balance with European trading countries.

Gül (2018) showed that the real exchange rate influenced export trends in half of the countries examined. Writer also found evidence that the elasticity of exports to the appreciation of the Turkish lira was greater than their elasticity to depreciation. A different study by Bilgin (2020), employing the Nonlinear ARDL method, found that the depreciation of the exchange rate positively impacted exports in sectors such as furniture, basic metals, textiles, clothing, food products, beverages, chemicals, and machinery and equipment. On the other hand, the appreciation of the real exchange rate had a positive impact on the rubber-plastic products, chemicals, and furniture sectors, but it had a negative effect on exports in the food products, beverages, clothing, and basic metal sectors.

Using the NARDL approach, Güler (2021) analyzed how the real effective exchange rate asymmetrically influences exports and the trade balance. The findings of the study suggest that the appreciation of the Turkish lira initially boosts exports, but the effect becomes negative in the subsequent periods. Conversely, the depreciation of the lira has a positive effect on exports.

Empirical studies on the relationship between real exchange rate and exports have yielded mixed results due to variations in methodology, sample size and time periods. Recently, there has been increased attention on the non-linear relationship between exchange rate and exports. Moreover, panel data estimation methods and country-based model estimation results are preferred over single model estimation for all countries to provide more effective policy recommendations.

Empirical Analysis

Model and Dataset

This study examines the relationship between Türkiye's machinery and transport equipment exports and the real exchange rate, utilizing monthly data covering January 2013 to August 2023 for 54 trading partners. Eq. (1) was formulated by adding exchange rate volatility and the number of Covid-19 cases into the standard export demand model introduced by Goldstein and Khan (1978).

$$X_{i,t} = c_0 + c_1 Y_{i,t} + c_2 RER_{i,t} + c_3 VOL_{i,t} + c_4 COV_{i,t} + \varepsilon_{i,t} \qquad i=1,2\ldots N; \quad t=1,2,\ldots T \qquad (1)$$

The variable $X_{i,t}$ in Eq. (1)[1] denotes the real export figures for the machinery and transport equipment sector between Türkiye and its trading partners. These real values are calculated by dividing country-specific export figures (in USD) by the sector's export price index. Nominal export data and unit value indices were obtained from the Turkish Statistical Institute (TUIK), based on the one-digit classification level (code 7) of the Standard International Trade Classification (SITC), which corresponds to machinery and transport equipment.

The variable $Y_{i,t}$ represents foreign demand, measured by the Industrial Production Index of Türkiye's trading partners, as used in previous studies (Marquez & Schindler, 2007, p.842; Le & Chang, 2012, p.79; Bahmani-Oskooee & Gelan, 2018, p.16). For countries dependent on oil and gas exports, production data of these resources

[1] *The TRAMO-SEATS method developed by Gómez and Maraval (1996, 1998) was used to seasonally adjust the series specifically for exports and the industrial production index.*

serves as the foreign demand indicator (Gül, 2018, p.11)[2]. Industrial Production Index data came from the IMF and World Bank GEM databases, while oil and gas production data was sourced from the U.S. Energy Information Administration (EIA). Increases in the Industrial Production Index indicate higher incomes in trading partner countries, which is expected to positively impact Turkish exports.

The variable $RER_{i,t}$ represents the bilateral real exchange rate between Türkiye and each of its trading partner countries. It is calculated by dividing Türkiye's Price Index (PI_t) by the product of the partner country's Price Index ($PI_{i,t}$) and the nominal exchange rate ($E_{i,t}$). The PI price index has been computed by giving equal weights to the Consumer Price Index (CPI) and Producer Price Index (PPI). The study's focus on the machinery and transport sector includes not only the essential capital and intermediate goods for production but also includes motorized passenger vehicles, along with sea and air transport. Hence, the real exchange rate was calculated using a price index derived from the weighted average of consumer and producer prices. CPI and PPI data were obtained from the IMF-International Financial Statistics (IFS) database and Refinitiv Eikon. The Bank for International Settlements (BIS) provided the nominal exchange rates. When the real exchange rate rises, meaning the local currency appreciates, the prices of exported products increase, which is expected to negatively affect exports.

The variable $VOL_{i,t}$ refers to the degree of variability in the real exchange rate, measured by the moving standard deviation of its growth rate for every country. Existing research provides mixed evidence regarding how uncertainty in exchange rates influences exports, with findings showing that its effect can be either positive or negative.

The variable $COV_{i,t}$ reflects the Covid-19 case numbers in each country, included to assess the pandemic's impact on exports. Data was sourced from the World Health Organization. The pandemic's effect on global trade is complex, with potential negative impacts from economic downturns and positive effects from shifts in sectors and supply chains. Therefore, the coefficient for $COV_{i,t}$ could be negative, positive, or insignificant.

Recent studies suggest that exchange rate appreciation and depreciation have different impacts on exports (Bahmani-Oskooee & Halıcıoğlu, 2017; Gül, 2018; Chang et al., 2018; Bilgin, 2020; Güler, 2022). To address this, the study uses the Nonlinear ARDL method by developed Shin et al. (2014), which accounts for the asymmetric effects of positive and negative shocks by incorporating them as separate partial sums in the model.

$$RER_t = RER_0 + RER_t^+ + RER_t^- \tag{2}$$

RER_t^+ and RER_t^-, represent positive and negative partial sums in RER_t respectively.

$$RER_t^+ = \sum_{j=1}^{t} \Delta RER_j^+ = \sum_{j=1}^{t} \text{maks}\,(\Delta\, RER_j, 0) \tag{3}$$

$$RER_t^- = \sum_{j=1}^{t} \Delta RER_j^- = \sum_{j=1}^{t} \min\,(\Delta\, RER_j, 0) \tag{4}$$

The model with a non-linear structure in the real exchange rate, as shown in Eq. (5)

$$X_{i,t} = c_0 + c_1 Y_{i,t} + c_2 RER_{i,t}^+ + c_3 RER_{i,t}^- + c_4 VOL_{i,t} + c_5 COV_{i,t} + \varepsilon_{i,t} \quad i=1,\ldots N;\ t=1,..T \tag{5}$$

An asymmetrical relationship is identified when the effects of positive and negative shocks on the dependent variable differ in direction or magnitude (Mory, 1993; Rafiq et al., 2009; Ghosh & Kanjilal, 2014). To statistically identify this asymmetry, a Wald test is conducted after estimating the nonlinear model, as recommended by Shin et al. (2014), Bahmani-Oskooee and Halicioglu (2017), Bilgin (2020), and Bahmani Oskooee and Durmaz (2021).

In the nonlinear specification, the coefficients c_2 and c_3 correspond to the estimated effects of positive and negative shocks in the real exchange rate, respectively. To assess the presence of potential asymmetry in this relationship, the following hypotheses are tested using the Wald test:

$$H_0: c_2 = c_3$$

$$H_1: c_2 \neq c_3$$

Rejecting the null hypothesis implies that the real exchange rate influence exports asymmetrically, confirming that the nonlinear approach is appropriate.

[2] *Oil and gas production in Algeria, Azerbaijan, Iran, Iraq, Libya, Nigeria, Saudi Arabia, and the United Arab Emirates has been utilized as an indicator of foreign demand.*

In the nonlinear model (Eq. (5)), positive shocks to the real exchange rate are anticipated to negatively impact exports, while negative shocks are predicted to boost exports. However, these effects are anticipated to differ statistically.

Empirical Methodology

To obtain reliable results in econometric analyses, it is essential that the time series data be stationary. Non-stationary series may produce spurious regressions, suggesting strong correlations between variables even when none exist. Therefore, testing for the presence of a unit root in the variables is a critical step before proceeding with model estimation. In the context of panel data, it is also important to account for cross-sectional dependence during unit root testing. Ignoring cross-sectional dependence can result in biased and inaccurate findings. To detect such dependence, the Pesaran (2004) CD test and the adjusted LM test developed by Pesaran et al. (2008) (LM adj) are commonly used.

The study performs CD and bias-adjusted LM tests to evaluate the null hypothesis of no cross-sectional dependence. According to the results presented in Table A1, evidence from both tests indicates that cross-sectional dependence is present in the models, regardless of whether they are linear or nonlinear.

In classical panel data analysis, it is generally assumed that unobserved heterogeneity is accounted for by fixed or random effects. However, shocks to the dependent variable may not affect all countries uniformly, leading to variations in their responses. To avoid biased estimations, it is therefore crucial to test the assumption of slope homogeneity before applying panel data techniques (Campello et al., 2019; Breitung et al., 2013:1). This study employs the delta test developed by Pesaran and Yamagata (2008) to assess the homogeneity of slope coefficients in the models. Both the delta and bias-adjusted delta test results indicate that the effects of the independent variables on exports differ considerably between countries (see Table A2).

To determine whether the variables used in this study exhibit a unit root, the Pesaran (2007) Cross-sectionally Augmented Dickey-Fuller (CADF) unit root test was applied. This test accounts for both cross-sectional dependence and slope heterogeneity by including cross-sectional averages of the lagged levels and first differences of the individual series into the ADF regression. The results of the Pesaran (2007) test indicate that all variables in the study are non-stationary at their levels but become stationary after first differencing (see Table A3).

Since all variables were found to be integrated of order one, the Westerlund (2007) panel cointegration test, which accounts for cross-sectional dependence and slope heterogeneity, was applied to examine the presence of a long-run relationship among the variables. This test comprises four statistics: two group statistics and two panel statistics, all derived from an error correction model framework. The Westerlund cointegration test results reject the null hypothesis of no cointegration across the main sample as well as all six sub-samples (see Table A4), demonstrating a long-term association between the variables in all model.

Once the long-term relationship between the variables was confirmed, the model was estimated employing the panel ARDL method. The ARDL method, developed by Pesaran et al. (2001), is suitable for analyzing long-run relationships when variables are a mix of I(0) and I(1), and it effectively addresses issues such as autocorrelation and endogeneity. However, the traditional ARDL model may yield biased estimates in the presence of cross-sectional dependence and slope heterogeneity. To overcome this limitation, the CS-ARDL estimator proposed by Chudik and Pesaran (2013) was employed. This extended version of the classical ARDL model incorporates cross-sectional averages of the dependent and independent variables, along with their lags, thereby accounting for cross-sectional dependence and slope heterogeneity and mitigating the bias associated with the standard ARDL approach.

In the CS-ARDL estimation approach, the model first estimates the short-run coefficients and subsequently derives the long-run relationships. A key advantage of this method is that it provides estimates for both short-run dynamics and long-run equilibrium.

A significant feature of the CS-ARDL technique is its ability to account for cross-sectional dependence, which often arises in panel data settings where countries, firms, or regions may be influenced by common shocks or unobserved global factors. Ignoring such dependence can lead to biased and inconsistent estimates, particularly when these common factors affect units simultaneously.

To address this issue, the CS-ARDL model includes cross-sectional averages of the dependent and independent variables into the regression. This augmentation helps control for the influence of unobserved common factors, thereby mitigating the risk of cross-sectional dependence. Moreover, the method does not impose homogeneity

restrictions on slope coefficients across cross-sectional units, allowing for heterogeneity in both short-run and long-run relationships.

This flexibility enables the model to capture unit-specific dynamics, which is particularly valuable in empirical contexts where structural differences exist between units. As a result, the CS-ARDL estimator yields reliable group-specific short-run and long-run coefficient estimates, offering more accurate insights into the underlying economic relationships across heterogeneous panels.

Based on Equation (6), the CS-ARDL estimation includes the cross-sectional averages of both dependent and independent variables into the model.

$$y_{i,t} = \alpha_i + \sum_{j=1}^{p_y} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{p_x} \beta'_{ij} x_{i,t-j} + \sum_{j=0}^{p_{\bar{v}}} \tau'_{ij} \bar{v}_{t-j} + e_{i,t} \quad (6)$$

In Eq. (6) $\bar{v}_{t-j}$ refers to lagged cross-sectional average $\left(\bar{v}_{t-j} = \left(\bar{y}_{i,t-j}, \bar{x}_{i,t-j}\right)\right)$

Subsequently, the long-run coefficients are derived as follows.

$$\hat{\theta}_{CS-ARDL,i} = \frac{\sum_{j=0}^{p_x} \hat{\beta}_{i,j}}{1-\sum_{j=1}^{p_y} \hat{\lambda}_{i,j}} \quad (7)$$

Model estimates were generated through the use of Ditzen's (2021) xtdcce2 command in Stata and all variables were expressed in logarithmic form. In the panel ARDL models, lag lengths were selected based on the Akaike Information Criterion (AIC) to ensure optimal model fit.

Empirical Findings

Initially, linear models were estimated to establish the baseline relationships between the variables. Subsequently, nonlinear models were used, in which positive and negative shocks to the real exchange rate were considered separately to capture potential asymmetric effects. This approach offers a more detailed insight into the different impacts of exchange rate fluctuations on manufacturing exports.

In all model specifications, the error correction term coefficients are negative and statistically significant, ranging between 0 and –1. This finding supports the presence of a stable long-term relationship between the variables. Moreover, it shows that short-run deviations from equilibrium gradually move back toward the long-run level.

Table 1 presents the estimation results for seven linear models. The analysis shows that, in the long term, foreign demand positively influences exports in the main model. However, no significant relationship is found between foreign demand and exports for 2013-2018 and 2014-2019. In other sub-samples, higher foreign demand increases exports. The real exchange rate significantly affects the exports of the machinery and transport equipment sector in all models, with local currency appreciation reducing exports.

Table 2 presents the results of the nonlinear model estimations. Except for the 2018-2023 sub-sample, the models show that the impact and significance of positive and negative exchange rate shocks on exports differ in both the short and long term, indicating asymmetry. The Wald test also confirms this asymmetry in all models except for 2018-2023 subsample.

Consistent with the linear model, the nonlinear model also reveals a positive long-term influence of foreign demand on exports in the main model. Nevertheless, for the sub-periods 2013-2018 and 2014-2019, the relationship between foreign demand and exports is not statistically significant.

The findings of the main model indicate that a depreciation in the real exchange rate has a positive and statistically significant impact on exports over the long run, while appreciation appears to have no meaningful effect. It is important to note that RER-NEG is negative when the exchange rate depreciates. Consequently, the negative coefficient associated with RER-NEG actually corresponds to a positive effect of depreciation on exports.

In the first three sub-samples, negative shocks to the real exchange rate increase exports. On the other hand, during the 2016-2021 and 2017-2022 periods, positive shocks decrease exports, while negative shocks have no effect. Unlike the other models, there is insufficient evidence to confirm an asymmetric relationship for the 2018-2023 period.

Table 1

Linear Models Estimation Results

Variables	2013-2023	2013-2018	2014-2019	2015-2020	2016-2021	2017-2022	2018-2023
Short-run estimates							
Intercept	-0.419	-1.328	-2.805	-0.969	-0.415	-0.022	0.017
X_{t-1}	0.284***	0.207***	0.254***	0.225***	0.124***	0.131***	0.123***
X_{t-2}	0.059***		0.062***				
X_{t-3}	0.071***						
Y_t	0.405***	-0.111	0.308	0.725***	0.609**	0.551***	0.615***
RER_t	-0.343**	-0.429**	-0.412*	-0.855***	-0.683**	-0.584***	-0.670***
VOL_t	0.003	0.039	0.051	0.021	0.006	-0.021	-0.036
COV_t	0.008			0.000	0.000	-0.001	0.000
Long-run estimates							
Y_t	0.879***	0.047	0.528	0.918***	0.722***	0.642***	0.778***
RER_t	-0.483**	-0.544**	-0.493*	-0.992***	-0.669**	-0.628***	-0.786***
VOL_t	0.019	0.033	0.074	0.029	0.002	-0.032	-0.083
COV_t	0.013			-0.003	-0.002	0.001	0.003
ECT	-0.586***	-0.793***	-0.684***	-0.775***	-0.876***	-0.869***	-0.877***
CD Test	0.31(0.755)	-0.63(0.529)	-1.27(0.204)	-0.88(0.379)	0.06(0.955)	-0.54(0.586)	-0.60(0.549)

***p<0.01; **p<0.05; *p<0.1. Values in parentheses correspond to CD test p values.

Over the long term, in the 2013-2023 period, a 1% negative shock to the real exchange rate led to a 1.3% increase in exports, while positive shocks had no significant effect on exports. These results are consistent with previous research, including studies by Bahmani-Oskooee and Halıcıoğlu (2017), Gül (2018), Bilgin (2020), Bahmani-Oskooee and Durmaz (2021), and Güler (2021), all of which also found an asymmetric impact of the real exchange rate on foreign trade.

The analysis for the periods 2013-2018, 2014-2019, and 2015-2020 shows that depreciation of the real exchange rate positively impacts exports, supporting the notion that a weaker local currency improves competitiveness and supports export growth. However, appreciation during these periods did not significantly affect exports. During the periods 2016-2021 and 2017-2022, positive shocks to the real exchange rate had a decreasing effect on exports. Specifically, a 1% positive shock to the real exchange rate reduced exports by 0.73% and 1.47% in these sub-samples, respectively. In contrast, for the period 2018-2023, only the foreign demand variable is statistically significant in explaining variations in exports.

This study aligns with Bahmani-Oskooee and Halıcıoğlu (2017) in finding that exchange rate appreciation has no significant impact on foreign trade, while depreciation does. Similarly, the sub-sampling analysis supports Güler (2021) by showing that real exchange rate depreciation boosts exports. However, Gül (2018) differs by finding that both appreciation and depreciation significantly affect foreign trade.

Table 2

Non-Linear Models Estimation Results

Variables	2013-2023	2013-2018	2014-2019	2015-2020	2016-2021	2017-2022	2018-2023
Short-run estimates							
Intercept	-0.667	-4.459	-3.171	-1.509	-0.692	-0.792	-1.207
X_{t-1}	0.206***	0.120***	0.134***	0.130***	0.071***	0.076***	0.065***
X_{t-2}	0.066***						
Y_t	0.323**	0.171	0.252	0.674**	0.499*	0.544***	0.603***
RER_POS_t	-0.123	0.638	0.515	-0.152	-0.719**	-1.203***	-1.020
RER_NEG_t	-0.884***	-1.344***	-1.556***	-1.655***	0.100	-0.103	-0.364
VOL_t	0.009	-0.033	-0.121	-0.022	0.057	0.109	0.023
COV_t	0.004			-0.004	-0.010	-0.001	0.002
$Wald\ Test$	3.13*	4.04**	4.40**	3.36*	3,79*	2.44*	0.34
Long-run estimates							
Y_t	0.459**	0.317	0.318	0.706**	0.478*	0.542***	0.642***
RER_POS_t	-0.243	0.591	0.449	-0.009	-0.733**	-1.470**	-1.184
RER_NEG_t	-1.335***	-1.402***	-1.710***	-1.829***	0.109	-0.117	-0.409
VOL_t	0.013	-0.032	-0.127*	-0.026	0.043	0.129	0.005
COV_t	0.006			-0.007	-0.010	0.000	0.005
ECT	-0.729***	-0.880***	-0.866***	-0.870***	-0.929***	-0.924***	-0.935***
$Wald\ Test$	4.20**	3.66**	4.58**	4.51**	3.85**	2.56*	0.40
$CD\ Test$	-1.22(0.221)	1.42(0.156)	0.32(0.746)	-0.59(0.552)	-076(0.445)	-0.87(0.385)	-0.73(0.463)

***p<0.01; **p<0.05; *p<0.1. Values in parentheses correspond to CD test p values.

The results imply that the effect of the real exchange rate on exports varies and is not consistent across cases and has varied over time, with significant influence from global events, particularly the pandemic. In earlier periods, declines in the real exchange rate boosted Türkiye's machinery and transport sector exports by making Turkish goods more competitive. Despite the appreciation of the Turkish lira, exports were likely unaffected due to the continued relative affordability of Turkish goods and the influence of trade agreements with Türkiye's trading partners.

As one of the key factors influencing this shift in the relationship, the Covid-19 pandemic has had a profound global impact since early 2020, with widespread closures intensifying in the second quarter of the year (Clemente-Suárez et al., 2021, p.6). These closures disrupted production and reduced consumer demand, as many countries shifted focus to essential goods like food and healthcare. As a result, non-essential goods production and trade declined sharply. Despite the Turkish lira's depreciation, the usual link between the real exchange rate and export performance weakened due to suspended trade activities and altered economic dynamics, reducing the real exchange rate's effectiveness in driving exports.

By 2021, pandemic-related constraints had eased, and economies began adapting to the new normal. However, supply chain disruptions continued, especially due to closures in major Asian economies, creating challenges in sourcing intermediate goods. This situation caused commodity prices to rise, especially affecting the machinery and transport sector, which suffered from the chip crisis. The shortage of essential chips, especially in automotive manufacturing, caused production delays and significant price increases (Ishak et al., 2023, p.440). The pandemic has also highlighted and worsened vulnerabilities in global supply chains, prompting many countries to reconsider their sourcing strategies. Disruptions in logistics and production have driven a shift towards nearshoring - sourcing from neighboring countries - to enhance supply chain security. This approach, noted during the China-U.S. trade tensions, has become more attractive as countries look for resilient and flexible supply chains amid global uncertainties (Vurdu, 2021, p.58).

In early 2022, escalating tensions between Russia and Ukraine caused a sharp rise in global commodity prices and increasing input costs, fueling inflationary pressures worldwide, including in Türkiye. Between 2018 and 2023, these factors caused shifts in the dynamics between the real exchange rate and trade performance. While the impact of currency depreciation on exports weakened after 2020, real exchange rate appreciation led to a decline in machinery and transport sector exports. Foreign demand also played a significant role in shaping export trends during this period.

These events highlight a major shift in global trade, as traditional economic patterns are reevaluated in response to new global challenges. The relationship between Türkiye's machinery and transport sector exports and the real exchange rate has experienced a structural shift, emphasizing the need to consider the impact of exchange rate fluctuations on exports over different periods.

In the later stages of the study, a detailed analysis examined the relationship between the real exchange rate and exports at the country level over different periods, using country-based long-term estimation results from the CS-ARDL panel estimator. Six sub-samples were analyzed alongside the main sample. The relationship's strength and direction varied, highlighting its complexity over time.

The estimation results indicate that the relationship between exports and real exchange rate depreciation varies significantly across different sub-sample periods for Türkiye's exports to certain countries (Table 3). For countries like Iran, Qatar, and Tunisia, this relationship is not statistically significant in any sub-sample periods, unlike the significant relationship found in the main sample. In contrast, for countries such as Australia, Belgium, Brazil, Croatia, France, India, Ireland, Mexico, Morocco, Netherlands, Portugal, Serbia, Slovenia, Spain, Sweden, and the UAE, the elasticity values are statistically significant in several sub-samples, even though they are not significant in the main sample.

The study shows that the impact of real exchange rate depreciation on exports of Türkiye to certain countries has changed over time. Some nations, like Belgium, Denmark, Germany, the Netherlands, Romania, South Africa, and the UAE, had a strong relationship between exchange rate depreciation and exports in earlier periods. However, as the analysis moved closer to 2023, this effect weakened, particularly in countries like France, Morocco, and Sweden, where the elasticity even reversed direction. This shift is likely linked to structural changes in these economies, influenced by the Covid-19 pandemic and its effects on international trade.

In general, across all samples, countries like Austria, Denmark, France, Germany, India, Italy, Pakistan, Russia, Serbia, Slovenia, South Africa, South Korea, Sweden, and Switzerland emerge as notable examples where the decline in the value of the Turkish Lira significantly affects Türkiye’s exports to these countries.

Real exchange rate depreciation usually correlates with increased exports, but in some cases, Türkiye's exports to certain countries have declined. This could be due to these nations shifting their demand to other trading partners through bilateral trade and economic agreements that exclude Türkiye. Additionally, other factors linked to real exchange rate depreciation may also impact exports.

Table 4 presents the elasticity values for real exchange rate appreciation across various countries and sub-sample periods. Like the values for depreciation, these elasticity values and their statistical significance vary significantly depending on the specific trading partner country and sub-sample combinations. In particular, for Iraq, Romania, Spain, Tunisia, and Uzbekistan, where the relationship between real exchange rate appreciation and exports was not significant in the sub-sample periods, a statistically significant correlation was observed in the main sample. On the other hand, for countries like Algeria, Austria, Canada, Czechia, Greece, Iran, Malta, Portugal, and Serbia, the elasticity values show statistical significance across various sub-samples during periods of real exchange rate fluctuations, but this significance is absent in the main sample.

Table 3

Long-term model estimation results by country (REER-NEG)

Countries	2013-2023	2013-2018	2014-2019	2015-2020	2016-2021	2017-2022	2018-2023
Algeria	-0.542	0.193	-0.788	1.579	0.620	0.250	2.710
Australia	-1.833	1.796	-1.430	-3.033	-3.301	-3.913*	-5.206*
Austria	-3.957***	-4.026***	-4.175***	-5.114***	-2.122	-2.940	-7.397***
Azerbaijan	0.002	-1.529	-1.516	-1.329	1.298	1.226**	0.806
Belgium	-2.103	-1.245	-2.702**	-3.119**	-0.497	-1.927	-1.243
Brazil	0.337	0.739	0.665	1.628*	-1.062*	-0.205	-0.623
Bulgaria	-3.102**	-2.944	-4.807	-2.043	2.347	0.403	-1.409*
Canada	-1.975	-0.520	0.963	4.150	0.879	1.048	0.292
China	-0.414	-1.536	-1.455	-0.803	-3.964	1.460	-2.182
Croatia	0.278	-2.112	-2.872	-4.357**	-6.514*	-6.251	-1.788
Czechia	-0.612	-3.020*	-1.795	-2.565	1.889	2.154	2.254
Denmark	-3.009**	-5.933**	-7.063**	-7.070***	-1.883	-1.919	-2.813
Egypt	-1.074	-0.374	-1.116**	-1.215	0.635	-1.647	-1.884
Finland	-1.898	-2.727	-1.746	-2.459	2.433	-5.138	-0.771
France	-0.882	-1.419***	-1.362**	-0.466	2.151	3.319***	1.349
Germany	-1.798***	-2.617**	-3.439***	-2.669***	-0.074	-0.631	0.045
Greece	-2.497	3.019	1.073	1.390	-0.261	-0.433	-0.696
Hungary	0.845	-3.140	-2.615	-3.201	-1.793	0.003	1.084
India	-2.222	-4.756**	-2.158*	0.323	0.100	-3.104**	-4.389***
Iran	-3.480***	-1.150	-0.968	-1.292	-0.373	-0.683	-0.728
Iraq	-0.256	-4.139	-5.684*	-2.126	0.844	-1.434	-1.548
Ireland	-2.237	4.762	1.541	0.211	18.085**	13.038*	0.822
Israel	-2.885*	-4.589*	-3.433	0.103	0.588	-3.112	-3.918**
Italy	-3.908**	-5.059***	-4.304**	-5.686**	1.498	-2.521**	-1.011
Jordan	-3.018*	-5.567	-3.919	-3.403	-3.838*	-3.442	-1.752
Kazakhstan	-0.395	-0.266	-1.014	-0.785	-0.606	2.914	4.397
Libya	-1.110	-3.390	-1.935	-3.252	0.788	-6.381***	-3.326
Malta	4.962	-14.819	-12.604	-16.198	0.369	-8.219	15.661
Mexico	-0.971	-2.208	-0.520	0.969	2.116*	2.340**	0.589
Morocco	-1.400	11.103**	2.447	-1.829	-6.902**	-2.581	-1.149
Netherlands	-1.603	-5.648*	-5.490*	-5.392	1.305	-2.008	-6.165

***p<0.01; **p<0.05; *p<0.1.

Table 3 (continued)

Long-term model estimation results by country (REER-NEG)

Countries	2013-2023	2013-2018	2014-2019	2015-2020	2016-2021	2017-2022	2018-2023
Nigeria	0.192	0.164	0.703	4.202	1.623	3.579	-1.145
Norway	2.615*	5.210	1.610	2.979	-4.985	3.132	4.366*
Pakistan	5.193**	9.002*	11.513**	4.692*	2.482	7.404**	5.500
Poland	-1.425	0.222	-0.444	-0.895	1.105	0.174	-1.106
Portugal	-1.325	-2.866	-4.155*	-7.266**	-4.460	-4.367	-5.502*
Qatar	-5.032*	-2.402	-3.441	-1.413	5.440	0.086	-0.275
Romania	-2.825**	-2.593**	-2.623*	-1.944	-0.702	-0.907	-1.484
Russia	-2.207***	0.566	0.658	0.178	-0.707*	-2.814***	-2.669***
Saudi Arabia	3.151	-0.551	-1.504	-0.610	-6.370	18.296**	10.720
Serbia	-0.835	-2.418**	-3.542***	-3.379**	-3.471	-5.997**	-1.941
Slovakia	-2.548	0.955	0.937	2.424	-0.282	1.604	0.902
Slovenia	-2.258	-1.835	-1.916	-4.829**	20.508**	13.481***	5.562
South Africa	-1.866***	-1.703***	-1.063**	-2.336**	-0.893	-0.843	-0.278
South Korea	-6.022***	-4.332**	-5.720***	-2.573	-5.438**	-3.194	-3.222*
Spain	-2.131	-1.436	-0.976	-4.509**	4.621**	2.269	1.707
Sweden	-0.208	-2.859***	-2.362***	-1.526*	0.257	2.490**	0.895
Switzerland	-3.994*	-1.348	0.897	-12.342***	-10.396***	-8.936**	-5.324
Tunisia	-4.170**	1.982	-0.076	-0.192	0.624	-0.927	-3.492
UAE	-1.410	-6.723**	-7.332**	0.179	-0.866	-1.998	-0.737
USA	-2.366	-2.110	-1.081	-3.051	-0.086	-4.072	-2.761*
Ukraine	-0.570	-0.498	-0.293	-0.535	-0.584	2.981	-3.138
UK	0.018	1.445	1.692	2.402	2.061	2.316*	-0.704
Uzbekistan	0.679	1.533	0.404	0.650	1.658*	0.262	2.014

***p<0.01; **p<0.05; *p<0.1.

In some countries, like Pakistan and Poland, the effect of real exchange rate appreciation on exports was not statistically significant before the pandemic, but it became noticeable in sub-samples from 2020 onward. Conversely, in countries such as Azerbaijan, Greece, Italy, and the UK, the elasticity values were statistically significant in the earlier sub-samples, but this significance diminished as the analysis approached 2023.

The appreciation of the Turkish Lira against other currencies significantly reduces exports in the machinery and transport sectors from Türkiye to countries such as Azerbaijan, Canada, France, Iran, Jordan, Kazakhstan, Morocco, Pakistan, Russia, Saudi Arabia, and the UK. Interestingly, contrary to economic expectation, the real appreciation of the TL actually increases exports to Germany, Italy, and Libya.

Overall, the effects of the real exchange rate on exports differ across countries. This variability may stem from the diversity of exported products and the influence of trade agreements. These findings are consistent with other studies, which show that export price and income elasticities vary among countries. Bozok et al. (2015) propose that product diversity may be the main cause of this variation, while Binatlı and Sohrabji (2009) find that elasticities differ across goods types (consumption, capital, and intermediate goods), partly explaining the variation among country groups.

In addition, Aslan and Akpiliç (2024) emphasize the significant impact of technological intensity in exports on the relationship between the exchange rate and exports. They observe that countries with more flexible exchange rate policies and those that depend significantly on imported materials for exports are more responsive to changes

in the exchange rate. Similarly, Çulha and Kalafatçılar (2014) find that regional differences in technological intensity contribute to varying price and income elasticities.

Table 4

Long-term model estimation results by country (REER-POS)

Countries	2013-2023	2013-2018	2014-2019	2015-2020	2016-2021	2017-2022	2018-2023
Algeria	-0.765	4.509*	2.202	4.060*	3.623	1.765	-6.031***
Australia	-1.374	-0.742	-2.698	-3.302**	0.288	-0.804	-1.510
Austria	1.070	-2.117*	-1.826	-1.672*	-1.390*	0.394	3.677***
Azerbaijan	-1.290*	-2.153***	-2.601***	-2.517***	0.394	0.496	0.604
Belgium	0.453	0.714	1.243	-0.253	-1.864	0.650	-1.660
Brazil	0.329	-0.227	-0.288	-0.710	-2.274**	-1.305	-0.856
Bulgaria	1.116	0.186	2.156	-0.082	-2.483	-0.765	1.250
Canada	-4.071	-6.076*	-8.916**	-8.027**	-5.707*	-11.000**	-5.798*
China	-0.087	-0.329	-0.395	-1.696	-2.001	-4.025	-3.841
Croatia	2.330**	-1.573	0.557	-3.303**	-2.211	2.552	7.233***
Czechia	0.635	3.275**	2.424	2.346	-0.823	-1.422*	-1.678**
Denmark	0.861	3.760	3.985	1.038	-0.076	0.119	0.697
Egypt	-0.528*	0.670**	-0.209	-0.278	-0.348	-0.211	-0.562
Finland	0.516	1.280	0.809	-1.689	-2.464	1.038	-0.396
France	-1.000*	-0.773**	-1.300**	1.127**	-1.103	-2.575***	-3.256***
Germany	0.961**	1.748**	2.004**	1.255**	0.890**	0.541	-1.731*
Greece	-2.352	-5.006**	-4.663**	-2.869	-2.856	-1.624	-1.681
Hungary	-1.044	3.320	1.241	-0.434	-3.022	-5.132**	-1.397
India	-0.343	0.025	0.538	0.236	0.702	-0.156	-2.340
Iran	-0.313	0.391	-4.429***	-4.436***	-4.181***	-2.826	-0.201
Iraq	2.293*	0.782	2.367	1.700	-0.610	-0.256	0.984
Ireland	4.199	1.660	-4.068	-1.870	1.637	-1.088	0.312

***p<0.01; **p<0.05; *p<0.1.

Table 4 (continued)

Long-term model estimation results by country (REER-POS)

Countries	2013-2023	2013-2018	2014-2019	2015-2020	2016-2021	2017-2022	2018-2023
Israel	-1.227	0.069	-0.169	0.985	1.147	1.254	0.691
Italy	3.159*	7.354***	6.847***	4.108**	2.125**	1.407	-2.522
Jordan	-5.526***	-4.930	-4.066**	-2.583	-4.836**	-2.988	-2.263
Kazakhstan	-1.980**	-1.667*	-2.624**	-1.555	-1.235	-2.704*	-6.868***
Libya	2.738***	12.678***	13.352***	9.767***	-1.228	1.447**	1.375**
Malta	-5.957	23.463	26.387**	17.464*	4.906	2.628	-14.024
Mexico	1.952	3.295	3.038	3.975*	2.443	1.744	-0.445
Morocco	-4.368***	-7.004**	-2.450	-0.930	-4.149***	-4.795***	-4.589***
Netherlands	1.869	0.900	0.638	-1.099	0.115	-0.714	4.192
Nigeria	-0.220	0.669	0.384	0.385	-0.119	-5.433*	-0.126
Norway	-0.040	-2.929	-1.781	-3.727	3.590	-0.673	2.262
Pakistan	-2.056*	-3.053	-3.199	-3.161**	-0.827	-6.370***	-7.133***
Poland	-0.432	-0.653	-0.190	-0.033	-1.754*	-1.219	-2.696*
Portugal	2.601	2.531*	2.705*	0.166	0.984	0.157	10.170***
Qatar	-2.411	-4.488	-2.589	-5.179	-2.419	-0.127	-1.442
Romania	1.879*	-0.172	0.536	-0.778	-0.365	-0.445	0.928
Russia	-2.646***	-1.476*	-2.091***	-2.678***	0.438	-2.375**	-1.418**
Saudi Arabia	-11.269**	-6.195**	-4.530	2.580	-2.659	-29.181***	-33.232**
Serbia	1.713	0.185	2.433**	-1.102	-0.560	1.861	5.458**
Slovakia	0.339	-0.775	-3.609	-0.669	0.929	-0.648	-0.959
Slovenia	1.840	1.936	0.290	1.629	-3.837	-2.956	-6.901
South Africa	-0.587	-0.314***	-0.814	0.444	0.275	-0.644	-0.797
South Korea	-1.441	5.512	3.796*	-0.029	2.984	0.053	-0.601
Spain	3.297**	1.435	1.300	2.181	0.738	1.841	-1.277
Sweden	0.729	0.928	0.981	1.467	1.560	0.145	0.849
Switzerland	3.224	1.492	0.649	-1.500	-8.153**	0.244	2.189
Tunisia	2.227*	-0.663	1.231	0.519	0.119	0.213	2.727
UAE	0.006	4.968	5.619	2.759	3.545	-0.335	0.901
USA	-2.186	-1.990	-2.964	-2.500	-4.674	-5.233**	2.567
Ukraine	0.349	0.275	-0.140	2.665**	-0.865	-0.125	2.967
UK	-1.291**	-3.181***	-3.016***	-2.984***	-1.597	-0.825	0.909
Uzbekistan	0.971**	0.405	0.185	0.295	-0.316	1.042	3.351

***p<0.01; **p<0.05; *p<0.1.

Conclusion

This study uses panel data analysis to investigate the impact of real exchange rates on exports of machinery and transport equipment, using monthly data from January 2013 to August 2023. The analysis focuses on Türkiye's exports to 54 trading partner nations. In addition to linear models, nonlinear models are applied to assess how both appreciation and depreciation of the real exchange rate influence exports. The main sample is divided into six sub-samples representing different time periods from 2013 to 2023: 2013-2018, 2014-2019, 2015-2020, 2016-2021, 2017-2022, and 2018-2023. This divisions aims to evaluate how the relationship between real exchange rates and exports evolves over time.

The analysis shows a long-term asymmetric relationship between machinery and transport equipment exports and the real exchange rate. This asymmetry is evident in both the main sample and all sub-samples, with the exception of the 2018-2023 period. The results suggest that positive and negative exchange rate shocks impact exports differently in terms of direction, intensity, or statistical significance.

The study detects a notable change in how the real exchange rate affects exports over time. From 2013 to 2020, the expected positive effect of exchange rate depreciation on exports was clear, showing that lower exchange rates improved the competitiveness of Turkish goods. However, in the periods 2016-2021 and 2017-2022, depreciation no longer significantly impacted exports, while appreciation began to negatively affect them. In 2018-2023, the nonlinear relationship disappeared, with neither depreciation nor appreciation explaining export trends. This shift is linked to supply chain disruptions, particularly in machinery and transport, exacerbated by the pandemic and subsequent global developments.

These results show that the relationship is dynamic and can change over time. Persistent supply chain disruptions, increased commodity prices, and production challenges, along with rising geopolitical tensions, have caused fluctuations in this relationship. The initial benefits of real exchange rate depreciation on exports diminished over time, while appreciation began to negatively impact exports in the machinery and transport sectors. In recent periods, the impact of the real exchange rate on exports has weakened.

Analyzing individual countries reveals significant variations in the relationship between the real exchange rate and Türkiye's exports of machinery and transport equipment, differing across time periods and trading partners. Structural shifts have been observed in several countries, where the initially positive impact of currency depreciation on exports weakened over time. Conversely, in some instances, currency depreciation, which initially showed no significant effect on exports, later became a statistically significant factor. Similar patterns are evident for real exchange rate appreciations. The pandemic seems to have triggered structural transformations in the dynamics between exchange rates and exports.

These findings highlight the complexity of the relationship between the real exchange rate and exports, showing that it fluctuates based on the timeframe and the particular trading partner concerned. Considering the asymmetric impacts of real exchange rate appreciation and depreciation is essential, as opposed to relying exclusively on aggregate analyses. Policymakers should avoid a uniform approach and use a more targeted strategy that considers the varying effects of real exchange rate changes across time and trading partners. Comprehensive, country-specific assessments are crucial before implementing policy changes to ensure effective strategies for enhancing export growth. By considering the features of exported goods and their destination markets, policymakers can better manage the exchange rate-export relationship and support sustainable export growth.

Future studies could strengthen the reliability of the results by using more detailed indicators, such as sector-specific demand factors or firm-level data, if such data are available. Since the current analysis focuses only on Türkiye’s exports of machinery and transport equipment, the findings cannot be easily generalized to other sectors. Expanding the analysis to cover different industries, bilateral trade flows, or regional economic blocs may offer a deeper understanding of how real exchange rate dynamics affect export performance across various contexts.

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Appendix

Table A1

Cross Section Dependence Test Results

Models	Pesaran (2004) CD Test		Bias-adjusted LM Test	
	Test Statistics	p-value	Test Statistics	p-value
Linear Model	55.85	0.000	619.7	0.000
Non-Linear Model	45.79	0.000	543.4	0.000

Table A2

Slope Homogeneity Test Results

Models	Test	Test Statistic	p-value
Linear Model	$\tilde{\Delta}$	40.665	0.000
	$\tilde{\Delta}_{adj}$	42.550	0.000
Non-linear Model	$\tilde{\Delta}$	38.547	0.000
	$\tilde{\Delta}_{adj}$	40.686	0.000

Table A3

Pesaran (2007) Unit Root Test Results

Variable	Level			First Difference		
	Model	Zt-bar	P-value	Model	Zt-bar	P-value
X	Constant	-2.057	0.020	Constant	-12.432	0.000
	Constant + Trend	1.673	0.953	Constant + Trend	-10.085	0.000
RER	Constant	-4.340	0.000	Constant	-8.371	0.000
	Constant + Trend	1.793	0.964	Constant + Trend	-6.646	0.000
RER_NEG	Constant	0.336	0.632	Constant	-7.555	0.000
	Constant + Trend	1.265	0.897	Constant + Trend	-4.787	0.000
RER_POS	Constant	-2.621	0.004	Constant	-5.961	0.000
	Constant + Trend	0.200	0.579	Constant + Trend	-4.811	0.000
Y	Constant	5.706	1.000	Constant	-10.185	0.000
	Constant + Trend	4.207	1.000	Constant + Trend	-7.382	0.000
VOL	Constant	0.575	0.717	Constant	-14.664	0.000
	Constant + Trend	1.673	0.953	Constant + Trend	-10.997	0.000
COV	Constant	-2.102	0.018	Constant	-11.691	0.000
	Constant + Trend	1.886	0.970	Constant + Trend	-10.113	0.000

Table A4

Westerlund Panel Cointegration Test Results

Sample Period	Test	Linear Model				Non-linear Model			
		Test Statistics	Z-value	p-value	robust p-value	Test Statistics	Z-value	p-value	robust p-value
2013-2022	Gt	-5.142	-18.457	0.000	0.000	-5.403	-19.062	0.000	0.000
	Ga	-49.899	-27.654	0.000	0.000	-50.817	-25.188	0.000	0.000
	Pt	-41.244	-21.952	0.000	0.000	-42.616	-22.236	0.000	0.000
	Pa	-54.187	-34.395	0.000	0.000	-54.281	-31.440	0.000	0.000
2013-2018	Gt	-4.290	-11.550	0.000	0.000	-4.475	-11.660	0.000	0.000
	Ga	-30.484	-11.152	0.000	0.000	-26.320	-5.639	0.000	0.000
	Pt	-36.576	-17.281	0.000	0.000	-37.765	-17.365	0.000	0.000
	Pa	-37.645	-20.276	0.000	0.000	-36.343	-16.830	0.000	0.000
2014-2019	Gt	-4.133	-12.058	0.000	0.000	-4.294	-11.585	0.000	0.000
	Ga	-32.112	-15.168	0.000	0.000	-28.728	-9.659	0.000	0.000
	Pt	-33.181	-16.023	0.000	0.000	-35.269	-15.973	0.000	0.000
	Pa	-34.411	-21.463	0.000	0.000	-36.301	-19.129	0.000	0.000
2015-2020	Gt	-4.098	-9.999	0.000	0.000	-4.384	-10.926	0.000	0.000
	Ga	-28.686	-9.623	0.000	0.000	-26.772	-6.000	0.000	0.000
	Pt	-33.174	-13.876	0.000	0.000	-34.655	-14.242	0.000	0.000
	Pa	-34.247	-17.376	0.000	0.000	-35.394	-16.056	0.000	0.000
2016-2021	Gt	-4.468	-12.997	0.000	0.000	-4.295	-10.217	0.000	0.000
	Ga	-32.999	-13.289	0.000	0.000	-29.358	-8.063	0.000	0.000
	Pt	-33.908	-14.611	0.000	0.000	-34.665	-14.252	0.000	0.000
	Pa	-35.196	-18.186	0.000	0.000	-34.761	-15.541	0.000	0.000
2017-2022	Gt	-4.403	-12.470	0.000	0.000	-4.399	-11.052	0.000	0.000
	Ga	-33.255	-13.507	0.000	0.000	-28.891	-7.691	0.000	0.000
	Pt	-32.932	-13.634	0.000	0.000	-31.816	-11.391	0.000	0.000
	Pa	-33.323	-16.587	0.000	0.000	-29.029	-10.872	0.000	0.000
2018-2023	Gt	-4.357	-12.092	0.000	0.000	-5.227	-17.661	0.000	0.000
	Ga	-30.272	-10.971	0.000	0.000	-33.858	-11.655	0.000	0.000
	Pt	-31.292	-11.993	0.000	0.000	-46.968	-26.606	0.000	0.000
	Pa	-30.167	-13.893	0.000	0.000	-43.203	-22.417	0.000	0.000

Genişletilmiş Özet

Amaç

Bu çalışma, reel döviz kuru değişimlerinin Türkiye'nin makine ve ulaştırma araçları ihracatına etkisini analiz etmeyi amaçlamaktadır. İncelenen sektör, Türkiye'nin toplam ihracatının %29'unu oluşturan ve bilgisayar, optik ekipman, elektrikli makineler ile motorlu taşıtlar gibi yüksek ve orta-yüksek teknolojili ürünleri kapsayan stratejik bir alandır. Katma değeri yüksek ürünler sunduğu için bu sektör, ekonomik büyüme ve teknolojik gelişim açısından büyük bir öneme sahiptir.

Çalışma, reel döviz kurundaki değer kazanma ve kaybetme durumlarının ihracat üzerindeki etkilerinin simetrik olup olmadığını incelemiştir. Bu kapsamda, Doğrusal Olmayan Panel ARDL yöntemi kullanılarak asimetrik etkiler analiz edilmiştir. Ayrıca, 2013-2023 yılları arasındaki örneklem verileri 6 alt döneme ayrılarak, döviz kuru ile ihracat arasındaki ilişkinin zamanla nasıl değiştiği değerlendirilmiştir. Sonuçlar, sektörün döviz kuru değişimlerine verdiği tepkilerin dönemsel olarak farklılaştığını ve zamanla değişen dinamikler sergilediğini ortaya koymuştur. Bu bulgular, sektörün küresel ekonomik değişimlere karşı duyarlılığını vurgulamaktadır.

Yöntem

Bu çalışmada, dış talep, reel döviz kuru, döviz kuru oynaklığı ve Kovid-19 salgının Türkiye'nin makine ve ulaştırma araçları ihracatı üzerindeki etkileri ülke bazında, aylık veriler kullanılarak 2013 Ocak-2023 Ağustos dönemi için analiz edilmiştir. Araştırma, Türkiye'nin makine ve ulaştırma araçları ihracatında %0,25 veya daha fazla paya sahip 54 ticaret ortağını kapsamaktadır.

Çalışmada kullanılan model, klasik ihracat talep modeline dayanmaktadır ve bağımlı değişken olarak Türkiye'nin ülke bazında gerçekleştirdiği reel makine ve ulaştırma araçları ihracatı esas alınmıştır. Dış talep göstergesi olarak, Türkiye'nin ticaret ortaklarının sanayi üretim endeksleri kullanılmıştır. Reel döviz kuru, doğrudan kotasyon yöntemi ile elde edilen döviz kurlarının Türkiye ve ticaret ortaklarının fiyat endeksleriyle reel hale getirilmesi ile hesaplanmıştır. Makine ve ulaştırma sektörü, üretimde kullanılan sermaye ve ara mallarını kapsamakta olup, aynı zamanda motorlu yolcu araçları ile deniz ve hava taşımacılığı ürünlerini de içermektedir. Bu nedenle, reel döviz kuru hesaplamalarında tüketici ve üretici fiyatlarının ağırlıklı ortalamasıyla oluşturulan fiyat endeksi kullanılmıştır. Kovid-19 etkisi, ülkelerin aylık vaka sayıları ile ölçülmüş, döviz kuru oynaklığı ise her ülke için reel döviz kuru büyümesinin hareketli standart sapmasıyla hesaplanmıştır.

Çalışmada ayrıca, reel döviz kuru ile makine ve ulaştırma araçları ihracatı arasındaki asimetrik ilişki de incelenmiştir. Döviz kurunun değer kazandığı ve kaybettiği dönemlerde ihracat üzerindeki etkilerin farklı olabileceği öngörülmektedir. Bu ilişkiyi incelemek için Westerlund (2007) panel eşbütünleşme testi uygulanmış ve kesit bağımlılığı ile eğim heterojenliği dikkate alınmıştır. Asimetrik etkilerin belirlenmesi için ise, Shin, Yu and Greenwood-Nimmo (2014) tarafından geliştirilen Doğrusal Olmayan Panel ARDL yöntemi kullanılmıştır.

2013-2023 yılları arasındaki dönem, altı farklı zaman dilimine ayrılarak, döviz kuru ile ihracat arasındaki ilişkinin zamanla nasıl değiştiği incelenmiştir.

Bulgular

Analiz, makine ve ulaştırma araçları ihracatı ile reel döviz kuru arasında uzun vadeli ve asimetrik bir ilişki bulunduğunu ortaya koymaktadır. Bu asimetrik yapı, 2013-2023 dönemini kapsayan ana örneklemde olduğu gibi, 2018-2023 dönemi hariç tüm alt dönemlerde de gözlemlenmiştir. Bulgular, pozitif ve negatif reel döviz kuru şoklarının ihracat üzerindeki etkilerinin yön, büyüklük ve istatistiksel anlamlılık açısından farklılaştığını göstermektedir.

Çalışma, reel döviz kurunun ihracat üzerindeki etkisinin zaman içinde yapısal değişikliklere uğradığını vurgulamaktadır. 2013 ile 2020 yılları arasında, döviz kurundaki değer kaybının ihracat üzerinde belirgin bir şekilde olumlu etkisi olduğu, düşük reel döviz kuru seviyelerinin Türk mallarının rekabet gücünü artırdığı görülmüştür. Ancak 2016-2021 ve 2017-2022 alt dönemlerinde, döviz kuru değer kaybının ihracat üzerindeki etkisi azalmış ve istatistiksel olarak anlamlılığını yitirmiştir. Bu dönemlerde döviz kuru değer kazanmaya başladığında ise ihracat üzerindeki etkisi olumsuz bir yöne kaymıştır. 2018-2023 dönemi analiz edildiğinde, bu asimetrik ilişki tamamen ortadan kalkmış ve ne döviz kuru değer kaybının ne de değer kazancının ihracat performansı üzerinde anlamlı bir etkisi olmadığı sonucuna varılmıştır.

Bu değişim, özellikle makine ve ulaştırma sektöründe pandemi ve küresel gelişmelerin tetiklediği tedarik zinciri bozulmaları ve artan belirsizliklerle ilişkilendirilmektedir. Bulgular, reel döviz kuru ile ihracat arasındaki

ilişkinin dinamik ve karmaşık bir yapıya sahip olduğunu göstermektedir. Süregelen tedarik zinciri sorunları, emtia fiyatlarındaki dalgalanmalar, üretim zorlukları ve jeopolitik gerilimler bu ilişkiyi daha da karmaşık hale getirmiştir. Başlangıçta reel döviz kurundaki değer kaybının ihracat üzerindeki olumlu etkisi zamanla azalırken, değer kazanması ihracatı olumsuz etkilemiştir. Son dönemde ise döviz kurunun ihracat üzerindeki etkisi zayıflamış ve bu ilişkinin gücü giderek azalmıştır.

Ülkeler bazında elde edilen sonuçlar, Türkiye'nin makine ve ulaştırma araçları ihracatı ile reel döviz kuru arasındaki ilişkinin farklı ticaret ortakları ve dönemler arasında önemli farklılıklar gösterdiğini ortaya koymaktadır. Bazı ülkelerle olan ticarette, döviz kuru değer kaybının başlangıçta ihracat üzerindeki olumlu etkisi zayıflarken, bazı durumlarda bu etkinin sonradan belirgin hale geldiği gözlemlenmiştir. Benzer şekilde, döviz kuru değer kazanması da bazı ticaret ortakları için dönemsel olarak farklı etkiler yaratmıştır.

Pandemi ve sonrasındaki küresel belirsizlikler, reel döviz kurları ile ihracat arasındaki dinamiklerde yapısal değişimlere yol açarak, tedarik zinciri sorunlarının yoğunlaştığı sektörlerde bu dönüşümleri daha belirgin hale getirmiştir.

Sınırlılıklar

Çalışmada kullanılan ihracat verileri TÜİK tarafından açıklanan genel ticaret sistemi verilerine dayanmaktadır. Bu metodoloji kapsamında veriler, 2013 yılından itibaren yayınlanmaktadır.

Öneriler

Çalışmada elde edilen bulgular, reel döviz kuru ile ihracat arasındaki ilişkinin karmaşık yapısını vurgulamakta ve bu ilişkinin hem zaman dilimine hem de belirli ticaret ortaklarına bağlı olarak değişiklik gösterdiğini ortaya koymaktadır. Sadece toplu analizlere dayanmak yerine, reel döviz kurunun değer kazanması ve kaybetmesinin asimetrik etkilerini dikkate almak önemlidir. Politika yapıcıların, her duruma uyan tek bir yaklaşım benimsemekten kaçınarak, reel döviz kuru hareketlerinin farklı zaman dilimleri ve ticaret ortakları üzerindeki çeşitli etkilerini hesaba katan daha etkili, koşullara uyun stratejiler geliştirmesi gerekmektedir. Politika değişikliklerini uygulamadan önce, ülkeye özgü kapsamlı değerlendirmeler yapılması, ihracat büyümesini artırmaya yönelik etkili stratejilerin oluşturulmasını sağlamak açısından kritik öneme sahiptir. İhraç edilen malların niteliklerine ve hedef pazarların özelliklerine odaklanarak, politika yapıcılar döviz kuru-ihracat ilişkilerinin karmaşıklıklarını daha iyi yönetebilir ve sürdürülebilir ihracat büyümesini teşvik edebilirler.

Özgün Değer

Bu araştırma, farklı zaman dilimlerini incelemesi, asimetrik etkileri ele alması ve hem panel veri analizi hem de ülke bazlı değerlendirmeler yapmasıyla literatüre önemli ve özgün bir katkı sağlamaktadır. Özellikle tek bir modelle sınırlı kalınmaması, dönemsel etkilerin yanı sıra ticaret ortaklarına özgü farklılıkların da detaylı olarak incelenmesine olanak tanımaktadır. Böylece, reel döviz kuru ile ihracat arasındaki ilişkinin sabit bir yapıda olmadığı, aksine zamanla ve ülkeler arasında değişen bir dinamik yapı sergilediği daha net bir şekilde ortaya konulmuştur.

Çalışma, döviz kurundaki dalgalanmaların farklı dönemlerde ihracat üzerindeki etkilerini ayrı ayrı analiz ederek, literatürde eksik kalan dönemsel ve ülke spesifik varyasyonları dikkate almıştır. Bu sayede, Türkiye'nin makine ve ulaştırma araçları ihracatında döviz kuru değişimlerinin etkisinin zaman içinde farklılaştığını ve bu farklılaşmanın küresel ekonomik gelişmelere, yapısal değişimlere ve ülke bazlı ekonomik koşullara bağlı olarak şekillendiğini göstermektedir. Bu kapsamlı yaklaşım, döviz kuru-ihracat ilişkisinin dinamik yapısını daha derinlemesine anlama ve politika yapıcılar için daha doğru stratejiler geliştirme imkanı sunmaktadır.