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Analysis of The Asymmetric Relationship Between Inflation and Economic Growth: The Case of Turkish Economy*

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Abstract

This study investigates the asymmetric effects of inflation shocks on Turkey's economic development using the real exchange rate and foreign direct investment (FDI) as control variables. Distributed Lag (NARDL) model together with nonlinear cointegration and causality tests, the study covers the period 2005Q1 through 2023Q3. Research supports the presence of asymmetric cointegration between the real exchange rate, inflation, economic growth, and foreign direct investment. In the near run, GDP is negatively impacted by rising inflation while it is positively impacted by dropping inflation. On the contrary, inflationary spikes have a more detrimental influence on economic growth over the long term than inflationary declines. Additionally, a unidirectional causal relationship exists between inflation and the real exchange rate, but a bidirectional causal relationship is shown between economic growth and foreign direct investment. These results highlight the necessity of considering the asymmetric nature of inflation shocks in macroeconomic policy design, especially in developing economies such as Turkey. In addition, the importance of ensuring price stability to support sustainable economic growth can be emphasized by taking into account external factors such as exchange rate fluctuations and foreign capital inflows.

Keywords: Economic growth, inflation, non-linear time series.

JEL Codes: E1, E31, F43.

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Enflasyon ve Ekonomik Büyüme Arasındaki Asimetrik İlişkinin Analizi: Türkiye Ekonomisi Örneği

Öz

Bu çalışma, enflasyon şoklarının Türkiye'nin ekonomik büyüme üzerindeki asimetrik etkilerini, kontrol değişkenleri olarak reel döviz kuru ve doğrudan yabancı yatırım (FDI) kullanarak araştırmaktadır. Gecikmesi Dağıtılmış Otoregresif (NARDL) Modeli, doğrusal olmayan eşbütünleşme ve nedensellik testlerinin kullanıldığı çalışma 2005:Q1 ile 2023:Q3 dönemini kapsamaktadır. Araştırma, reel döviz kuru, enflasyon, ekonomik büyüme ve doğrudan yabancı yatırım arasında asimetrik eşbütünleşmenin varlığını desteklemektedir. Kısa vadede, ekonomik büyüme artan enflasyondan olumsuz etkilenirken, düşen enflasyondan olumlu etkilenmektedir. Aksine, enflasyonist artışlar, uzun vadede ekonomik büyüme üzerinde enflasyonist düşüşlerden daha zararlı bir etkiye sahiptir. Ek olarak, enflasyon ve reel döviz kuru arasında tek yönlü bir nedensel ilişki vardır, ancak ekonomik büyüme ve doğrudan yabancı yatırım arasında çift yönlü bir nedensel ilişki gösterilmiştir. Bu sonuçlar, özellikle Türkiye gibi gelişmekte olan ekonomilerde, makroekonomik politika tasarımında enflasyon şoklarının asimetrik doğasının dikkate alınmasının gerekliliğini vurgulamaktadır. Ayrıca döviz kuru dalgalanmaları ve yabancı sermaye girişleri gibi dışsal faktörler de dikkate alınarak sürdürülebilir ekonomik büyümenin desteklenmesi açısından fiyat istikrarının sağlanmasının önemi vurgulanabilir.

Anahtar Kelimeler: Ekonomik büyüme, enflasyon, doğrusal olmayan zaman serileri.

JEL Kodları: M00, M40, I23.

1. Introduction

A primary objective for all nations in the globe today is economic growth. Countries with varying degrees of development have used a variety of approaches to this problem over time. A number of variables directly affect economic growth in emerging nations like Turkey. To solve economic difficulties and improve economic performance, policies have been put in place that specifically target the real exchange rate, inflation rate, and foreign investments. Reducing inflation, minimizing currency rate risks, and optimizing the beneficial effects of foreign investments on the economy are important goals in guaranteeing economic progress.

Over the years, Turkey has used a number of methods and policy measures in response to inflation and currency rate swings, which have traditionally been among its most urgent economic concerns. A lot of research has been done on how these policies have affected the economy. The present research examines at the asymmetric link between Turkey's economic expansion and inflation for the years 2005Q1–2023Q3, considering foreign direct investment and the real exchange rate as control variables. By looking at the data from multiple viewpoints, this investigation seeks to contribute to the economic literature, as recent structural changes in macroeconomic variables have changed the linearity of economic time series.

The second half of the study focuses at how the real exchange rate, inflation, and foreign direct investments impact economic development within a conceptual framework. The third part presents the literature regarding the relationships between inflation, expansion of the economy, foreign direct investment, and the real exchange rate. The fourth segment includes an in-depth account of the dataset and methodology. The fifth portion includes the findings. An analysis and discussion of the results round out the conclusion section.

2. Conceptual Framework

A range of interconnected factors has influenced the global economic development over the past 200 years. During this period, capitalism deepened, technical advancements accelerated, and market mechanisms and fiscal policies grew in significance (Klinov, 2010:81). These changes contributed to structural transformation, shaping both progress and disparity in different countries' economic growth.

Particularly since the Industrial Revolution, technological advancements have transformed production methods, raised productivity, and fostered new sectors. These innovations, alongside favorable tax and budgetary policies, have driven economic growth by stimulating investment and demand. At the same time, effective policy management has maintained sustainable public debt and economic stability (Ulchenko, 2014:108).

The transformation of the global economy over the past two centuries reflects the complexity of economic relations and the key role of policies. This process underscores that progress results from the interaction and combined effects of various factors.

For developing countries with financial constraints, attracting international investors is crucial for economic development. In agricultural economies, securing FDI that provides higher wages and employment opportunities is a key priority (Coniglio et al., 2015:1248).

Recently, FDI has grown significantly, becoming a key external financing source for many emerging economies. Recognizing its role in fostering economic expansion, some states have implemented measures to attract such investment (Michalowski, 2012:692). Historically, developing countries have viewed FDI as a key driver of growth. Studies show FDI helps resolve organizational issues, provide financial support, create employment, and enhance skills, while strengthening production capacity and competitiveness (Todaro & Smith, 2003:86).

A persistent increase in the average level of prices for goods and services is known as inflation, is another key factor related to economic growth. It erodes purchasing power and distorts measurement and valuation, making its rate of change a significant indicator. According to Mankiw and Reis (2002:1305), inflation has both positive and negative effects. While high inflation raises cash-holding risks, causes shortages, and complicates investment, it also allows central banks to adjust real financing costs and support capital investments, helping to mitigate recessions.

The relationship between growth and inflation is a key macroeconomic issue. Post-World War II Keynesian approaches linked rising demand to inflation and output growth. However, growth models highlight inflation's negative effects on capital accumulation and technological progress, with high, volatile inflation increasing uncertainty and harming investment (Bruno, 1993:15; Pindyck & Solimano, 1993:271).

In developed countries, tax policies favoring certain sectors mean even anticipated inflation can reduce capital gains rates and undermine investor confidence. Inflation's impact on growth also affects key factors like technological research and human capital development, known as its effect on investment and accumulation (Jones et al., 1993:498).

In market economies, inflation can hinder sustained growth by reducing productivity efficiency, though this link is complex and not direct (Stiglitz, 2005:21). High inflation causes frequent price changes, raising business costs and complicating cash management, which leads to resource misallotment. While theory addresses this efficiency loss, isolating it empirically remains difficult (Miles, 1978:431).

One important component of economic expansion is the real exchange rate, influencing domestic trade and production. Its impact depends on the exchange rate regime, with fixed and flexible systems producing varied outcomes. Exchange rate volatility creates financial uncertainty affecting trade, capital markets, monetary policy, and investment. Flexible rates can promote growth by reducing liquidity risk and transaction costs, though their instability may also hinder development (Azid et al., 2005:758). Exchange rate fluctuations can negatively affect long-term economic growth by creating instability that harms trade, tourism, capital flows, investment, and industrial output (Miles, 2006:97; Güloğlu & Akman, 2007:48; Eichengreen, 2007:11). Volatility in the real exchange rate creates investor uncertainty, delaying investments and causing resource reallocation across sectors and countries, which can hinder economic expansion and advancement (Kogid et al., 2012:10).

2.1 Theoretical Relationship's Position in Turkish Economy

In Turkey, the 1980s liberal reforms, export-oriented strategies, and privatization deepened global market integration. However, the persistent current account deficit poses a major risk to macroeconomic stability due to external borrowing and exchange rate volatility (Duman, 2017:235). Despite these challenges, Turkey's significant recent growth positions it among the top global economies in the coming decade (Bulut, 2013:57). Achieving this potential requires sustainable policies, a competitive corporate environment, increased R&D and education investments, and trade diversification.

Turkey's economic development goals linked to FDI include boosting global competitiveness, economic growth, and attracting foreign capital. Between 2000 and 2007, FDI notably impacted the service sector (Halıcıoğlu, 2008:2). Turkey's EU candidacy and political developments have enhanced its investment appeal, with accession efforts and democratization seen as key drivers of FDI inflows (Güllü & Kılıç, 2017:73; Hadjit & Moxon-Browne, 2005:330).

In assessing the correlation among economic growth and inflation under the structure of Turkey, the inflation rate was measured at 7.7% in 2005. Although fluctuations in inflation were observed in subsequent periods, it remained around 10%. Reforms adopting price stability and primary surplus policies in the public sector have led the Turkish economy to become dependent on foreign investments. The decline in foreign capital inflows resulted in a depreciation of the national currency, which, in turn, triggered a currency crisis and high inflation rates. Following a decrease in capital mobility after 2016, inflation rose from 12% in 2017 to 20.3% in 2018. After a short-lived decline due to base effects in 2019, inflation began to rise again, reaching 64.2% in 2022. In 2023, the inflation rate remained at the same level (www.imf.org/en/Countries/TUR).

In Turkey, the real exchange rate's impact on development depends on capital and trade mobility. Increased capital inflows raise demand for tradable and non-tradable goods, pressuring non-tradable prices and widening trade imbalances via imports. Capital inflows mainly finance current account deficits and can lead to nominal exchange rate appreciation or inflation through monetary expansion (Kofoğlu & Alaca, 2024:522).

3. Literature Review

Numerous studies that examine economic growth in relation to different factors are included in the literature. The effects of inflation on economic growth, both favorable and unfavorable have been noted in these studies, which were carried out throughout a variety of time periods, using a variety of approaches, and with a focus on various nations. The results of these research, which have been conducted over time in a variety of nations and areas, have added to the corpus of existing literature. In this section of the study, a selection of these studies is summarized in the table below. While the studies included in the table primarily examine economic growth and inflation as key variables, they also consider the indirect effects of the impact of real exchange rates and foreign direct investment on economic expansion as control variables.

Table 1

Literature Review

Authors and Year of Study	Method	Findings
Koyuncu (2010)	For the Turkish economy during the period 1990-2009, a Structural VAR (SVAR) analysis has been conducted.	A significant connection between economic growth, foreign direct investments, and the amount of foreign direct investments during the prior period.
Omankhanlen (2011)	Regression analysis for the Nigerian economy during the period 1980-2009	It has been demonstrated that neither the inflation rate nor FDI greatly impacts economic growth or inflows of FDI. Nonetheless, over the same period, FDI inflows are greatly affected by the foreign exchange rate.
Altunöz (2013)	ARDL Model for Turkish economy for the periods 1988:1-2007:4	Evidence has indicated that inflation has a detrimental effect on economic expansion.
Bibi, Ahmad and Rashid (2014)	Cointegration and dynamic regression analysis for Pakistan economy during 1980-2011 period.	Investigation demonstrates that while inflation has a negative impact on economic growth, foreign direct investments and exchange rates have a beneficial impact. Furthermore, the existence of a cointegration connection between the variables has been proven.
Amoah, Nyarko and Asare (2015)	Johansen Cointegration and VAR analysis for the Ghanaian economy during the period 1980-2013	It was shown that while inflation had a positive effect on economic development, exchange rates and foreign direct investments had a negative impact on economic growth for the variables showing a cointegrated structure.

Sağdıç (2018)	Causality analysis of the Turkish economy for the period 2003:Q1–2017:Q3	There was no causal connection identified between the real exchange rate and economic growth, but there was a unidirectional connection established between the real exchange rate and inflation and between inflation and economic growth.
Foeh, Suryani and Silpama (2020)	Panel data analysis for the economies of 11 Asian countries during the period 2007-2016	Foreign direct investments have been observed to be beneficially affected by exchange rates and negatively impacted by inflation. Furthermore, there is no discernible relationship between economic development and foreign direct investments.
Mostafa (2020)	Vector Error Correction Model (VECM) for Bangladesh economy during 1980-2017	According to the research, foreign direct investment (FDI) is adversely affected by inflation over the long run, and FDI is expected to rise in Bangladesh if inflation declines.
Ngoc (2020)	NARDL model for the Vietnam Economy in the period 1990-2017	Inflation negatively and asymmetrically affects long-term growth, while money supply has a positive impact. Findings stress the need for effective inflation control to ensure sustainable development.
Chen et al. (2020)	NARDL model for the Kenya Economy in the period 1972-2017	Inflation shocks have asymmetric effects on growth: positive shocks reduce, while negative shocks increase it. The findings suggest that maintaining stable and sustainable inflation, alongside regulated government spending and a deepening financial system, supports economic growth.
Demir et al. (2021)	Causality analysis for the Turkish economy in the period 1980-2020	Inflation and foreign direct investments have been found to be causally related in both directions, but economic growth and foreign direct investments are causally related in only one way.
Dey et al. (2021)	Linear regression analysis for Bangladesh economy during 2000-2019 period	Based on the evidence, foreign direct investments and exchange rates and economic growth are favorably and statistically significantly correlated. Nonetheless, there is a negative and statistically insignificant correlation between foreign direct investments and inflation.
Albayrak (2022)	NARDL model for the Turkish Economy in the period 1990-2021	Although a long-term cointegration link between inflation and economic growth was found, inflation had an unbalanced short-term influence on growth and a symmetric long-term impact.
Alper and Kök (2023)	ARDL model for the Turkish Economy for the period 1988-2020	Long-term economic growth and inflation have been displayed to be adversely connected.
Trejo-Garcia et al. (2024)	NARL model for the Mexican Economy for the period 1994-2023	The key empirical result indicates that fluctuations in the inflation, whether increases or decreases, have produced varying effects both in direction and intensity on economic growth over time.

In the literature, there are studies that examine the pairwise or trio relationships between the four relevant variables in various forms. However, within the scope of this study, since all four variables are addressed within a single model, only studies that have considered these

variables together are compiled. The most significant difference of our study in terms of the literature is that, due to the changes the relevant variables have undergone in the Turkish economy, they have started to lose their linearity. In other words, the use of nonlinear time series analyses to examine the relationship between these four variables is expected to make the study unique and fill the relevant gap in the literature.

4. Data Set and Method

2005:Q1-2023:Q3 quarterly data are used in this study. Nominal GDP per capita, which has been converted using the natural logarithm and adjusted for inflation using the Consumer Price Index (CPI), is the dependent variable. Foreign direct investment (FDI) and the actual exchange rate are control variables. It applies the natural logarithm to foreign direct investment and real exchange rate. The rate of change of the CPI represents inflation. The Central Bank of Turkey's Electronic Data Distribution System (EVDS) is the source of all variables. The general model examined in the study is presented in Equation 1:

$$lnrgsyih_t = f(enf_t, lndyy_t, lnrdk_t) \quad (1)$$

In the specified model, lnrgsyih denotes economic growth, enf refers to inflation, lndyy stands for foreign direct investment, and lnrdk indicates the real exchange rate. Since both inflation and real exchange rate are generally believed to put downward pressure on economic growth, the relationship is expected to be negative. Conversely, FDI is considered a key driver of national welfare and development; therefore, it is expected to have a positive impact on economic growth.

In traditional time series, the structure of the series is often assumed to be linear. However, permanent or temporary shocks experienced by the series may result in changes to its linearity. For example, changes in the employment rate during economic expansion periods may not be of the same magnitude as those observed during contraction periods. Therefore, significant changes can occur in the time trajectory of the series. This situation not only considers linearity but also overlooks the presence of linear nonlinearity. In this context, detecting linear nonlinearity plays an important role in the analysis of time series. Its most significant role lies in the stationarity analysis and model estimation, as failure to detect linearity can lead to erroneous econometric analyses.

The linearity test examined in the analysis is the Harvey et al. (2008) test. In the Harvey et al. (2008) test, the stationarity structures of the series are considered separately. To conduct this test, the series are analyzed under the assumption of either level stationarity or difference stationarity. In other words, separate regression tests are considered for stationary series at the level and for difference-stationary series. For the regressions under consideration, the presence of unit roots in the series is determined using the models presented in Equations 2 and 3 (Harvey et al., 2008:11).

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-1}^2 + \beta_3 y_{t-1}^3 + \sum_{j=1}^{p} \beta_{4,j} \Delta y_{t-j} + \varepsilon_t \quad (2)$$

$$H_0: \beta_2 = \beta_3 = 0 \rightarrow W_0$$
$$\Delta y_t = \lambda_1 \Delta y_{t-1} + \lambda_2 (\Delta y_{t-1})^2 + \lambda_3 (\Delta y_{t-1})^3 + \sum_{j=1}^{p} \lambda_{4,j} \Delta y_{t-1} + \varepsilon_t \quad (3)$$
$$H_0: \lambda_2 = \lambda_3 = 0 \rightarrow W_1$$

A key assumption in time series analysis is that the variables involved must be motionless. The time series is said to be stationar if its mean and variance remain constant across period, and that its covariance depends solely on the time interval, rather than the actual time at which it is measured. If a series is non-stationary, analyses based on it may yield misleading or spurious results. Hence, verifying the stationarity of the variables is an essential preliminary step. The first unit root test applied in this study is the Smooth Transition Autoregressive (STAR) unit root test developed by Kapetanios, Shin, and Snell (2003). STAR models are autoregressive models designed to capture gradual, nonlinear changes in a time series around a specific threshold. These models assume that different autoregressive processes are active in different regimes and that the transition between these regimes is smooth and continuous. Thus, STAR models are particularly useful in identifying nonlinear dynamics and structural shifts in time series data (Kapetanios et al., 2003: 365). The second test used is the Asymmetric Exponential Smooth Transition Autoregressive (AESTAR) unit root test developed by Sollis, which allows for asymmetric adjustments in the behavior of the series around the threshold level. This approach provides a more nuanced understanding of asymmetric regime shifts (Sollis, 2009: 120). The final test considered is the Exponential Smooth Transition Autoregressive (ESTAR) unit root test proposed by Kruse (2011). ESTAR models are employed to detect exponential, yet non-smooth, transitions in the autoregressive structure of time series data, making them suitable for modeling nonlinearities that do not follow a symmetrical path (Kruse, 2011: 76).

Following the initial linearity and stationarity assessments conducted in the study, the relationship between growth and its potential determinants is examined using the Nonlinear Autoregressive Distributed Lag (NARDL) model. The NARDL approach enables the analysis of asymmetric and nonlinear dynamics by incorporating interaction terms between the dependent and independent variables. Specifically, the model captures these nonlinearities by including the products of the current values of the explanatory variables with the lagged values of the dependent variable, thereby reflecting both short- and long-run asymmetric effects.

When we add these interaction terms, the NARDL model takes the form of Equation 4 (Shin et al., 2014:285) :

$$\Delta lnrgsyih_t = \alpha_0 + \delta_0 lnrgsyih_{t-1} + \delta_1^+ enf_{t-1}^+ + \delta_1^- enf_{t-1}^- + \delta_2 lndyy_{t-1} + \delta_3 lnrdk_{t_{t-1}} + \sum_{i=1}^{p} \beta_0 \Delta lnrgsyih_{t-1} + \sum_{i=0}^{q} \beta_1^+ \Delta enf_{t-1}^+ + \sum_{i=0}^{q} \Delta\beta_1^- \Delta enf_{t-1}^- + \sum_{i=0}^{r} \beta_2 \Delta lndyy_{t-1} + \sum_{i=0}^{s} \beta_3 \Delta lnrdk_{t_{t-1}} + \varepsilon_t \quad (4)$$

The cointegration of economic growth, the beneficial and detrimental elements of inflation, the real exchange rate, and foreign direct investment is examined using the F-test in equation (4). To ascertain cointegration, the The F-value is compared to the Pesaran critical values (Pesaran et al., 2001).

In the final part of the study, a nonlinear causality test was conducted. The nonlinear causation examination's objective is to assess how well a specific variable can predict other variables. This test aims to obtain more accurate results by considering the nonlinear characteristics of the causality relationship between the variables. The nonlinear causality test is conducted by applying causality to the error terms obtained from the VAR model estimation (Diks and Panchenko, 2006: 1653). This test is both a non-parametric and nonlinear causality test below.

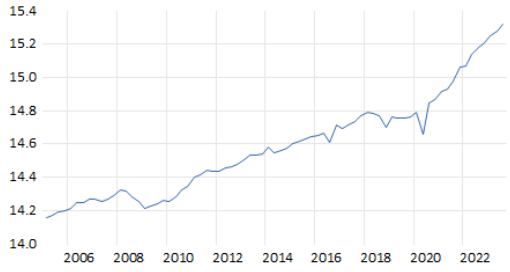
$$T_n(\varepsilon) = \frac{n-1}{n(n-2)} \sum_i (\hat{f}_{X,Y,Z}(,Z_i)\hat{f}_Y(Y_i)X_i, Y_i - \hat{f}_{X,Y}(X_i, Y_i)\hat{f}_{Y,Z}(Y_i, Z_i)) \quad (5)$$

5. Findings

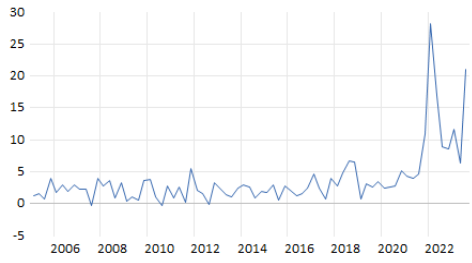
Before moving on to the analysis in the study, information about the graphs and structures of the series was given.

Figure 1

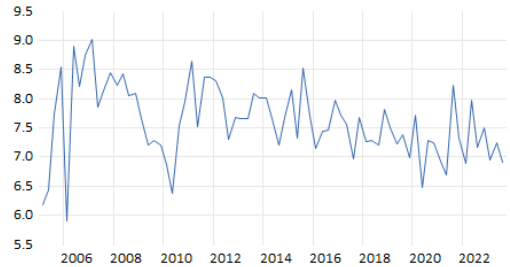
Graphs of Variables



lnrgsyih



inflation



lndyy

lnrdk

When the structure of the series is examined, it can be said as preliminary information that it does not show linearity in the general structure. However, it can be seen that the economic growth series (lnrgsyih) contains a trend. Inflation and foreign direct investment series are distributed around the average but with great variability. In particular, there have been very serious breakdowns in the inflation series in recent years. The opposite is also true for foreign direct investment. When the sequence of actual rates of exchange is examined, a gradual

decrease is observed. It cannot be said that there is a clear trend as in economic growth. It has shown a course around the average in some periods.

Table 2 displays the outcomes of the linearity test that was performed before the model estimate.

Table 2

Harvey et al. (2008) Linearity Test Results

Variables	Test Statistics (W_λ)- Critic Value	Decision
lnrgsyih	37.66>5.99	The variable is non-linear.
enf	12.88>5.99	The variable is non-linear.
lndyy	8.05>5.99	The variable is non-linear.
lnrdk	13.73>5.99	The variable is non-linear.

Note: The critical value is 5.99, as developed by Harvey et al. (2008).
The hypotheses for the test are as follows:
H_0: The variable is linear.
H_a: The variable is non-linear.

The linearity test conducted in the study indicates that the variables exhibit a nonlinear structure. Before estimating the model, unit root tests were applied to determine the stationarity properties of the series. The results are summarized in Table 3.

Data corrected for the constant term, data adjusted for both the constant and trend, and raw data were the three series versions to which the nonlinear unit root test was applied. Although the alternative hypothesis suggests that a series is stationary without a unit root, the null hypothesis maintains that the series is non-stationary with a unit root. The unit root analyses show that economic growth and foreign direct investment are level, while inflation and the real exchange rate stabilize after some initial volatility. Therefore, inflation and the real exchange rate are considered I(1) variables, while economic growth and foreign direct investment are considered I(0) variables. The table below summarizes the findings of the NARDL model about the asymmetric relationship between inflation and economic growth.

Table 3

Non Linear Unit Root Test Results

Kapetanios, Shin, and Snell (2003) Test (STAR Model Type)	Test Statistic for Raw Data	Test Statistic for Data Without Constant	Test Statistic for Data Without Constant and Trend
lnrgsyih	4.308***	1.731	-2.112
k*	2	2	2
enf	-1.155	-1.260	-1.280
k*	3	3	3
denf	-3.986***	-3.928***	-3.787**
k*	4	4	4
lndyy	-0.443	-4.121***	-3.725**
k*	2	2	2
lnrdk	-1.649	-1.257	-2.432
k*	4	0	4
dlnrdk	-3.628***	-3.577***	-3.153*
k*	2	2	2
Critic Values (%10, %5, %1)	-1.92,-2.22,-2.82	-2.66,-2.93,-3.48	-3.13,-3.40,-3.93
Sollis 2009 Test (AESTAR Model Type)	Test Statistic for Raw Data	Test Statistic for Data Without Constant	Test Statistic for Data Without Constant and Trend
lnrgsyih	11.463***	4.261*	15.103***
k*	1	1	0
enf	0.585	1.096	2.567
k*	4	4	4
denf	13.857***	13.560***	13.378***
k*	4	4	4
lndyy	1.248	9.912***	9.260***
k*	4	4	4
lnrdk	1.720	0.837	2.957
k*	4	4	4
dlnrdk	5.425**	5.040**	3.802
k*	4	4	4
Critic Values (%10, %5, %1)	3.49, 4.29,6.06	4.17, 4.97, 6.80	5.59, 6.59, 8.95
Kruse 2011 Test (ESTAR Model Type)	Test Statistic for Raw Data	Test Statistic for Data Without Constant	Test Statistic for Data Without Constant and Trend
lnrgsyih	22.804***	14.582***	25.874***
k*	1	1	0
enf	1.962	2.751	1.448
k*	4	4	4
denf	17.247***	17.010***	17.304***
k*	4	4	4
lndyy	3.915	20.492***	17.592***
k*	4	4	4
lnrdk	4.193	4.390	5.951
k*	4	4	4
dlnrdk	10.785**	10.499**	9.012
k*	4	4	4
Critic Values (%10, %5, %1)	7.85, 9.53, 13.15	8.60,10.17,13.75	11.10, 12.82, 17.10

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4

NARDL Model Estimation Results

Dependent Variable: lnrgsyih
Iteration Number: 500
Model Selection Criterion: AIC (Akaike Information Criterion)
Selected Model: ARDL(1,0,0,0)

Variables	Coefficient	t-stats	Probability Value
C(Constant)	3.706	4.832	0.000***
lnrgsyih (-1)	0.991	8.334	0.000***
denf_neg	-0.0032	-5.022	0.001***
denf_pos	-0.0226	-3.407	0.027**
lndyy	0.046	3.855	0.000***
dlnrdk	-0.013	-4.179	0.000***
@Trend	0.0025	-2.776	0.039**

R^2:0.992,
Model F Statistics (Probability Value): 1457.303 (0.000)
Breusch-Godfrey Autocorrelation Test Statistics (Probability Value): 2.778(0.372)
Breusch-Pagan-Godfrey Heteroscedasticity Test Statistics (Probability Value): 3.599(0.461)
Ramsey Reset Model Specification Test (Probability Value): 2.884 (0.193)
χ^2_{NORM}(Probability Value): 0.406 (0.523)
W_{LR}: 36.094***
$Ws_{R:}$ 12.447***

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

In the Nonlinear ARDL (NARDL) model estimated for the period 2005Q1–2023Q3, the positive inflation shock has a more substantial impact on economic growth than the negative shock. The real exchange rate negatively, and FDI positively, affects growth. The significance of Wald statistics indicates that the asymmetry structure between the variables is valid in both the short and long term. The overall model is statistically significant, with no evidence of econometric issues such as autocorrelation, heteroscedasticity, or model misspecification. In addition, the model error terms also provide the normality assumption. The trend variable in the economic growth structure was also significant in the model, indicating the validity of the deterministic trend.

After determining the structure of the NARDL model, the short- and long-term coefficient estimates are presented.

When evaluating the short-term estimation, the error correction model coefficient (-0.174) being between -1 and 0 is econometrically consistent with expectations. Long-term results emerge in response to shocks. In other words, it can be said that the shocks occurring on a process basis will reach equilibrium in approximately 6 years (1/0.174). In the short term, decreases in inflation increase economic growth, while increases in inflation reduce economic growth.

Table 5

Short- and Long-Term Coefficient Estimation Results

Dependent Variable: d(lnrgsyih): Short Term			
Variables	Coefficient	t-stats	Probability Value
Cointeq* (EC_{t-1})	-0.174	-5.886	0.000***
C(Constant)	0.347	6.199	0.000***
denf_neg	0.883	2.913	0.041**
denf_pos	-0.575	-3.291	0.007***
lndyy	1.766	2.017	0.085*
dlnrdk	-0.096	-4.173	0.000***
@Trend	0.0006	1.660	0.174
Dependent Variable: lnrgsyih: Long Term			
Variables	Coefficient	t-stats	Probability Value
C(Constant)	9.336	107.870	0.000***
denf_neg	-0.022	-4.885	0.000***
denf_pos	-0.073	-3.645	0.000***
lndyy	0.059	3.807	0.000***
dlnrdk	-0.011	-4.066	0.000***
@Trend	0.0033	3.002	0.028**

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Over time, a one-unit inflation shock lowers economic growth by 2.2%, but a positive shock lowers it by 7.3%, suggesting that positive shocks have more detrimental impacts. Growth increases by 0.059 units for every 1% increase in foreign direct investment, but growth decreases by 0.011 for every 1% increase in the real exchange rate. It is undeniable that foreign investments contribute significantly to the national economy. However, a real depreciation of the national currency reduces domestic production while increasing import dependency and inflation. From an economic relationship perspective, the study's findings align with those of Koyuncu (2010), Altunöz (2013), and Alper & Kök (2023). The presence of a long-term cointegration relationship among the selected variables was tested using the F-Bounds test.

Table 6

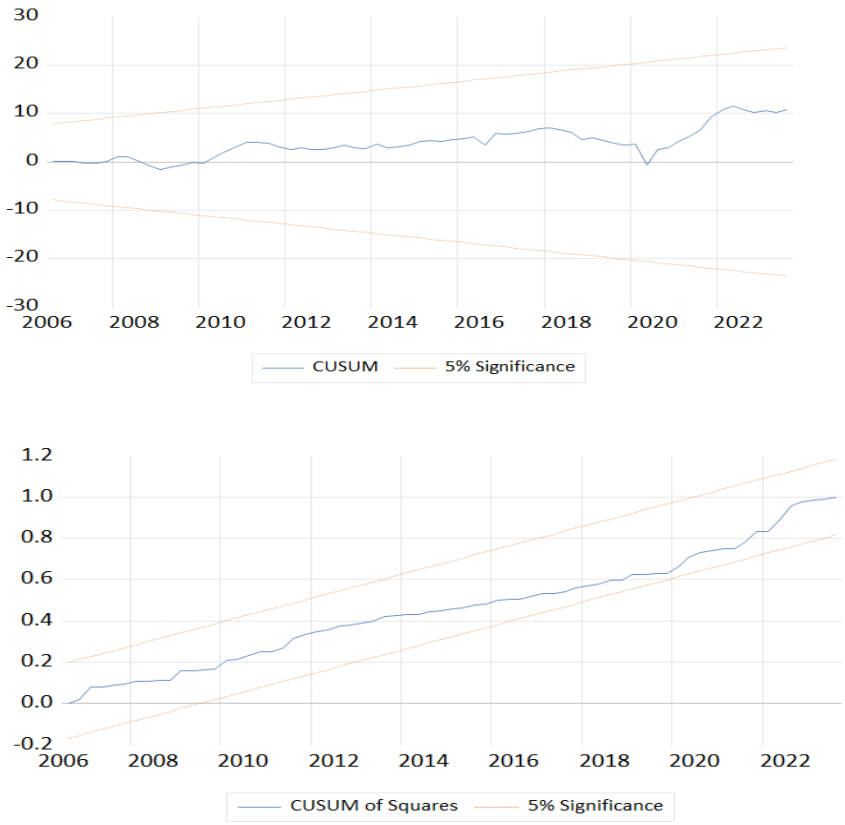
NARDL Bound Test Result

	NARDL	F- Stats Bound Test
lnrgsyih	(1,0,0,0)	8.913
Significance Level	Lower Bound	Upper Bound
%1	4.055	5.071
%5	2.873	3.848
%10	2.389	3.407

Since the F-statistic (8.913) shows a long-term equilibrium link between the variables and surpasses the upper bound critical values at all conventional significance levels, the null hypothesis of no cointegration is rejected. This demonstrates how well the NARDL model captures these processes.

Figure 2

Cusum and Cusum Q Graph



The CUSUM test verifies the model's parameters' long-term stability, as your description makes clear. This implies that during the course of the research period, the estimated correlations between inflation, economic growth, foreign direct investment, and the real exchange rate stay constant. Furthermore, the CUSUM test's graphical depiction supports the notion that the long-term estimation is structurally stable, hence confirming the dependability of the NARDL model's output. It can be said that the stability process in the graphs did not experience a break over time and remained within the confidence intervals. The Nonlinear Causality Test was performed as the last step in the investigation.

The results of the causality analysis demonstrate that there is a unidirectional association between inflation and the real exchange rate and a bidirectional causal connection between economic growth and foreign direct investment. Additionally, there is a bidirectional association between foreign direct investment and the real exchange rate, but a significant unidirectional causal relationship between inflation and the real exchange rate. Nevertheless, there was no proof that foreign direct investment and inflation were causally related. These findings align with studies conducted by Sağdıç (2018) and Demir et al. (2021).

Table 7

Non Linear Causality Test (Diks- Panchenko (2006))

Hypothesis: Inflation does not the cause of Economic Growth	Hypothesis: Economic Growth does not the cause of Inflation	Decision
15.585 (0.000)***	1.061(0.306)	$enf \rightarrow lnrgsyih$
Hypothesis: Foreign Direct Investments do not the cause of Economic Growth	Hypothesis: Economic Growth does not the cause of Foreign Direct Investments	Decision
6.646 (0.012)**	5.152 (0.026)**	$lndyy \leftrightarrow lnrgsyih$
Hypothesis: Real Exchange Rate does not the cause of Economic Growth	Hypothesis: Economic Growth does not the cause of Real Exchange Rate	Decision
8.181 (0.005)***	0.181 (0.671)	$lnrdk \rightarrow lnrgsyih$
Hypothesis: Real Exchange Rate does not the cause of Foreign Direct Investments	Hypothesis: Foreign Direct Investments do not the cause of Real Exchange Rate	Decision
4.174 (0.044)*	7.192 (0.006)***	$lndyy \leftrightarrow lnrdk$
Hypothesis: Real Exchange Rate does not the cause of Inflation	Hypothesis: Inflation does not the cause of Real Exchange Rate	Decision
0.003 (0.950)	18.180 (0.000)***	$enf \rightarrow lnrdk$
Hypothesis: Inflation does not the cause of Foreign Direct Investments	Hypothesis: Foreign Direct Investments do not the cause of Inflation	Decision
0.214 (0.644)	0.862 (0.356)	$enf \leftrightarrow\neq lndyy$

6. Conclusion

The instability observed in the global economy has been a subject of discussion in economic literature from the Classical Economists to the present day. Although economic crises manifest differently in each country, the economic instability they induce has reached a global scale. In Turkey, such crises have placed the country at a disadvantage in terms of production and income, negatively affecting its economic growth. Furthermore, the currency depreciation triggered by rising exchange rates during crises have led to a devaluation of the national currency. In the aftermath of crises, high inflation rates, declining foreign direct investment, and economic stagnation have become prevalent challenges.

Using the real exchange rate and foreign direct investments as control variables, this investigation examines the asymmetric link between inflation and economic growth, within the context of the Turkish economy from 2005:Q1 to 2023:Q3. The presence of temporary or permanent shocks in the series trends highlights the fact that many macroeconomic variables today are unlikely to remain mathematically linear. As a result, the possibility of nonlinear structures was tested, and based on these test outcomes, the time series analysis proceeded accordingly. Since the four variables in question exhibit nonlinear characteristics, nonlinear unit root tests were used instead of traditional ones. The findings demonstrated that while inflation and the real exchange rate stabilized after initially straying, economic growth and foreign direct investment volumes stayed stable at level values. Since the series exhibit stationarity on many levels, the interactions between them were modeled using the Nonlinear Autoregressive Distributed Lag (NARDL) model. The NARDL model's results indicate that both positive and negative shocks to inflation have a negative effect on economic growth, and that the real

exchange rate also slows it down. Nevertheless, economic growth is positively impacted by foreign direct investments. The short-term error correction coefficient is -0.174, indicating that the long-term correction rate for the adverse impacts of shocks on economic growth is 0.174. These findings are consistent with expectations, showing that foreign direct investments boost economic development while inflation and the real exchange rate have a negative impact.

Overall, it can be stated that the effects of economic crises, the pandemic, and natural disasters continue to affect the Turkish economy, which has struggled to recover from these adverse situations. For the national economy, inflation can be controlled through measures such as the production of high value-added technology and knowledge-intensive products, with a focus on export-oriented production that reduces dependence on imports. In the short term, encouraging capital inflows and, in the long term, promoting foreign direct investment will provide significant contributions to achieving economic stability.

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ETHICS

The authors declare that this article complies with ethical standards and rules.

AUTHOR CONTRIBUTION

Özlem Çelikel | General contribution rate: 50%.
Hakan Öndes | General contribution rate: 50%.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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