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How Geopolitical Risks Influence Real Exchange Rate Dynamics in Türkiye? Evidence from Fourier Cointegration Test with Non-Normal Errors

Abstract. *Türkiye is one of the countries that directly and significantly affected by geopolitical risks due to its strategic location. However, the impact of these risks on the real exchange rate—one of the key determinants of macroeconomic stability—remains unclear. This study aims to address this gap in the literature by examining the effects of geopolitical risks on real exchange rate dynamics in Türkiye. In doing so, it also considers essential factors such as terms of trade, real interest rates, and productivity, which are fundamental components of real exchange rate models. The analysis covers quarterly data from 2000:Q1 to 2024:Q1 and employs the newly developed RALS Fourier ADL cointegration test, which offers a robust methodological framework. The findings reveal that geopolitical risks causes to depreciation in Türkiye's real exchange rate. Specifically, heightened geopolitical risks lead to capital outflows as investors postpone investment decisions, disrupt portfolio investments, and create inflationary pressures. These dynamics result in higher demand for foreign exchange, ultimately driving up the real exchange rate. The study highlights the crucial role of geopolitical risks in modelling Türkiye's real exchange rate. If policymakers estimate exchange rates without accounting for these risks, their assessments may yield misleading results.*

Keywords: *Geopolitical risk, reel exchange rate, Fourier ADL cointegration test.*

JEL Classification: C32, D80, F31, F41.

Received: 22 June 2025	**Revised: 24 June 2025**	**Accepted: 8 September 2025**

DOI: 10.24818/18423264/59.3.25.15

1. Introduction

Türkiye is a country that faces considerable geopolitical risks due to its strategic position at the crossroads of multiple regions. Its southern borders are adjacent to Middle Eastern nations such as Iraq, Iran, and Syria, all of which have experienced prolonged internal conflicts, both military and political, over the years. To the east, Türkiye shares borders with the South Caucasus countries of Azerbaijan and Armenia, which have historical disputes that occasionally escalate into military confrontations. Furthermore, its northern and northeastern borders are adjacent to the North Caucasus region, which includes countries like Russia and Ukraine—both of which are currently embroiled in one of the largest conflicts in recent history. Given this complex geopolitical landscape, Türkiye has undertaken significant efforts to protect its economic, social, and cultural integrity from these external risks.

Türkiye's geographical and historical ties with the European countries on its western border place it at the intersection of the unstable "Eastern" nations and the more developed "Western" countries. This unique positioning endows Türkiye with a significant political and diplomatic responsibility in strategic areas such as migration, trade, and logistics, all of which are influenced by regional instabilities. The "Grain Corridor" agreement, established during the Russia-Ukraine conflict, and the burden of hosting approximately 4.5 million refugees following the Syrian Civil War, are prime examples of this responsibility. Additionally, Türkiye functions as a crucial barrier for migration flows from the Middle East to Europe and serves as an energy corridor for Russian natural gas destined for Europe. Due to its military, political, and diplomatic capabilities, Türkiye is recognised as one of the most influential regional actors. However, this role often introduces challenges that disrupt Türkiye's pursuit of sustainable economic growth and development.

Geopolitical risks are among the most significant external factors often overlooked when evaluating the Turkish economy. There is limited literature that connects geopolitical risks to various macroeconomic variables in the context of the Turkish economy. For instance, Mansour-Ichrakieh and Zeaiter (2019) examine the relationship between geopolitical risks and financial stability for Türkiye. Their findings indicate that geopolitical risks originating from Saudi Arabia exacerbate financial stress in Türkiye, whereas risks stemming from Russia have no significant effect. Bilgili et al. (2022) investigate the impact of geopolitical risk on several macroeconomic variables, finding that exchange rate movements play a significant role in shaping inflation dynamics, while geopolitical risks influence overall economic uncertainty. Erdoğan et al. (2022) examine the impact of geopolitical risk on the real returns of the Turkish stock market and identify a positive long-term relationship. This finding suggests that investors may perceive geopolitical risks as investment opportunities. Similarly, Saadaoui et al. (2024) investigate the impact of geopolitical risk on CO_2 emissions in Türkiye and find that geopolitical risk plays a crucial role in reducing CO_2 emissions in the country.

However, the impact of exchange rate fluctuations has not been adequately addressed within these macroeconomic perspectives. As is well known, exchange rates are of critical importance for the Turkish economy, which exhibits a fragile economic structure. They serve as a primary source of inflation, current account deficits, and monetary shocks that have affected the country in recent years. Figure 1 illustrates the quarterly changes in nominal exchange rates in the Turkish economy since the early 21st century. It is evident that the exchange rate increases, which began following the global economic crises of 2008-2012, were exacerbated by internal turmoil after 2016 and the implementation of flawed macroeconomic policies. Figure 2, however, highlights the persistent and escalating geopolitical risks in Türkiye, particularly since the onset of the Syrian Civil War in 2011. Other notable events, such as the Iraq War (2003-2011), the ISIS terrorist attacks (2013-2019), the ongoing Syrian Civil War (2011-2024), the Taliban's invasion of Afghanistan in 2021, and the Russia-Ukraine War (2022), have further contributed to the rising geopolitical risks. Despite this, the extent to which these developments influence exchange rate fluctuations remains unclear. Therefore, investigating the effects of geopolitical risks on exchange rate fluctuations is crucial for a more realistic evaluation of the Turkish economy.

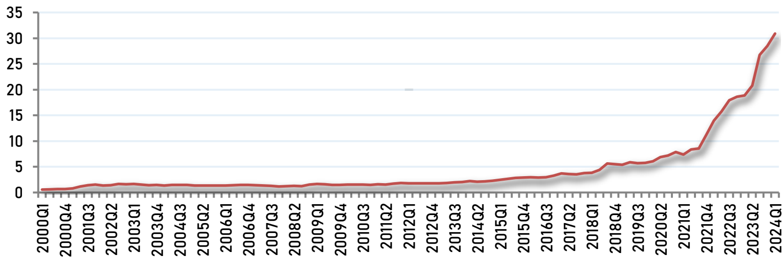

Figure 1. Trends in Nominal Exchange Rates in Türkiye, 2000-2024
Source: Authors' own creation.

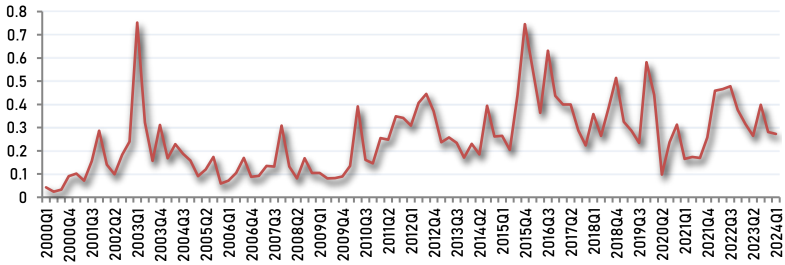

Figure 2. Trends in GPR Index in Türkiye, 2000-2024
Source: Authors' own creation.

Theoretically, the effects of geopolitical risks on real exchange rates can manifest through several channels. First, an increase in geopolitical risks can deter both direct foreign capital investments and portfolio investments, leading to a shortage of foreign exchange. This results in heightened demand for foreign currency and a depreciation of the national currency. Second, increased geopolitical risks can create uncertainty and insecurity among capital owners and investors. In this scenario, capital outflows from the country accelerate, potentially leading to a significant reduction in foreign exchange supply. Such outflows can drive up the exchange rate, further contributing to the depreciation of the national currency. Third, heightened geopolitical risks can lead to price increases in strategic sectors, such as food and energy, thereby intensifying inflationary pressures. Rising inflation levels can contribute to the depreciation of the national currency, consequently driving up exchange rates. Finally, increased geopolitical risks may disrupt trade relations, particularly with key trading partners, thereby cutting off foreign exchange resources. As a result of these channels, the national currency loses value, and the exchange rate rises. Therefore, it is anticipated that geopolitical risks will exert increasing effects on real exchange rates.

In countries with a fragile economic structure, such as Türkiye, which also experience high geopolitical risks, exchange rate fluctuations can occur more intensely and sharply. This, in turn, leads to more severe consequences for macroeconomic stability, economic growth, inflation, and external debt. For instance, Hossain et al. (2024) demonstrated that major geopolitical crises, particularly the Russia-Ukraine war, exert pressure on foreign exchange markets in energy-dependent countries, accelerating the depreciation of national currencies and amplifying inflationary effects. Bilgili et al. (2022) showed that geopolitical risks exacerbate inflationary pressures by increasing financial stress for Türkiye. Mansour-Ichrakieh and Zeaiter (2019) demonstrated that external geopolitical risks can negatively affect Türkiye's financial stability.

Based on above information, this study aims to investigate the effects of geopolitical risks on the real exchange rate dynamics in Türkiye. Employing a newly developed and robust time series analysis method—RALS Fourier cointegration analysis—this research will comprehensively assess the impact of terms of trade, real interest rates, productivity differentials, and geopolitical risks on the real exchange rate. A critical review of the existing literature reveals that previous studies on real exchange rate have had a limited focus, predominantly concentrating on isolated factors such as economic policy uncertainty, financial market dynamics, or regional trade balances. This study distinguishes itself as the first comprehensive analysis to integrate geopolitical risks into real exchange rate models for Türkiye. By addressing this underexplored dimension, the study not only fills a significant gap in the literature but also provides actionable insights for policymakers and contributes to broader academic discussions. The opportunity to address this gap serves as the primary motivation for undertaking this research.

The structure of the paper as follows: Section 2 reviews the relevant literature. Section 3 outlines the data and empirical framework. Section 4 presents the econometric methodology. Section 5 discusses empirical findings. Finally, Section 6 is the conclusion and the policy recommendation.

2. Literature review

Recent studies have employed various measures to assess the relationship between geopolitical risk and exchange rate dynamics. One of the widely used indicators in the literature is economic policy uncertainty (EPU), which captures uncertainty related to government policies, regulations, and economic decision-making. Several studies have examined the impact of EPU on exchange rate volatility and returns. Roubaud and Arouri (2018) utilise VAR and Markov-switching VAR models to analyse the interactions between oil prices, exchange rates, and stock markets under EPU. Their findings reveal nonlinear and regime-dependent relationships, with stronger linkages observed during periods of heightened market volatility. Bartsch (2019) employs a GARCH model to examine the impact of EPU on the US Dollar–British Pound exchange rate volatility. The findings indicate that UK EPU increases exchange rate volatility, whereas US EPU has no significant effect. Similarly, Wang et al. (2022) adopt an EGARCH model to investigate the effects of US EPU on the volatility of the Chinese RMB exchange rate. Their results suggest that rising US EPU amplifies volatility spillovers, particularly following key financial reforms and during periods of intensified trade tensions.

Another dominant approach in the literature is the direct use of GPR Index, which quantifies geopolitical tensions based on news-derived measures. Several studies have relied on the GPR Index to examine its effect on exchange rates and macroeconomic stability. Caldara and Iacoviello (2022) demonstrate that rising geopolitical risks reduces investment and employment, increases economic risks, and negatively impacts GDP growth, with firm-level analysis showing stronger effects in industries more exposed to geopolitical shocks. Reivan-Ortiz et al. (2023) conduct a panel regression analysis on the effects of geopolitical risks, currency fluctuations, and economic policy on tourism in BRICS countries, finding that geopolitical risk and currency volatility negatively impact tourist arrivals, while economic policy exerts a positive long-term effect. Hung (2024) uses a time-varying Granger causality approach to examine the relationship between geopolitical risks and major exchange rate markets during the COVID-19 pandemic and the Russia–Ukraine crisis, identifying bidirectional causality in early stages but a weakening effect as the war progresses.

Beyond these conventional measures, some studies have incorporated alternative variables to capture geopolitical risk and uncertainty. Lee and Wen (2023) explore exchange rate policy uncertainty and its effects on Chinese manufacturing firms, demonstrating that the uncertainty positively influences firms with low returns on equity, but negatively affects those with high returns, highlighting heterogeneous firm-level impacts. Eichengreen (2024) examines the implications of geopolitical tensions on international monetary systems, emphasising the continued dominance of the U.S. dollar while highlighting emerging challenges posed by global financial shifts. Hossain et al. (2024) study the Russia–Ukraine war's impact on foreign exchange markets, revealing that geopolitical risks linked to the conflict significantly devalued exchange rates in energy-dependent and geopolitically exposed nations while intensifying volatility and depreciation pressures.

In the context of Türkiye, several empirical studies have investigated how geopolitical risks influence financial markets, exchange rate dynamics, and macroeconomic stability. Mansour-Ichrakieh and Zeaiter (2019) evaluate geopolitical risk's effect on Türkiye's financial stability through a threshold VAR model, revealing that risks from Saudi Arabia heighten financial stress, while those from Russia have no significant impact. Kyriazis and Economou (2022) examine the impact of geopolitical uncertainty on the Turkish lira's exchange rate using GARCH models and the geopolitical risk index, finding that geopolitical risk has minimal influence compared to inflation, which emerges as the primary driver of currency depreciation. Bilgili et al. (2022) investigate the exchange rate pass-through effect on Türkiye's domestic prices using a Markov regime-switching model, demonstrating a positive nonlinear relationship between exchange rate movements and inflation, while geopolitical risks have a dampening effect in low-volatility periods. Ursavaş et al. (2025) examine the tourism–economic growth relationship in Türkiye by incorporating geopolitical risk as a distinguishing factor. Using monthly data from 1996 to 2022, they apply fuzzy clustering to group tourist-origin countries by risk levels and employ the Fourier-Toda-Yamamoto causality test. Their findings confirm a consistent tourism-led growth effect across all risk clusters, with short-run feedback and time-dependent causal patterns.

3. Data and Empirical Framework

This study investigates the impact of geopolitical risks on real exchange rate dynamics in Türkiye, utilising quarterly data from 2000:Q1 to 2024:Q1. The empirical model employed in this study is presented in Equation (1).

$$\ln RER_t = \beta_0 + \beta_1 \ln TT_t + \beta_2 ID_t + \beta_3 \ln PRO_t + \beta_4 \ln GPR_t + \varepsilon_t \quad (1)$$

The dependent variable, RER, represents the real exchange rate and is computed using the formula in Equation (2).

$$\log(RER) = \log(NER) + \log(P_{US}) - \log(P_{TR}) \quad (2)$$

NER denotes the nominal exchange rate, expressed as the national currency per US dollar. P_{TR} represents the domestic price level, while P_{US} represents the foreign price level. These variables correspond to the consumer price index (CPI) of Türkiye and the United States, respectively. All three variables are sourced from the International Money Fund-International Financial Statistics (IMF-IFS) database.

As an independent variable, TT, represents the terms of trade and is calculated according to Equation (3), where X_P and M_P refer to Türkiye's export and import price indices, respectively.

$$TT = X_P / M_P \quad (3)$$

Another independent variable, ID, captures the real interest rate differential and is determined using the formula in Equation (4):

$$ID = RIR_{TR} - RIR_{US} \quad (4)$$

RIR_{TR} and RIR_{US} denote the real interest rates of Türkiye and the United States, respectively. The real interest rate is derived using nominal interest rate (IR) and inflation rate (CPI) data. The nominal interest rate is proxied by the monetary-policy related interest rate, while inflation is measured by the consumer price index of each country.

The variable PRO represents the labour productivity differential and is computed based on Equation (5).

$$\mathrm{PRO} = \mathrm{PRO}_{\mathrm{TR}} - \mathrm{PRO}_{\mathrm{US}} \tag{5}$$

PRO_{TR} and PRO_{US} correspond to the labour productivity of Türkiye and the United States, respectively. Labour productivity is calculated using total labour force (L) and gross domestic product (GDP) data. The labour force data for Türkiye is sourced from the Turkish Statistical Institute (TUIK), while the corresponding data for the United States comes from the International Labour Organisation (ILO). GDP data for both countries is obtained from the OECD database.

Finally, GPR represents the geopolitical risk index, derived from the methodology developed by Caldara and Iacoviello (2022). A detailed description of all variables is provided in Table 1.

Table 1. Variable Definitions

		RER – Real Exhange Rate	
NER	Nominal Exchange Rate	National currency per US dollar	IMF-IFS
P_{TR}	Consumer Price Index (TR)	Consumer Prices (2010=100)	IMF-IFS
P_{US}	Consumer Price Index (US)	Consumer Prices (2010=100)	IMF-IFS
		TT – Terms of Trade	
X_P	Export Price Index	Rolling weights, Index	IMF-IFS
M_P	Import Price Index	Rolling weights, Index	IMF-IFS
		ID – Real Interes Rate Differentials	
IR	Nominal Interest Rate	Monetry-Policy Relates Interest Rate	IMF-IFS
P	Consumer Price Index	Consumer Prices (2010=100)	IMF-IFS
		PRO – Labour Productivity Differentials	
L	Labour Force	Total, Age 15+	TUIK, ILO
GDP	Gross Domestic Product	US dollar, PPP converted	OECD
		GPR – Geopolitical Risk Index	
GPR	Geopolitical Risk	Index	www.matteoiacoviello.com

Source: Authors' processing.

The availability of PRO data is a key factor in determining the analysis period, as quarterly data on Türkiye's total labour force have been available only since 2000. To mitigate the effects of outliers and heterogeneity, the real exchange rate, geopolitical risk, productivity, and terms of trade series are transformed into their natural logarithmic form. Due to the presence of negative values, the ID series is not log-transformed.

To account for seasonality in the data, we apply the TRAMO/SEATS method. Accordingly, seasonal components are detected in the PRO, ID, and TT series, which are subsequently adjusted for seasonality.

4. Econometric Methodology

4.1 RALS Fourier ADL cointegration test

Robust time series analyses are essential for identifying the dynamic characteristics of real exchange rates and examining their relationship with highly volatile geopolitical risks. In this context, we incorporate the recently developed RALS Fourier ADL cointegration test into our study. This method builds upon the Fourier ADL cointegration test proposed by Banerjee et al. (2017) and has been further extended by Yilanci et al. (2023) through the RALS approach.

The RALS method for the Fourier ADL cointegration approach offers several key advantages. First, RALS-based cointegration tests are more powerful than traditional tests, as they incorporate information from non-normal errors that standard approaches typically overlook. Second, RALS procedures utilise nonlinear moment conditions associated with non-normal errors, enabling them to account for nonlinear relationships. Non-normal errors may indicate partially neglected nonlinearities in the relationships among variables (Lee et al. 2015). Finally, the Fourier approximation effectively captures nonlinear structures and accommodates an unknown number of multiple structural breaks, making it a robust tool for analysing complex time series dynamics.

The following model is employed in the Fourier ADL test:

$$\Delta y_{1t} = \gamma_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \varphi' \Delta y_{2t} + \epsilon_t \quad (6)$$

In Equation (6), γ and φ represent the parameter vectors, and y_{2t} denotes the explanatory variables. Following Im and Schmidt (2008), the RALS term is defined as follows:

$$\hat{w}_t = [\hat{e}_t^2 - m_2, \hat{e}_t^3 - m_3 - 3m_2\hat{e}_t]' \quad (7)$$

$\hat{e}_t$ shows the residuals obtained from Equation (6) and $m_j = T^{-1}\sum_{t=1}^{T} \hat{e}_t^j$. The RALS cointegration regression is obtained by augmenting $\hat{w}_t$ to Equation (6):

$$\Delta y_{1t} = \gamma_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \varphi' \Delta y_{2t} + \hat{w}_t \gamma + v_t \quad (8)$$

In the RALS-FADL test, Equation (8) is estimated using ordinary least squares, and the t-statistic is subsequently calculated. The asymptotic distribution of the test statistic is provided in Equation (9):

$$t^* \rightarrow \rho t + \sqrt{1-\rho^2} Z \quad (9)$$

t and t^* denote the Fourier ADL and RALS Fourier ADL test statistics, respectively. Z represents the standard normal random variable, and ρ denotes the long-run correlation between the residuals (ϵ_t) of Equation (6) and the residuals (v_t) of Equation (8).

4.2 Bayer-Hanck cointegration test

Cointegration tests used in empirical studies, which involve various econometric procedures, can sometimes yield contradictory results. To address this issue, the robustness check procedure is commonly employed in the literature. In line with this approach, we also apply the Bayer-Hanck cointegration procedure, a robust cointegration analysis. This method enhances the reliability of findings by combining the results of several individual tests, namely those of Engle and Granger, Johansen, Banerjee et al., and Boswijk. Bayer and Hanck (2013) propose combining the p-values from these cointegration tests using the Fisher (1932) formula. The test statistics suggested by Bayer and Hanck (2013) are computed through Equation (10) and Equation (11), incorporating the Fisher (1932) approach.

$$\mathrm{EG}-\mathrm{J}=-2\left[\ln\left(\mathrm{P_{EG}}\right)+\ln\left(\mathrm{P_J}\right)\right] \tag{10}$$

$$\mathrm{EG}-\mathrm{J}-\mathrm{BA}-\mathrm{BO}=-2\left[\ln(\mathrm{P_{EG}})+\ln\left(\mathrm{P_J}\right)+\ln(\mathrm{P_{BA}})+\ln(\mathrm{P_{BO}})\right] \tag{11}$$

P_{EG}, P_J, P_{BA} and P_{BO} denote the p-values of Engle and Granger, Johansen, Banerjee et al. and Boswijk cointegration tests, respectively.

4.3 Fourier Toda-Yamamoto causality test

In the final stage, we apply the Fourier Toda-Yamamoto causality analysis to examine the causal relationships between the series. The test allows for the inclusion of series with different integration degrees. However, these tests do not account for structural breaks, and ignoring such breaks in econometric analyses can lead to misspecification issues and misleading conclusions (Banerjee et al. 2017). To overcome this limitation, the Fourier causality procedure is employed, as it enables the modelling of gradual and smooth structural changes.

The Fourier causality test, proposed by Nazlioglu et al. (2016), is based on the Toda-Yamamoto procedure. In this approach, the VAR(p+d) model is estimated as follows:

$$\mathrm{y_t}=\delta+\beta_1\mathrm{y_{t-1}}+\cdots+\beta_{\mathrm{p+d}}\,\mathrm{y_{t-(p+d)}}+\epsilon_\mathrm{t} \tag{12}$$

In Equation (12), p denotes the optimal lag length, d represents the maximum level of integration, and ϵ_t indicates the white-noise residuals. Nazlioglu et al. (2016) define the VAR(p+d) model by relaxing the assumption of a constant intercept term δ over time, allowing for the consideration of structural breaks.

$$\mathrm{y_t}=\delta_0+\beta_1\mathrm{y_{t-1}}+\cdots+\beta_{\mathrm{p+d}}\,\mathrm{y_{t-(p+d)}}+\epsilon_\mathrm{t} \tag{13}$$

In Equation (13), δ_0 represents the structural breaks in $\mathrm{y_t}$. The model considered in the Fourier Toda−Yamamoto test is defined in Equation (14):

$$\mathrm{y_t}=\delta_0+\gamma_1\sin\left(\frac{2\pi\mathrm{kt}}{\mathrm{T}}\right)+\gamma_2\cos\left(\frac{2\pi\mathrm{kt}}{\mathrm{T}}\right)+\beta_1\mathrm{y_{t-1}}+\cdots+\beta_{\mathrm{p+d}}\,\mathrm{y_{t-(p+d)}}+\epsilon_\mathrm{t} \tag{14}$$

In the Fourier Toda−Yamamoto test, the null hypothesis of non-causality ($\mathrm{H_0}$: $\beta_1=\cdots=\beta_\mathrm{p}=0$) is tested using Wald statistics.

5. Results and discussion

To determine the appropriate estimation method in econometric analyses, it is essential to investigate the stationarity properties of the variables. Therefore, we conduct the DF-GLS unit root test at both the level and the first difference. Elliott et al. (1996) proposed a modification of the ADF unit root test, known as the DF-GLS test, which is based on GLS-detrending.

Table 2. DF-GLS Unit Root Test Results

	Level		**First Difference**	
Variable	**Lag Length**	**Test Stat.**	**Lag Length**	**Test Stat.**
RER	0	-0.968	6	-3.143**
TT	2	-1.475	0	-6.643*
ID	6	-2.665	0	-15.550*
PRO	0	-2.014	4	-4.149*
GPR	4	-1.924	6	-3.051***

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively.

Source: Authors' processing.

Table 2 presents the results of the DF-GLS unit root test for the real exchange rate, terms of trade, real interest rate, labour productivity, and geopolitical risk. The results fail to reject the null hypothesis at the level for all series, indicating that none of the series are stationary. However, all variables exhibit stationary properties after taking their first differences. These findings allow for the investigation of the cointegration relationship. In the next stage, the Fourier ADL and RALS Fourier ADL cointegration tests are applied to analyse the long-run relationship between the series.

Table 3. Fourier ADL and RALS Fourier ADL Cointegration Test Results

	Min AIC	**Freq.**	**Test Stat.**	**Rho**
Fourier ADL	-2.802	0.5	-6.227*	-
RALS Fourier ADL	-2.603	1	-4.891**	0.949
Critical Values				
	1%	5%	10%	
Fourier ADL	-5.686	-5.012	-4.654	
RALS Fourier ADL	-5.538	-4.860	-4.512	

Note: * and ** demonstrate statistical significance at the 1% and 5% level, respectively. The critical values of Fourier ADL and RALS Fourier ADL tests are obtained from Ilkay et al. (2021) and Yilanci et al. (2023), respectively.

Source: Authors' processing.

Table 3 summarises the results of the cointegration tests. Since the test statistics for both the Fourier ADL and RALS Fourier ADL cointegration tests exceed the 5% critical values, the null hypothesis is rejected. This indicates the existence of a cointegration relationship between the real exchange rate, terms of trade, real interest rate, labour productivity, and geopolitical risk in Türkiye. Therefore, the long-run analysis using the level values of the series will not suffer from spurious regression.

Table 4. Bayer-Hanck Cointegration Test Results

	Test-statistics	Critical Values		
		1%	5%	10%
EG – J	15.759**	15.973	10.532	8.272
EG – J – BA − BO	17.772***	30.836	20.440	16.086

Note: ** and *** demonstrate statistical significance at the 5% and 10% level, respectively.
Source: Authors' processing.

To assess the robustness of the Fourier ADL and RALS Fourier ADL test outcomes, we also employ the Bayer-Hanck (2013) cointegration test. The results are shown in Table 4. In this test, a cointegration relationship is confirmed if the calculated test statistic exceeds the critical values. As shown, the test statistic for the EG – J test (15.759) exceeds the 5% critical value. Furthermore, the test statistic for the EG – J – BA – BO (17.772) is greater than the 10% critical value. Thus, the Bayer-Hanck cointegration test confirms the existence of a cointegration relationship between the real exchange rate and its regressors. This finding is consistent with the cointegration results from the Fourier ADL and RALS Fourier ADL methods.

Table 5. The Long-Run Coefficients

Variable	Dependent Variable: RER			
	Coefficient	Std. Error	t-stat.	Prob.
TT	-2.495**	1.090	-2.290	0.025
ID	-0.015*	0.003	-4.974	0.000
PRO	0.362*	0.079	4.613	0.000
GPR	0.050**	0.021	2.410	0.019
C	0.775*	0.088	8.807	0.000
@TREND	0.006*	0.002	4.281	0.000
SS	-0.033	0.024	-1.423	0.159
CC	0.379*	0.020	19.231	0.000

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively. "CC" and "SS" represent the cosine and sine Fourier functions, respectively.
Source: Authors' processing.

The next stage of the empirical analysis is to investigate the impact of positive and negative changes in terms of trade, real interest rate, labour productivity, and geopolitical risk on real exchange rate in Türkiye. For this purpose, we apply the dynamic ordinary least squares (DOLS) regression suggested to estimate the long-run coefficients. The DOLS regression includes the leads and lags of all explanatory variables. This method helps eliminate potential endogeneity in the explanatory variables and serial correlation in the error terms, which are common issues in OLS estimation (Esteve and Requena 2006). The results of the DOLS regression, where trigonometric terms are included in the model, are presented in Table 5.

The results offer valuable insights into Türkiye's macroeconomic outlook. Notably, the findings highlight that the terms of trade are a significant factor affecting Türkiye's real exchange rate dynamics. The long-term coefficient analysis reveals a negative and statistically significant coefficient (-2.495) for the terms of trade variable. This indicates that a 1% increase in the terms of trade leads to an approximate 2.5% decline in real exchange rates. Consequently, an improvement in the terms of trade positively impacts Türkiye's export revenues and increases the supply of foreign exchange. The increased foreign exchange supply may, in turn, result in an appreciation of the real exchange rate.

Second, the real interest rate differential exerts a similar effect on the real exchange rate as the terms of trade. The estimated coefficient for the real interest rate differential is negative and statistically significant (-0.015). This negative relationship supports the argument that an increase in the real interest rate differential stimulates capital inflows, thereby expanding the supply of foreign exchange. In recent years, Türkiye has significantly diverged from global markets in its efforts to combat inflation, leading to substantial increases in both nominal and real interest rates. Consequently, the Turkish Lira has become more attractive, encouraging portfolio investments and boosting foreign exchange supply. The rise in foreign exchange reserves has been a key factor in the decline (appreciation) of the real exchange rate.

Third, an opposite trend is observed for labour productivity, a fundamental determinant in real exchange rate models. The long-term coefficient analysis reveals a positive and statistically significant coefficient (0.362) for the labour productivity differential. This suggests that a 1% increase in labour productivity leads to an approximately 0.36% rise in real exchange rates. On a global scale, Türkiye's labour productivity remains relatively low. The persistent lag in labour productivity compared to other countries may raise the production costs of Turkish exports, thus reducing their competitiveness. Furthermore, sustained low productivity levels may contribute to the real depreciation of the Turkish Lira, which could exacerbate inflationary pressures. Over time, this may lead to an overall increase (depreciation) in the real exchange rate.

Finally, the central focus of this analysis is the geopolitical risks, which have a positive and statistically significant impact on the real exchange rate. The long-term coefficient results indicate that a 1% increase in geopolitical risks results in an approximate 0.05% increase in the real exchange rate. The most significant consequence of geopolitical risks for Türkiye is that both domestic and foreign investors may delay investment decisions, reallocating capital to foreign markets. This accelerates capital outflows from Türkiye and heightens the demand for foreign exchange. Increased foreign exchange demand, in turn, may lead to a depreciation of the Turkish Lira, ultimately driving up the real exchange rate. Moreover, heightened geopolitical risks can elevate risk premiums, reducing portfolio investments. A decline in portfolio investments may further diminish the foreign exchange supply, exacerbating the depreciation of the Turkish Lira and contributing to an increase in the real exchange rate. Geopolitical risks may also trigger supply-side shocks in key sectors such as energy and food, leading to inflationary pressures. This inflation could further weaken the Turkish Lira, further raising the real exchange rate. Additionally, geopolitical risks may strain Türkiye's trade relations with its primary partners, potentially resulting in a decline in exports. A reduction in exports would diminish the supply of foreign exchange, leading to additional depreciation of the Turkish Lira, which would further increase the real exchange rate.

Table 6. Causality Analysis

	TY Causality		Fourier TY Causality		
Causality Path	**WALD Stat.**	**Bootstrap p−value**	**Optimal Frequency**	**WALD Stat.**	**Bootstrap p−value**
GPR → RER	2.527	0.471	1	6.961***	0.080
PRO → RER	0.132	0.710	1	0.765	0.678
ID → RER	0.007	0.930	1	0.437	0.494
TT → RER	2.765	0.427	1	0.040	0.979
RER → GPR	5.460	0.153	1	3.456	0.328
RER → PRO	8.703*	0.004	1	6.864**	0.038
RER → ID	5.221**	0.030	1	6.816**	0.014
RER → TT	1.486	0.682	1	0.238	0.881

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively.

Source: Authors' processing.

In the final stage of the empirical analysis, we apply two causality estimation methods: the traditional Toda−Yamamoto (TY) approach and the Fourier-based Toda−Yamamoto (Fourier TY) approach. The results are presented in Table 6. The findings from the TY causality test reveal no causal relationship between the real exchange rate and the geopolitical risk index. However, the Fourier TY test results show a unidirectional causal relationship from the geopolitical risk index to the real exchange rate. This suggests the importance of accounting for structural breaks in causality analyses and supports the findings obtained in the long-term analyses. The existence of this causal relationship also confirms that geopolitical risks are a significant factor in exchange rate determination for Türkiye. On the other hand, both the TY and Fourier TY test results indicate bidirectional causality between the real exchange rate, the geopolitical risk index, and productivity. Furthermore, the TY and Fourier TY causality tests reveal no causal relationship between the real exchange rate and the terms of trade.

6. Conclusions and Policy Recommendations

Türkiye has long been exposed to significant geopolitical risks due to its strategic location. Ongoing internal conflicts in the Middle East and Russia's efforts to expand its influence in the region make Türkiye particularly vulnerable to geopolitical instability. Today, Türkiye plays a pivotal role in various economic, social, and political activities, particularly in areas such as migration, trade, and logistics, bridging the East and West. As a key regional actor, Türkiye possesses substantial military, political, and diplomatic capabilities. However, these factors often create challenges that hinder the country's sustainable economic growth and development.

This study investigates the impact of geopolitical risks on Türkiye's real exchange rate. The Turkish economy, as a developing market, is inherently fragile and heavily reliant on external resources. Exchange rate instability can undermine macroeconomic stability, leading to persistent issues such as inflation, imbalances in foreign trade, and rising external debt. Despite its importance, however, the effect of geopolitical risks on Türkiye's real exchange rate has largely been neglected in the literature. Geopolitical risks, by generating uncertainty and instability, may trigger capital outflows, foreign exchange shortages, and ultimately, currency depreciation in emerging market economies like Türkiye.

The study employs quarterly data from 2000:Q1 to 2024:Q1 and uses the newly developed, robust RALF Fourier ADL cointegration method for analysis. In addition, key determinants of real exchange rates, including terms of trade, real interest rates, and productivity, are incorporated into the model. The findings reveal that geopolitical risks significantly contribute to an increase in the real exchange rate. Specifically, rising geopolitical risks exacerbate uncertainty and insecurity, which accelerates capital outflows from Türkiye and reduces the foreign exchange supply. This, in turn, leads to currency depreciation and an increase in the real exchange rate. Higher real exchange rates can drive cost-push inflation, increase both short- and long-term external debt, reduce corporate profitability, and weaken domestic demand—factors that collectively threaten the macroeconomic stability of the Turkish economy.

In contrast, terms of trade and real interest rate differentials exhibit negative relationships with the real exchange rate, while labour productivity shows a positive relationship. Improvements in the terms of trade and an increase in interest rate differentials enhance foreign exchange supply, leading to the appreciation of the national currency and, consequently, a decrease in the real exchange rate.

Conversely, low labour productivity increases the cost of exported goods, diminishing international competitiveness. Therefore, persistently low labour productivity may contribute to currency depreciation, further increasing real exchange rates.

The findings have several significant implications for policymakers. First, it is recommended that Türkiye acknowledge the inevitability of geopolitical risks due to its geographic location and incorporate these risks into real exchange rate modelling. By doing so, future real exchange rate forecasts will be more realistic. Second, in order to mitigate the uncertainties caused by geopolitical risks, robust and stable macroeconomic policies must be implemented. In particular, recent economic policies that have exacerbated vulnerabilities must be reassessed, as they risk deepening currency crises and destabilising the economy. Third, to better manage global risks, including geopolitical threats, it is essential for Türkiye to adopt foreign trade and investment policies aimed at reducing its dependency on foreign exchange as a strategic economic priority. Finally, future research on the Turkish economy should consider modelling economic policy uncertainty alongside geopolitical risks.

References

[1] Banerjee, P., Arčabić, V., Lee, H. (2017), *Fourier ADL cointegration test to approximate smooth breaks with new evidence from crude oil market. Economic Modelling,* 67, 114-124.

[2] Bartsch, Z. (2019), *Economic policy uncertainty and dollar-pound exchange rate return volatility. Journal of International Money and Finance*, 98, 102067.

[3] Bayer, C., Hanck, C. (2013), *Combining non-cointegration tests. Journal of Time series analysis,* 34(1), 83-95.

[4] Bilgili, F., Ünlü, F., Gençoğlu, P., Kuşkaya, S. (2022), *Modeling the exchange rate pass-through in Turkey with uncertainty and geopolitical risk: a Markov regime-switching approach. Applied Economic Analysis,* 30(88), 52-70.

[5] Caldara, D., Iacoviello, M. (2022), *Measuring geopolitical risk. American economic review,* 112(4), 1194-1225.

[6] Eichengreen, B. (2024), *International finance and geopolitics. Asian Economic Policy Review,* 19(1), 84-100.

[7] Elliott, G., Rothenberg, T.J., Stock, J.H. (1996), *Efficient tests for an autoregressive unit root. Econometrica*, 64, 813-836.

[8] Erdoğan, L., Ceylan, R., Abdul-Rahman, M. (2022), *The impact of domestic and global risk factors on Turkish stock market: Evidence from the NARDL approach. Emerging Markets Finance and Trade*, 58(7), 1961-1974.

[9] Esteve, V., Requena, F. (2006), *A cointegration analysis of car advertising and sales data in the presence of structural change. International Journal of the Economics of Business,* 13(1), 111-128.

[10] Hossain, A.T., Masum, A.A., Saadi, S. (2024), *The impact of geopolitical risks on foreign exchange markets: Evidence from the Russia–Ukraine war. Finance Research Letters,* 59, 104750.

[11] Hung, N.T. (2024), *Relationship of global geopolitical risk and exchange rates: Evidence from Covid-19 and Russia–Ukraine crisis, January 2020–August 2022. Regional Statistics*, 14(01), 91-107.

[12] Ilkay, S.C., Yilanci, V., Ulucak, R., Jones, K. (2021), *Technology spillovers and sustainable environment: Evidence from time-series analyses with Fourier extension. Journal of Environmental Management,* 294, 113033.

[13] Im, K.S., Schmidt, P. (2008), *More efficient estimation under non-normality when higher moments do not depend on the regressors, using residual augmented least squares. Journal of Econometrics*, 144(1), 219-233.

[14] Kyriazis, N.A., Economou, E.M. (2022), *The impacts of geopolitical uncertainty on Turkish Lira during the Erdoğan administration. Defence and Peace Economics,* 33(6), 731-750.

[15] Lee, C.C., Wen, X. (2023), *How does exchange rate policy uncertainty affect corporate performance: Evidence from China. Emerging Markets Finance and Trade,* 59(9), 3060-3075.

[16] Lee, H., Lee, J., Im, K. (2015), *More powerful cointegration tests with non-normal errors. Studies in Nonlinear Dynamics & Econometrics*, 19(4), 397-413.

[17] Mansour-Ichrakieh, L., Zeaiter, H. (2019), *The role of geopolitical risks on the Turkish economy opportunity or threat. The North American Journal of Economics and Finance,* 50, 101000.

[18] Nazlioglu, S., Gormus, N.A., Soytas, U. (2016), *Oil prices and real estate investment trusts (REITs): Gradual-shift causality and volatility transmission analysis. Energy economics,* 60, 168-175.

[19] Reivan-Ortiz, G.G., Cong, P.T., Wong, W.K., Ali, A., Thu, H.T.T., Akhter, S. (2023), *Role of geopolitical risk, currency fluctuation, and economic policy on tourist arrivals: temporal analysis of BRICS economies. Environmental Science and Pollution Research*, 30(32), 78339-78352.

[20] Roubaud, D., Arouri, M. (2018), *Oil prices, exchange rates and stock markets under uncertainty and regime-switching. Finance research letters*, 27, 28-33.

[21] Saadaoui, H., Dogan, M., Omri, E. (2024), *The impacts of hydroelectricity generation, financial development, geopolitical risk, income, and foreign direct investment on carbon emissions in Turkey. Environmental Economics and Policy Studies*, 26(2), 239-261.

[22] Toda, H.Y., Yamamoto, T. (1995), *Statistical inference in vector autoregressions with possibly integrated processes. Journal of econometrics*, 66(1-2), 225-250.

[23] Ursavas, U., Yilanci, V., Ghosh, S. (2025), *Geopolitical Risk and Türkiye's Tourism Growth: Testing a Shifting Relationship. Economic Computation & Economic Cybernetics Studies & Research*, 59(1), 104-119.

[24] Wang, P., Li, Y., Wu, S. (2022), *Time-varying effects of US economic policy uncertainty on exchange rate return and volatility in China. Emerging Markets Finance and Trade,* 58(7), 1807-1820.

[25] Yilanci, V., Ulucak, R., Zhang, Y., Andreoni, V. (2023), *The role of affluence, urbanization, and human capital for sustainable forest management in China: Robust findings from a new method of Fourier cointegration. Sustainable Development,* 31(2), 812-824.