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Research Article

Dynamic relationship between foreign trade and inflation: Empirical evidence from Türkiye

Dış ticaret ve enflasyon arasındaki dinamik ilişki: Türkiye'den ampirik bulgular

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ÖZET

Bu çalışma, Türkiye'de dış ticaret dengesi ile enflasyon arasındaki ilişkiyi, aylık veriler ve seçilmiş makroekonomik değişkenler çerçevesinde incelemektedir. Analiz, zaman alanı ve frekans alanı dinamiklerini birlikte yakalayabilmek amacıyla Otoregresif Dağıtılmış Gecikme (ARDL) yaklaşımı, kümülatif dinamik çarpanlar ve Frekans Alanı Granger Nedensellik yöntemi kullanılarak gerçekleştirilmiştir. Elde edilen bulgular, reel efektif döviz kuru ve enflasyonun dış ticaret dengesi üzerinde uzun dönemde negatif etkilere sahip olduğunu, buna karşılık faiz oranlarının pozitif etki gösterdiğini ortaya koymaktadır. Kısa dönem dinamikleri, enflasyon ve sanayi üretimindeki şokların dış ticaret dengesi üzerindeki yansımalarının gecikme uzunluklarına bağlı olarak farklılaştığını göstermektedir. Diğer taraftan, faiz oranı şoklarının pozitif etkisinin zaman içerisinde daha belirgin hale geldiği gözlenmektedir. Frekans alanı bulguları, enflasyon, faiz oranları ve sanayi üretiminden dış ticaret dengesine doğru farklı frekans bantlarında tek yönlü Granger nedenselliği bulunduğunu, ancak reel efektif döviz kuru için anlamlı bir nedensellik ilişkisine rastlanmadığını ortaya koymaktadır. Özellikle, enflasyon kaynaklı nedensellik ilişkisinin kısa dönem frekanslarında daha belirgin olduğu, faiz oranları ve sanayi üretimine ilişkin nedensellik bulgularının ise uzun dönem frekanslarında daha güçlü hale geldiği anlaşılmaktadır. Ayrıca, ticari kredi faiz oranlarının uzun dönemde dış ticaret dengesi üzerinde pozitif etkisi olması, piyasa etkisinin döviz kuru etkisine kıyasla daha baskın olduğuna işaret etmektedir.

Anahtar Kelimeler:

Dış ticaret dengesi, Enflasyon, Frekans alanı Granger nedenselliği, ARDL sınır testi, Kümülatif dinamik çarpanlar

ABSTRACT

This paper examines the association between the foreign trade balance and inflation in Türkiye based on monthly data and selected macroeconomic variables. The analysis is conducted through the Autoregressive Distributed Lag approach with cumulative dynamic multipliers, and Frequency Domain Granger Causality in order to capture both time-domain and frequency-domain dynamics separately. The analysis results indicate that the real effective exchange rate and inflation have negative effects on the foreign trade balance, whereas interest rates exhibit a positive effect in the long run. Short-run dynamics indicate that the effects of shocks to inflation and industrial production on the trade balance vary across lags; in contrast, the positive impact of interest rate shocks becomes more visible over time. Frequency-domain results reveal unidirectional causality from inflation, interest rates, and industrial production to the trade balance at different horizons, while no causal relationship is found for the real effective exchange rate. Notably, the causal influence of inflation is more evident in the short run, whereas the effects of interest rates and industrial production become more relevant over longer horizons. In addition, the long-run positive effect of commercial loan interest rates points to the market effect being more pronounced than the exchange rate effect.

Keywords:

Foreign trade balance, Inflation, Frequency domain Granger causality, ARDL Bounds Testing, Cumulative dynamic multipliers

1. Introduction

The foreign trade and inflation nexus has long been discussed in developing economies where inflationary pressures and external imbalances tend to exist together (Ha et al., 2019: 27). Türkiye is a typical example of this structure, with persistent inflation and recurring current account deficits observed over a long period. Inflation and foreign trade are connected in such economies through several channels, including exchange rates, interest rates, import dependency, and production conditions (Kara and Öğünç, 2012: 2–3; Erduman et al., 2019: 3).

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In economies where production relies heavily on imported intermediate and capital goods, changes in external prices can be transmitted to domestic prices through cost-related channels. Inflation may also affect foreign trade performance through production costs and external competitiveness. Rising costs can weaken firms' competitive positions in international markets and, over time, deteriorate the foreign trade balance. Inflation and foreign trade are closely linked in open economies, yet this interaction cannot be explained through a single transmission channel (Yang et al., 2024: 9237; Uslu, 2023: 550-551).

Several studies highlight the importance of cost and price mechanisms in shaping inflation dynamics. For instance, Yilmazkuday and Alvarez (2024) showed that trade costs affect import prices and real exchange rate movements, which then influence domestic prices. Similarly, Kara and Öğünç (2012) found that import prices are as influential as exchange rates in the formation of inflation in Türkiye. From another perspective, Turna and Özcan (2021) noted that inflation distorts relative prices and, through the exchange rate channel, reduces external competitiveness, thereby worsening the trade balance.

In economies such as Türkiye, where industrial production and trade rely heavily on imported inputs, the impact of inflation on the trade balance may change over time. Factors such as financing conditions, production capacity, and competitiveness can alter this relationship through different channels and time horizons. The existing literature largely focuses on inflation dynamics or foreign trade separately, such as Chiu and Ren (2019), Shahbaz et al. (2012), or Turna and Özcan (2021), while relatively fewer studies examine their interaction within a unified empirical framework.

This paper may contribute to the literature by using an integrated framework to examine the interaction between the foreign trade balance and key macroeconomic variables in Türkiye. By combining frequency-domain and time-domain methods, the analysis captures long-run dynamics, short-run adjustments, and causal linkages across different horizons. The results offer additional empirical evidence on how inflation and foreign trade are connected in the Turkish economy.

The paper is organized as follows. Section 2 reviews the related literature. The data and empirical methodology are introduced in Sections 3 and 4. Section 5 presents the results, and Section 6 concludes.

2. Literature review

Earlier research largely focused on trade openness as one of the key determinants of inflation, while more recent research expanded this view to analyze foreign trade by separating exports, imports, or other trade components. This distinction helps clarify how different trade channels may influence inflation dynamics.

A number of country-specific studies report that exports and imports may affect inflation through different mechanisms. Ahmed et al. (2018) documented a long-run relationship between exports, imports, and inflation in Pakistan, alongside evidence of a causal relationship from exports to inflation. In contrast, Muktadir-Al-Mukit and Shafiullah (2014) showed that import growth increases inflation in Bangladesh, while export growth reduces it. Çütcü (2020) provided evidence that inflation and exports are cointegrated, while no long-run link exists between inflation and imports in trade with the EU-28. The study also found a one-way causality from imports to inflation, which highlights the link between import dependency and the domestic price movements. Kukaj and Nimani (2022), using monthly data for Kosovo, reported that imports Granger-cause consumer prices bidirectionally, while exports do not display such a relationship. Their impulse response analysis showed that import shocks generate stronger and more persistent effects on inflation.

Several studies also examine inflation together with broader macroeconomic factors related to external sector performance. Ali et al. (2022) reported that inflation, foreign trade, and the real effective exchange rate are linked in the long run for Pakistan, and their causality analysis indicates a one-way relationship from inflation to trade. For Türkiye, Uslu (2023) applied symmetric and asymmetric causality tests and found that inflation is symmetrically caused by exports, while asymmetric causality runs from imports to inflation. The results also point to complex cointegration patterns involving trade balance variables under structural breaks, with real effective exchange rate and interest rates playing a role in asymmetric causality relationships.

The causal direction between inflation and foreign trade variables are studied in some papers. Galal and Lan (2017) reported a long-run relation between inflation and foreign trade volume in Egypt, and a unidirectional causality from inflation to trade. In a similar context, Manual and San (2019) showed that inflation plays a determining role in the evolution of the trade balance in Malaysia, with significant effects observed in both the short and long run. Focusing on Türkiye, Özer and Kutlu (2019) demonstrated that the real effective exchange rate Granger-causes inflation, while inflation Granger-causes the foreign trade balance. Although their results did not

reveal a direct causal link between the exchange rate and the trade balance, impulse response analysis showed that the trade balance responds to shocks from the exchange rate and inflation.

Gür (2021) identifies a persistent association between trade openness and inflation in BRICS-T countries, with weaker trade–inflation transmission in Türkiye compared to other countries in the group. Afari et al. (2021) found that trade openness has an inflationary effect in Sub-Saharan Africa in the short and long run, with bidirectional causality. Using a meta-analysis, Yang et al. (2024) reported that trade openness positively affects price dynamics in non-OECD countries, while its effect is not statistically significant for OECD economies.

Overall, the empirical literature has pointed out that import-related channels are more frequently associated with inflation dynamics than export-related channels, particularly in economies with high import dependency, such as Türkiye. Some studies emphasize the role of trade-related mechanisms in inflation dynamics, particularly through import-dependent channels (Muktadir-Al-Mukit and Shafiullah, 2014; Çütcü, 2020; Kukaj and Nimani, 2022).

Although the literature on inflation and foreign trade has expanded over time, empirical evidence has largely been based on conventional time-domain approaches. In the case of Türkiye, relatively few studies have examined this relationship using cumulative dynamics or frequency-domain methods. Previous studies indicate that the direction and strength of the relationship vary across countries and time horizons, and may depend on macroeconomic factors such as exchange rates and interest rates. Accordingly, this study employs the autoregressive distributed lag (ARDL) framework together with cumulative dynamic multipliers and the frequency-domain Granger causality (FDGC) analysis to examine the interaction of inflation and the foreign trade balance in Türkiye, alongside selected macroeconomic variables.

3. Data

Monthly data covering the period from January 2005 to March 2024 are used in this study. The dataset consists of five key macroeconomic indicators. Foreign trade balance is represented by the export-to-import coverage ratio, which is commonly used to capture external balance conditions. Inflation is proxied by the annual percentage change in the consumer price index (CPI). The CPI-based real effective exchange rate (REER) is included as a measure of relative price competitiveness. The interest rate variable reflects the weighted average commercial TRY loan rate. Real economic activity is captured by the industrial production index. All series are compiled from the Central Bank of the Republic of Türkiye and the Turkish Statistical Institute. Variable definitions and data sources are presented in Table 1, while descriptive statistics are summarized in Table 2.

TABLE 1. Variables used in the analysis

Variable	Description	Source
INF (Inflation)	YoY % change in CPI (2003=100)	TURKSTAT
FTB (Trade Balance)	Export / Import × 100	Authors' calculation
REER (Real Effective Exchange Rate)	CPI-based REER (2003=100)	CBRT
INT (Interest Rate)	Commercial TRY loan rate	CBRT
IP (Industrial Production)	Industrial Production Index (2021=100)	TURKSTAT

TABLE 2. Descriptive statistics

	FTB	INF	INT	IP	REER
Mean	68.53	16.40	17.51	71.06	94.45
Median	67.02	9.52	15.94	69.30	102.23
Maximum	93.76	85.84	59.74	111.42	128.37
Minimum	49.80	3.81	8.28	41.71	48.36
Std. Dev.	8.76	18.10	7.89	20.32	22.82
Skewness	0.69	2.46	2.69	0.34	-0.57
Kurtosis	3.05	7.90	12.88	1.95	1.95
Jarque-Bera	18.13	464.11	1218.92	15.11	23.06
Probability	0.00	0.00	0.00	0.00	0.00
Sum	15831.04	3787.64	4044.57	16415.09	21818.82
Sum Sq. Dev.	17662.67	75313.81	14331.63	94979.91	119803.41
Observations	231	231	231	231	231

4. Methodologies

This study investigates the dynamics of inflation and foreign trade in Türkiye within an integrated empirical framework that addresses both time and frequency dimensions separately. The time-domain analysis is based on an ARDL model enhanced with an error correction mechanism (ECM), which makes it possible to simultaneously capture both short-term adjustments and long-term relationships. Cumulative dynamic multiplier analysis is further used to examine the dynamic effects of shocks.

Alongside the ARDL approach, causality dynamics are further investigated using the FDGC, which provides evidence across different time horizons. Following Breitung and Candelon (2006), this method allows short-run and long-run causal linkages to be evaluated separately. It also provides complementary evidence on dynamic adjustment and causality patterns between inflation and foreign trade.

Before econometric analysis, all series are seasonally adjusted by using the STL decomposition method. Unit root properties of the series are evaluated through the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests under different deterministic specifications. The unit root tests suggest that the series are integrated of order one, becoming stationary after differencing once. Therefore, all series are integrated of order one, I(1). Accordingly, the ARDL framework is appropriate for the empirical analysis. The results obtained from the unit root tests are summarized in Table 3.

TABLE 3. Unit root test results

Variable Note: D( ) stands for First Difference	**ADF test statistics**		**PP test statistics**		**Decision**
	Intercept	Trend and Intercept	Intercept	Trend and Intercept	I(0) or I(1)
FTB	-2.77* (0.063)	-4.09*** (0.007)	-4.97*** (0.000)	-6.53*** (0.000)	I(1)
D(FTB)	-15.63*** (0.000)	-15.60*** (0.000)	-28.27*** (0.000)	-28.20*** (0.000)	
INF	0.12 (0.967)	-1.01 (0.938)	-0.67 (0.849)	-1.78 (0.707)	I(1)
D(INF)	-4.59*** (0.000)	-5.38*** (0.000)	-8.24*** (0.000)	-8.26*** (0.000)	
INT	-0.42 (0.901)	-0.98 (0.942)	0.08 (0.964)	-0.53 (0.981)	I(1)
D(INT)	-7.34*** (0.000)	-7.58*** (0.000)	-7.33*** (0.000)	-7.57*** (0.000)	
IP	-0.45 (0.896)	-4.15*** (0.006)	0.27 (0.976)	-3.82** (0.016)	I(1)
D(IP)	-17.21*** (0.000)	-17.19*** (0.000)	-20.13*** (0.000)	-20.58*** (0.000)	
REER	-0.32 (0.917)	-3.01 (0.131)	-0.29 (0.922)	-3.12 (0.103)	I(1)
D(REER)	-12.30*** (0.000)	-12.33*** (0.000)	-10.79*** (0.000)	-10.85*** (0.000)	

Note: Values in parentheses below the t-Stat represent probability values. *** Stationary at 1% significance level, ** Stationary at 5% significance level, * Stationary at 10% statistical significance level.

4.1. ARDL model

The ARDL bounds testing approach is employed to assess whether a long-run association exists among the variables. This approach was initially introduced by Pesaran and Shin (1995) and extended by Pesaran, Shin, and Smith (2001). It provides flexibility when the variables are integrated at different levels, whether I(0), I(1), or mixed orders. Besides, it can also be used in cases where all variables are found to be I(1).

The bounds test evaluates the null hypothesis of no cointegration against the alternative hypothesis of a long-run relationship. If the test statistics exceed the upper critical bound, cointegration is confirmed. In this case, long-run coefficients are estimated and short-run dynamics are examined using an error correction model (ECM).

The general specification of an ARDL(p, q) model is expressed as follows:

$$\Delta Y_t = \alpha + \sum_{i=1}^{\rho} \beta_i Y_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta X_{t-j} + \phi_1 Y_{t-1} + \phi_2 X_{t-1} + u_t \quad (1)$$

In this representation, the differenced terms capture short-run dynamics, while the lagged level variables represent the long-run relationship.

In this study, the ARDL model is constructed to examine the relationship between the foreign trade balance (FTB) and its determinants, including inflation (INF), interest rate (INT), industrial production (IP), and the real effective exchange rate (REER). The estimated ARDL model is as follows:

$$\Delta FTB_t = \alpha + \sum_{i=1}^{\rho} \beta_i \Delta FTB_{t-i} + \sum_{j=0}^{q_1} \gamma_j \Delta INF_{t-j} + \sum_{k=0}^{q_2} \delta_k \Delta INT_{t-k} + \sum_{l=0}^{q_3} \phi_l \Delta IP_{t-l} + \sum_{m=0}^{q_4} \psi_m \Delta REER_{t-m} + \phi_1 FTB_{t-1} + \phi_2 INF_{t-1} + \phi_3 INT_{t-1} + \phi_4 IP_{t-1} + \phi_5 REER_{t-1} + u_t \quad (2)$$

Following the confirmation of cointegration, the short-run dynamics are analyzed through the error correction representation:

$$\Delta FTB_t = \alpha + \sum_{i=1}^{3} \beta_i \Delta FTB_{t-i} + \sum_{j=0}^{2} \gamma_j \Delta INF_{t-j} + \sum_{k=0}^{0} \delta_k \Delta INT_{t-k} + \sum_{l=0}^{4} \phi_l \Delta IP_{t-l} + \sum_{m=0}^{1} \psi_m \Delta REER_{t-m} + \lambda ECT_{t-1} + u_t \quad (3)$$

The lagged error correction term, ECT_{t-1}, is obtained from the long-run cointegrating relationship and captures deviations from equilibrium. The coefficient of the error correction term is expected to be negative and statistically significant, indicating convergence toward the long-run equilibrium.

Additionally, Cumulative Dynamic Multipliers (CDM) are also employed to observe the response path of the dependent variable following unit shocks to the explanatory variables. This approach provides an opportunity to observe how the effects change over time and complements the static results of the ARDL model.

4.2. Frequency domain Granger causality

In addition to the ARDL framework, frequency domain Granger causality (FDGC) is employed to investigate the causal relationships among the variables across different frequency ranges. This approach, developed by Breitung and Candelon (2006), allows the examination of causal relationships at different frequency ranges, which can be associated with short-run, medium-run, and long-run dynamics.

The FDGC approach is based on a standard VAR(p) model and tests whether one variable Granger-causes another at a given frequency $\omega \in (0,\pi]$. The null hypothesis of no causality is defined as::

$$H_0: R(\omega).\beta = 0 \quad (4)$$

Where β is the vector of coefficients corresponding to the lagged values of the explanatory variable in the VAR system, and $R(\omega)$ is a frequency-specific restriction matrix constructed using sine and cosine functions.

The restriction matrix $R(\omega)$ is defined as:

$$R(\omega) = \begin{bmatrix} \cos(\omega) & cos(2\omega) & \dots & cos(p\omega) \\ sin(\omega) & sin(2\omega) & \dots & sin(p\omega) \end{bmatrix} \quad (5)$$

Testing this null hypothesis is equivalent to examining whether the weighted sum of lagged coefficients is jointly equal to zero at frequency ω. This leads to the following linear constraints:

$$\sum_{k=1}^{\rho} \beta_k \cos(k\omega) = 0 \text{ and } \sum_{k=1}^{\rho} \beta_k \sin(k\omega) = 0 \quad (6)$$

These two linear restrictions are jointly tested using an F-statistic, which asymptotically follows an F-distribution with degrees of freedom $(2,\ T\text{-}2\rho)$.

The null hypothesis of no causality at frequency ω is rejected if the F-statistic exceeds the critical value, indicating statistically significant frequency-domain Granger causality. In this context, lower frequencies represent long-run dynamics, while higher frequencies capture short-run fluctuations.

5. Results

5.1. ARDL results

The stability based on the ARDL model is initially assessed using the CUSUM and CUSUM of Squares tests. Stability checks show that the CUSUM statistic lies within the 5% confidence interval, while the CUSUM of Squares test suggests structural instability at the 5% level. The structural break shown in Figure 1 corresponds to the transition towards a negative real interest rate regime; from this point onwards, significant changes occur in interest rate and inflation trends.

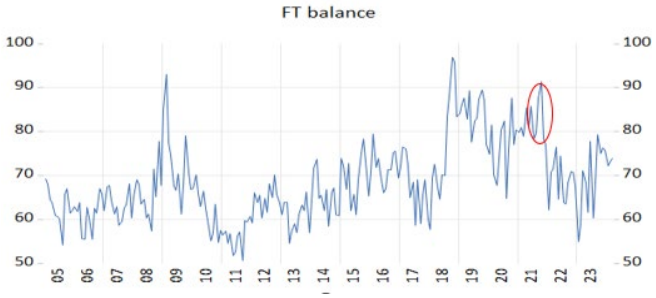

FIGURE 1. Structural break detection (2021M07-2021M11)

To account for this instability, a dummy variable covering the period from 2021M07 to 2021M11 is introduced into the model to ensure stable estimation results.

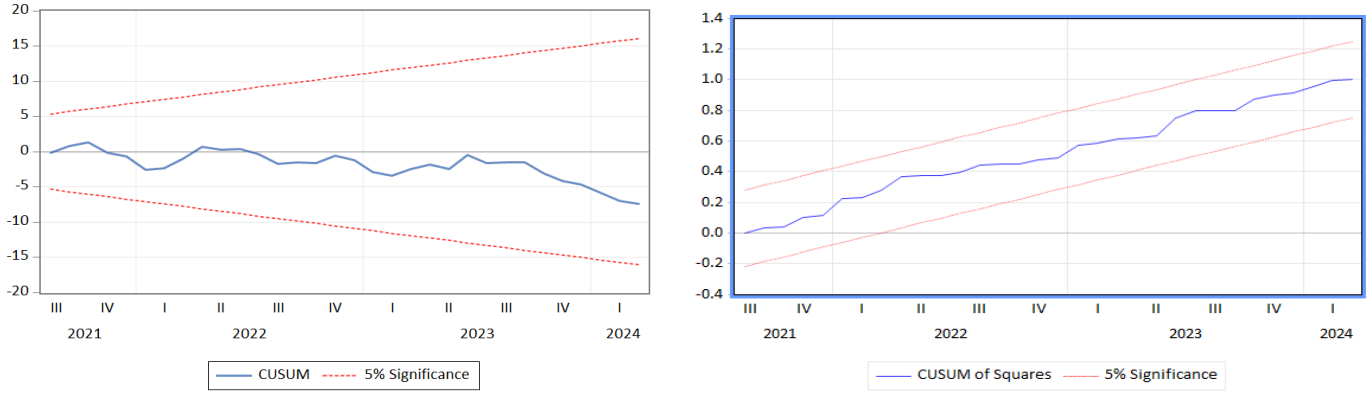

FIGURE 2: Cusum and Cusum of Squares test results after the Dummy variable

The optimal lag length of the ARDL model is determined according to the Akaike Information Criterion (AIC), and the selected model is ARDL(3,2,0,4,1). Short-run and long-run relationships are subsequently examined within this specification.

As shown in Table 4, the calculated F-statistic lies above the upper critical value at the 1% level, implying rejection of the no-cointegration hypothesis. These results indicate a stable long-run relationship between the foreign trade balance and the explanatory variables.

TABLE 4. ARDL bounds test

		Critical Values					
		Lower Bound I(0)			Upper Bound I(1)		
F-stat	k	1%	5%	10%	1%	5%	10%
6.732	4	3.74	2.86	2.45	5.06	4.01	3.52

Null Hypothesis: No levels of relationship

Standard residual diagnostic tests indicate no evidence of serial correlation or heteroskedasticity, and the Ramsey RESET test suggests no model misspecification. Although the Jarque–Bera test rejects normality, this does not affect the consistency of the ARDL estimates. Detailed diagnostic test results and stability analyses are reported in Appendix 1.

Following the confirmation of cointegration, the ARDL(3,2,0,4,1) model is estimated to obtain the long-run coefficients.

$$FTB_t = \alpha + \sum_{i=1}^{3} \beta_i FTB_{t-i} + \sum_{j=0}^{2} \gamma_j INF_{t-j} + \sum_{k=0}^{0} \delta_k INT_{t-k} + \sum_{l=0}^{4} \phi_l IP_{t-l} + \sum_{m=0}^{1} \psi_m REER_{t-m} + \kappa DUMMY2021 + u_t \quad (7)$$

TABLE 5. Estimated long-run cointegrating coefficients for the ARDL (3,2,0,4,1) model

Variable	Coefficient	Std. Error	Prob.
INF	-0.4568	0.1013	0.0000
INT	0.5978	0.1811	0.0011
IP	-0.1049	0.1485	0.4809
REER	-0.4762	0.1336	0.0004

The results, shown in the above table, indicate that inflation and the real effective exchange rate exert statistically significant negative effects on the foreign trade balance. The results point to the importance of price dynamics and external competitiveness in explaining the long-run behavior of Türkiye's foreign trade balance. On the other hand, the interest rate shows a statistically significant positive effect on the foreign trade balance. Industrial production does not have a statistically significant effect in the long-run. The contribution of domestic production appears to be limited within this framework.

Short-run estimation outcomes are presented in Tablee 6. The coefficient of the error correction term is negative and statistically significant at the 1% level, confirming a stable adjustment process toward the long-run equilibrium. Its magnitude suggests that nearly 29% of any disequilibrium is eliminated within a single period. In the short run, the foreign trade balance responds significantly to its own lagged values, inflation, industrial production, and the real effective exchange rate, whereas the interest rate does not display a statistically significant short-run effect.

TABLE 6. Estimated short-run coefficients and error correction term for the ARDL (3,2,0,4,1) model

Dependent Variable: D(FTB)	
Variable	**Coefficient - (Std. Error)**
D(FTB(-1))	-0.4249*** - (0.0639)
D(FTB(-2))	-0.1886*** - (0.0602)
D(INF)	-0.4300*** - (0.1362)
D(INF(-1))	0.3177** - (0.1338)
D(IP)	0.2557** - (0.1144)
D(IP(-1))	-0.2477** - (0.1164)
D(IP(-2))	-0.3483*** - (0.1173)
D(IP(-3))	-0.4100*** - (0.1186)

D(REER)	-0.3061***	- (0.1058)
DUMMY2021	-0.7167	- (2.0304)
CONSTANT	34.2772***	- (5.8224)
ECT(-1)	-0.2882 ***	- (0.0492)
R^2		0.928159
$\bar{R}^2$		0.926399

Note: *** indicates statistical significance at 1%, ** at 5%, * at 10% levels.

Overall, it is understood that interest policy does not have a significant effect in the short run, while it becomes one of the important variables for the foreign trade balance in the long run. Increasing interest rates have two important effects in general. It not only leads to a contraction in the market and slows down economic activity, but also appreciates the local currency.

From a market perspective, a disinflationary environment may affect both production and consumption sides. The slowdown in economic activity leads to a decrease in imports when we consider the import-dependent structure of production in Türkiye. Consistent with this, the short-run findings regarding industrial production also indicate that its positive effect turns negative up to the third lag. In addition, it may also help control prices and suppress inflation, so demand for domestically produced goods may increase rather than imported consumption goods. Our findings also point out that inflation has a negative effect on the foreign trade balance both in the short-run, except for the first lag, and in the long-run.

From a local currency perspective, it strengthens the Turkish lira against foreign currencies through financial markets, and this may weaken export price competitiveness. Indeed, it is found that the real effective exchange rate has a negative effect on the foreign trade balance. Therefore, the positive association between interest rates and foreign trade balance over the long-run suggests that the influence of commercial loan interest rates through market conditions is more dominant than their effect via domestic currency valuation in explaining the foreign trade balance in Türkiye.

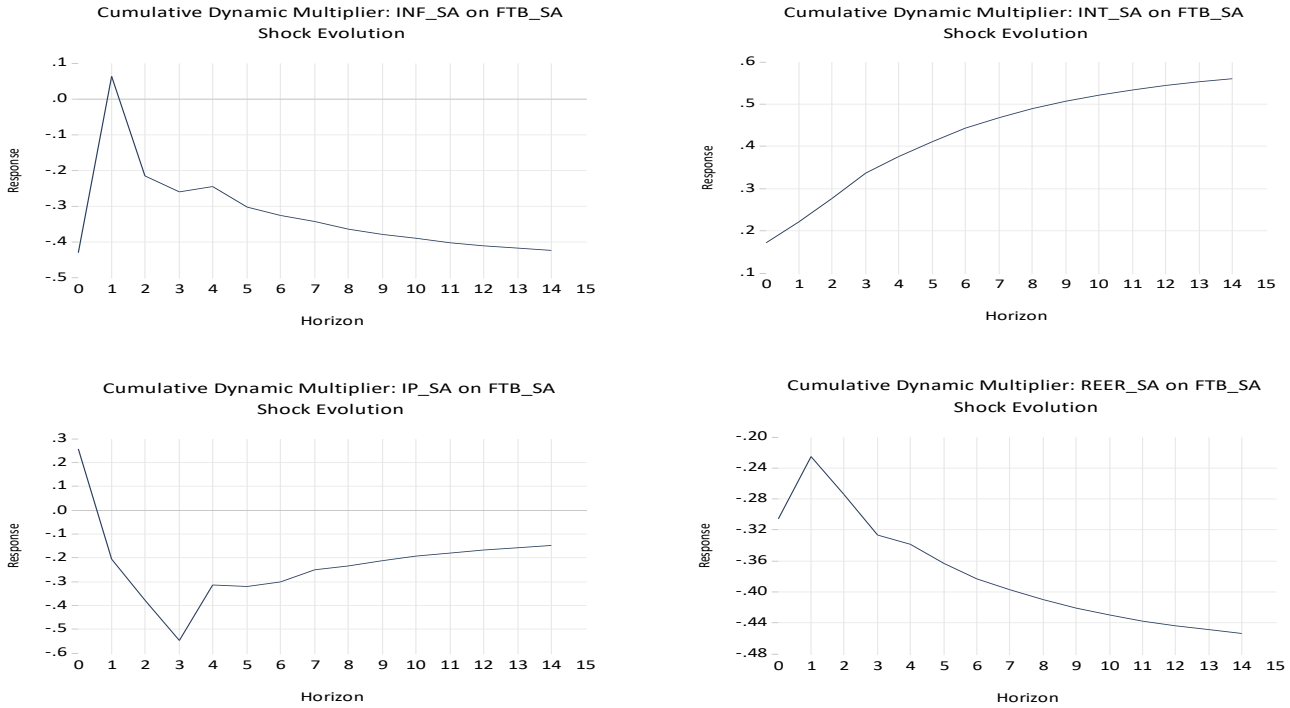

FIGURE 3. Cumulative dynamic multiplier graphics

The ARDL model decomposes the long-run and short-run effects of the explanatory variables on the foreign trade balance. Therefore, cumulative dynamic multipliers are analyzed for each variable to better understand how shocks affect the foreign trade balance over time.

As shown in Figure 3, shocks to inflation, industrial production, and the real effective exchange rate generate adverse cumulative responses in the foreign trade balance over the adjustment horizon. Although the response to an inflation shock displays a brief positive deviation in the initial period, it subsequently converges to a negative path. Shocks to industrial production lead to a noticeable deterioration in the trade balance up to period 3, followed by a modest recovery over time. In contrast, interest rate shocks produce a positive cumulative response that strengthens gradually.

5.2. FDGC results

The FDGC analysis is conducted within a VAR framework. The optimal lag structure is identified using standard model selection criteria, namely the Akaike Information Criterion, Hannan–Quinn, Schwarz Criterion, and Final Prediction Error measures. AIC and FPE criteria indicate an optimal lag length of three, whereas HQ and SC point to a shorter lag (see Appendix 2). Considering the relatively better performance of AIC and FPE, the VAR(3) model is selected for the FDGC analysis.

Before conducting the FDGC analysis, the diagnostic and stability properties of the VAR(3) model are examined. The residual diagnostic tests indicate the existence of serial correlation and heteroskedasticity, and the normality assumption is also rejected. Hence, the FDGC analysis is conducted using heteroskedasticity- and autocorrelation-consistent (HAC) standard errors to obtain robust results across different frequency bands. In addition, CUSUM stability tests are applied to each equation of the VAR model. The results show that all parameters remain within the 5% confidence bands, indicating that the VAR model provides stability over the sample period (see Appendix 3).

The FDGC summary results are presented in Table 7, where causality relationships are reported across three different frequency bands corresponding to long-run, medium-run, and short-run horizons. In the frequency domain framework, long-term dynamics correspond to low frequencies ($0 \le \omega \le 0.5$), medium-term dynamics to intermediate frequencies ($0.5 < \omega < 2.5$), and short-term dynamics to high frequencies ($2.5 \le \omega \le \pi$)[1]. Following Bozoklu and Yılancı (2013), lower frequencies ($\omega \le 0.5$) are interpreted as long-term (permanent) causality effects, whereas higher frequencies ($\omega \ge 2.5$) reflect short-term (temporary) causality.

TABLE 7. Frequency-Based summary of causal interactions

Causality Direction	Long-term ($0 \le \omega \le 0.5$)	Medium-term ($0.5 < \omega < 2.5$)	Short-term ($2.5 \le \omega \le \pi$)	Result
FTB→INF	✗	✗	✗	Unidirectional **INF→FTB**
INF→FTB	✓	✗	✓	
FTB→INT	✗	✗	✗	Unidirectional **INT→FTB**
INT→FTB	✓	✓	✓	
FTB→REER	✗	✗	✗	No Granger Causality
REER→FTB	✗	✗	✗	
FTB→IP	✗	✗	✗	Unidirectional **IP→FTB**
IP→FTB	✓	✓	✓	

Note: The binary outcomes (✓/✗) reflect statistical significance at the 5% level.

The FDGC results indicate a unidirectional causal relationship running from industrial production, interest rates, and inflation to the foreign trade balance across different frequency bands. Industrial production Granger-causes the foreign trade balance, with the strength of causality becoming more apparent at lower frequencies. Interest rates also Granger-cause the foreign trade balance at all frequency bands, especially the causal effect increases toward the longer-run period. By contrast, the causal impact of inflation appears to be more frequency-dependent. Inflation Granger-causes the foreign trade balance mainly in the short-run period, whereas its effect

[1] The period (in months) corresponding to each frequency is calculated using the standard transformation as Period = $2\pi/\omega$.

weakens and becomes insignificant at medium frequencies, before regaining relevance at longer-run frequencies. Moreover, no Granger causality is detected between the foreign trade balance and the real effective exchange rate at any frequency bands. In short, the power of causality from interest rate and industrial production is becoming stronger, though inflation's causality effect is becoming weaker in the long-run period.

6. Conclusion

This paper examines the relationship between the foreign trade balance and selected macroeconomic variables in Türkiye by employing the ARDL framework, cumulative dynamic multipliers, and frequency domain Granger causality analysis. Movements in the foreign trade balance are shaped by both long-run relationships and short-run adjustment processes according to the empirical findings. Inflation and the real effective exchange rate have statistically significant negative effects on the foreign trade balance in the long run. Persistent price pressures and declines in price competitiveness tend to weaken external balance performance over time. In addition, while the short-run relationship between industrial production and the foreign trade balance is initially positive, it turns negative starting from the first lag, which is consistent with the import-dependent structure of production in Türkiye. By contrast, interest rates exhibit a positive long-run relationship with the foreign trade balance. Higher financing costs may restrain domestic demand and reduce import volumes.

The positive long-run association between interest rates and the foreign trade balance appears to operate mainly through demand-side conditions. Although interest rates may also affect the external balance through exchange rate channels, the results indicate that the contractionary effects on domestic demand and imports play a more dominant role. In this respect, the results point to the importance of market-driven channels rather than exchange rate movements for the Turkish foreign trade balance in the long run.

Dynamic responses show that shocks to inflation and industrial production generate short-term responses in the trade balance that vary in sign and mostly turn negative after the initial period. In contrast, real effective exchange rate shocks display a consistently negative short-run impact. The frequency domain Granger causality findings complement these findings by demonstrating unidirectional causality from inflation, interest rates, and industrial production to the foreign trade balance across different frequency bands. While the causal impact of inflation is relatively stronger in the short-run period, the causal effect of interest rates and industrial production becomes stronger at lower frequencies, corresponding to long-run periods. These findings are consistent with several time-domain studies[2] that document relatively stable causality patterns; however, the frequency-domain results of this study reveal both the strength and the persistence of causal relationships across different horizons.

From a policy perspective, maintaining price stability and reducing import dependency in production appear to be important conditions for achieving a more sustainable foreign trade balance. Policies aimed at increasing brand value and expanding the share of high-value-added and technology-intensive exports may help limit the adverse effects of price-based competition. In this context, an increase in the value-added content of exports and a decline in price-based demand elasticity weaken the role of imports in shaping the foreign trade balance. Under such conditions, price stability and moderate financing costs reduce the dominance of import demand in terms of external balance outcomes.

Declarations

Ethical declaration

The authors declare that scientific and ethical principles were adhered to during the conduct and writing of this study, and that all sources have been appropriately cited.

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[2] Özer and Kutlu (2019) also reported unidirectional causality from inflation to the foreign trade balance, while no direct causal link is detected for the real effective exchange rate.

AI disclosure

The authors declare adherence to ethical principles, transparency, and accountability in the use of artificial intelligence tools and affirms that their academic responsibilities have been duly fulfilled. AI was used to improve language clarity and readability. All outputs were reviewed and edited by the authors, who remain fully responsible for the content.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors' contributions

Conceptualization, methodology, investigation / Kavramsallaştırma, yöntem, inceleme: G. Aktaş, F. Ö. Hiç

Data curation / Veri düzenleme: G. Aktaş

Formal analysis, Validation / Biçimsel analiz, doğrulama: G. Aktaş

Software, visualization / Yazılım, görselleştirme: G. Aktaş

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Supervision, project administration / Danışmanlık ve proje yönetimi: F. Ö. Hiç

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***Note:** This information has been provided by the authors.*

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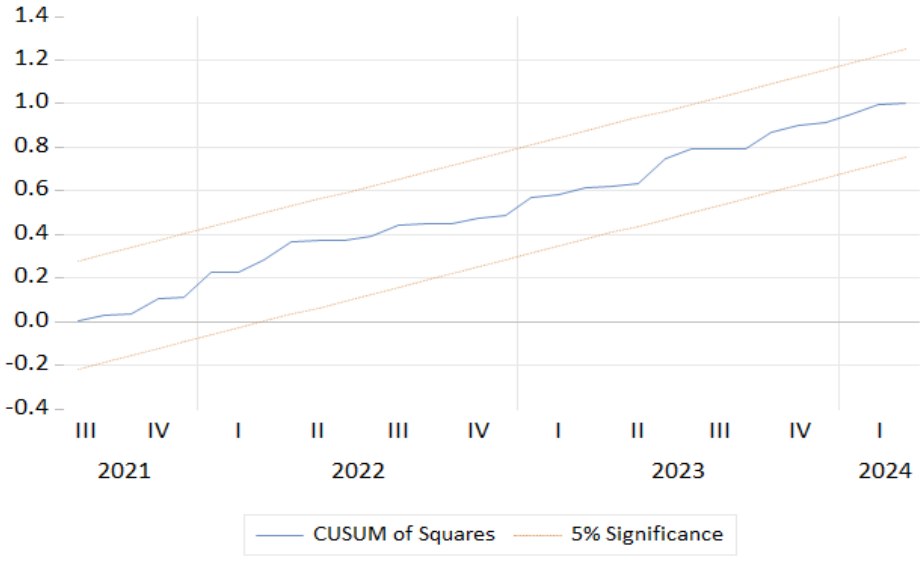
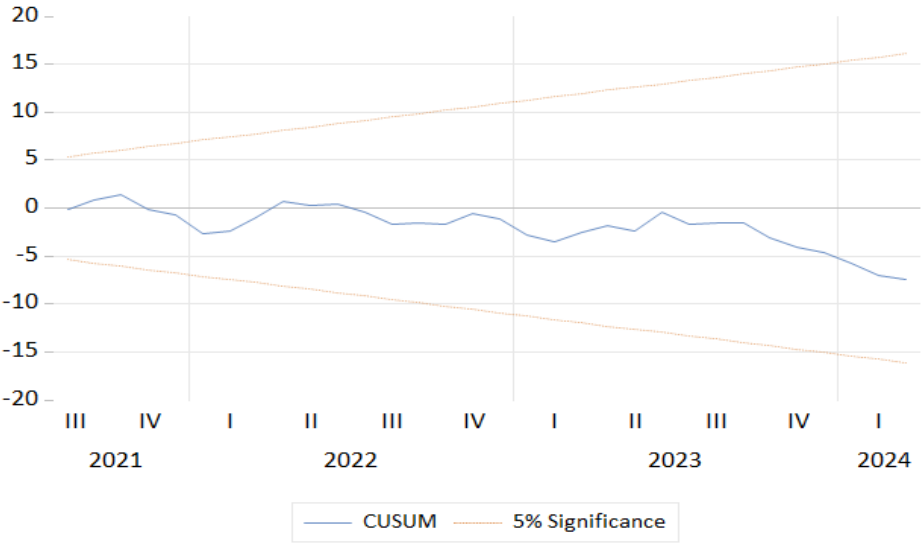
APPENDIX 1. ARDL(3,2,0,4,1) model coefficients and diagnostic test results

Dependent Variable: FTB		
Variables	**Coefficient (Std. Error)**	**Residual and Stability Diagnostic Tests Results**
FTB(-1)	0.2869*** (0.0668)	-Serial Correlation (Breusch-Godfrey) LM Test: Chi-square (2) Prob. Value: 0.318
FTB(-2)	0.2362*** (0.0665)	-Heteroskedasticity (Breusch-Pagan-Godfrey): Chi-square (15) Prob. Value: 0.128
FTB(-3)	0.1886*** (0.0625)	-Regression Specification Error Test (RESET): Ramsey RESET Test [1] Prob. Value: 0.689
INF	-0.4300*** (0.1402)	
INF(-1)	0.6161** (0.2380)	
INF(-2)	-0.3177** (0.1382)	
INT	0.1723*** (0.0514)	
IP	0.2557** (0.1165)	
IP(-1)	-0.5336*** (0.1509)	
IP(-2)	-0.1006 (0.1557)	
IP(-3)	-0.0617 (0.1552)	
IP(-4)	0.4100*** (0.1212)	
REER	-0.3061*** (0.1097)	
REER(-1)	0.1688 (0.1129)	
DUMMY2021	-0.7167 (2.1587)	
CONSTANT	34.2772*** (9.0221)	
R^2	0.7589	
$\bar{R}^2$	0.7418	



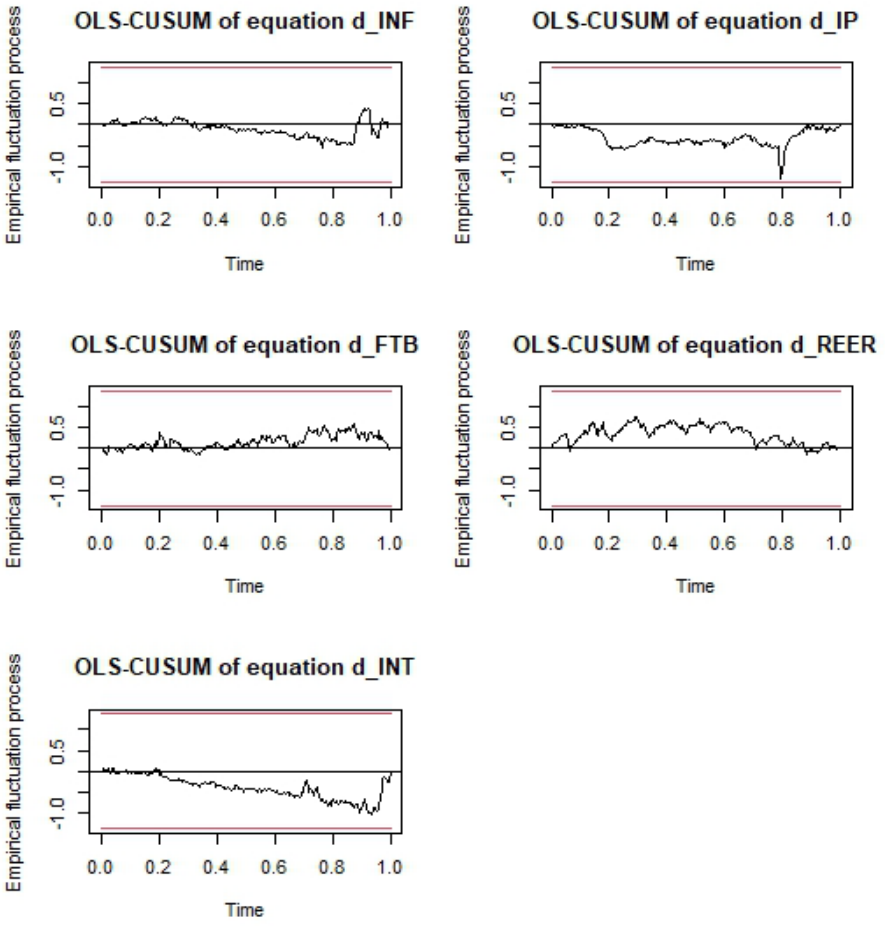


Note: Values in parentheses below the coefficients represent White-Hinkley (HC1) heteroskedasticity consistent standard errors. *** indicates statistical significance at 1%, ** at 5%, * at 10% levels.

APPENDIX 2. Optimal lag length selection for the FDGC analysis

Lag	AIC(n)	HQ(n)	SC(n)	FPE(n)
1	9.833	***10.021****	***10.299****	18646.696
2	9.826	10.171	10.679	18509.522
3	***9.750****	10.252	10.992	***17177.387****
4	9.845	10.503	11.475	18914.864
5	9.897	10.712	11.915	19975.314
6	9.879	10.851	12.286	19708.570
7	9.912	11.040	12.706	20471.479
8	10.005	11.290	13.188	22643.060
9	10.111	11.553	13.681	25406.155
10	10.094	11.693	14.053	25291.330
11	9.946	11.701	14.293	22124.684
12	9.756	11.668	14.491	18628.128

APPENDIX 3. CUSUM stability tests for VAR models used in the FDGC analysis



APPENDIX 4. FDGC pair results