

The Inflation-Interest Rate Relationship in The Turkish Economy: Evidence of Cointegration and Granger Causality

Türkiye Ekonomisinde Enflasyon-Faiz Oranı İlişkisi: Bütünleşme ve Granger Nedenselliğinin Kanıtı

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Abstract: This study examines the relationship between inflation and interest rates in Türkiye using monthly data from 2012M01 to 2024M12. Lee-Strazizich's results show that the series are sensitive to various structural break points. This result indicates that structural changes caused by economic shocks affect the Turkish economy. The results of the Engle-Granger, Phillips-Ouliaris, and Johansen tests based on the VECM show long-run relationships among the variables. Moreover, there is a significant positive correlation between interest rates and inflation, as shown by the cointegration coefficients of FMOLS, DOLS, and CCR. VECM-based Granger results show the causal relationship between inflation and interest rates in the short run. This study contributes to the literature by demonstrating a two-way relation between long-term inflation and interest rates. Depending on the breakdown of the differentials, interest rates have little impact on inflation. The research findings indicate that inflation is the root cause of the economy's problems. Therefore, to resolve economic problems and ensure sustainable stability, the emphasis should be on combating inflation, and coordination between monetary and fiscal policies should be ensured.

Keywords: Inflation, Interest Rates, Engle-Granger, Phillips-Ouliaris, DOLS.

Özet: Bu çalışma, 2012M01'den 2024M12'ye kadar aylık veriler kullanarak Türkiye'de enflasyon ve faiz oranları arasındaki ilişkiyi incelemektedir. Lee-Strazizich'in sonuçları, serinin çeşitli yapısal kırılma noktalarına duyarlı olduğunu göstermektedir. Bu sonuç, ekonomik şokların yol açtığı yapısal değişikliklerin Türkiye ekonomisi üzerindeki etkisini göstermektedir. VECM'e dayalı Engle-Granger, Phillips-Ouliaris ve Johansen testlerinin sonuçları, değişkenler arasında uzun vadeli ilişkiler göstermektedir. Ayrıca, FMOLS, DOLS ve CCR'nin eşbütünleşme katsayılarıyla gösterildiği gibi, faiz oranları ve enflasyon arasında anlamlı bir pozitif korelasyon vardır. VECM tabanlı Granger sonuçları, enflasyon ve faiz oranları arasında kısa vadede nedensel ilişki olduğunu göstermektedir. Bu çalışma, uzun vadeli enflasyon ve faiz oranları arasındaki iki yönlü ilişkiyi göstererek literatüre katkıda bulunmaktadır. Diferansiyellerin bozulmasına bağlı olarak, faiz oranlarının enflasyon üzerinde çok az etkisi vardır. Araştırma bulguları, ekonominin sorununun enflasyondan kaynaklandığını göstermektedir. Dolayısıyla ekonomik sorunların çözümü ve sürdürülebilir istikrarın sağlanması için enflasyonla mücadelede ağırlık verilmeli, para ve maliye politikaları arasında eşgüdüm sağlanmalıdır.

Anahtar Kelimeler: Enflasyon, Faiz Oranı, Engle-Granger, Phillips-Ouliaris, DOLS.

1. Introduction

In economics, inflation is defined as a sustained increase in the general price level of goods and services over a while (Judith and Chijindu, 2016). An increase in inflation is a major problem in most countries. Another way to define inflation is the devaluation of the currency and an increase in the price index. From an economic and business perspective, foreign exchange investment, exchange rates, and the level of domestic production, interest rates, budget deficits, energy crises, regulatory laws, and frameworks, etc., are factors affect economic stability (Farooq et al., 2014). Inflation is one of the most important problems that developing countries and Türkiye are trying to solve. Türkiye is a country that has been facing

high inflation for more than 40 years. This situation leads to a deterioration of income distribution, a negative impact on economic indicators, and a decline in the level of prosperity. Structural demand affects resource allocation through growing trade deficits and pricing mechanisms that reflect the relative and absolute rarity of goods. While inflation makes speculative trading and leasing sectors more attractive, it also increases the severity of various problems in real investment and output growth (Uysal, 2007: 22).

The Turkish economy clearly demonstrates that the economic consequences of policy changes must be carefully monitored, and policies that are resilient to supply and

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demand shocks must be developed. For example, the low interest rate policy implemented by the Central Bank of the Republic of Türkiye (CBRT) in the 2021-2023 period aimed to increase economic growth but it increased inflation above 85%. It was predicted that inflation would decrease to 36% in 2025 with the increase in interest rates to 50% starting in 2023, but this policy led to a slowdown in the construction sector and consumer spending (CBRT, 2025). The CBRT's tight monetary policy was implemented by meticulously monitoring inflation expectations and economic activity indicators, which indicated that the economic effects of policy changes should be closely monitored (Yeldan and Özsan, 2024). This process emphasizes the importance of data-driven monitoring, especially in a period when external factors such as exchange rate volatility and global trade uncertainties are intense.

Policies that are resilient to supply and demand shocks are evident in Türkiye's energy and fiscal policies with concrete examples. Against fluctuations in global energy prices, Türkiye has increased its renewable energy investments and reduced its energy dependency by making agreements with new gas suppliers such as Azerbaijan and Russia. This strategy has reduced energy inflation from 120% in 2022 to 50% in 2024 and provided resistance to supply shocks (Bloomberg HT, April 10, 2025). Similarly, targeted subsidies for low-income households in 2024 prevented high inflation from suppressing consumer demand, creating a buffer against demand shocks (Ministry of Treasury and Finance, 2024). Academic studies confirm that such policies reduce Türkiye's structural vulnerabilities and support economic stability (Akçay, 2023).

Finally, uncertainties in the global trade environment, especially the tariffs implemented by the US in 2025, create new shock risks for import-dependent economies like Türkiye. In this context, strategies such as export diversification and fiscal policies supporting domestic demand are critical for building resilience against shocks. For example, the 2024-2026 Medium Term Program of the Ministry of Treasury and Finance aims to develop flexible fiscal policies by monitoring global trade risks (Ministry of Treasury and Finance, 2024). Academic literature emphasizes that such proactive approaches increase economic resilience, especially against external factors such as energy prices and exchange rate shocks (Gürkaynak and Sayek, 2024). These examples clearly show that economic policies should be both monitored and designed to be resilient to shocks.

One of the most important effects of inflation is uncertainty. The Friedman-Ball hypothesis states that high inflation increases inflation uncertainty. Research by Friedman (1977) and Ball (1992) shows that there is a positive relationship between inflation and the uncertainty resulting from it. Monetary authorities have difficulties dealing with price increases because of the impact of uncertainties resulting from rising inflation. Future inflation increases uncertainties because of the unpredictability of currency growth.

According to Keynesians, an increase in the money supply does not always lead to an increase in the general price level. At full employment, the money supply directly affects the general price level. When the economy is between underemployment and full employment, price increases are smaller than money supply increases (Oruç, 2016: 298). Gibson found a positive long-run relationship between UK bond yields and general price levels. Keynes called this the "Gibson paradox", which contradicts classical theory. With the emergence of Gibson's paradox, the existence and direction of possible relationships between interest rates and general price levels have also been theoretically debated.

The relationship between inflation and interest rates is explained using the traditional analytical framework of the IS-LM curve. This approach states that monetary tightening effectively reduces economic activity and inflation along the Phillips curve. Since interest rates are one of the determinants of money demand, price stability is achieved in a short term when interest rates rise (Yıldırım and Sarı, 2020: 148). The relationship between short-term and long-term interest rates plays an important role in the implementation and effectiveness of the monetary policy. While central banks usually make decisions about monetary policy by changing the availability and price of credit offered to the banking system or by controlling the short-term interest rates determined by the market, long-term interest rates may change according to the developments in the price (Gerlach, 1996: 261).

Neoclassical economists, on the other hand, argue that money supply growth is determined by economic agents and that money supply expansion affects inflation in the short and long run. Monetarists believe that inflation is a purely monetary phenomenon (King, 2001: 111). The real inflation rate for each period is the result of monetary expansion in the current and previous periods. Monetarists state that printing money is the real cause of inflation, as inflation requires more money per unit of production due to the effects of the government's fiscal policies, cost pressures, and food and fuel shortages (Humphrey, 1975: 13). According to the structuralist approach, if food or export prices react faster than the rest of the economy, the rate of inflation will reflect not only excess money supply but also relative prices that reflect sectoral excesses (Fischer and Mayer, 1980: 41).

Monetary policy critiques by some heterodox economists are also important. According to this view, not taking financial instability into account is an important shortcoming. Second, the concept of the natural interest rate is doubtful because it is based on conflicting views on the functioning of an economic system in which "asset" and "money" are completely independent and money is neutral. On the "real" side, the balance will come from the equity between saving and investing, which determines the "natural" interest rate. On the "financial" side, what is considered an independent supply and demand for money may differ from the "natural" interest

rate and will set market interest rates, creating inflationary or deflationary pressures on the economy. Third, Taylor's rule ignores the fact that interest rates affect the distribution of income and wealth, which is critical to the financial and macroeconomic stability of the system (Amitrano and Vasconcelos, 2019: 292). Additionally, Rehman (2015) states that changes in interest rates can affect inflation in three ways. This perspective provides important information and projections to consider when addressing recent economic instability because it helps understand the impact of interest rates on inflation. Therefore: a) First, if demand-side effects prevail and interest rates rise and inflation falls, the relationship between these two variables is expected to be negative. In this case, a tight monetary policy is required. b) Second, if supply-side (cost-side) effects dominate and the increase in inflation increases with interest rates, the relationship between these two variables must be positive. In this case, contrary to expectations, the implementation of tight monetary policy has the opposite effect. In the third case, assuming that the side effects of supply and demand are similar, the effect of interest rates on inflation is negligible, and only aggregate output falls when interest rates rise. In this case, tight monetary policy does not affect prices; the overall growth rate falls.

Recently, there has been a divide among economists and politicians regarding the direction of the relationship between inflation and interest rates. Politicians believe that inflation is caused by interest rates (Blanchard, O., and Bernanke, B. S., 2024), Powell, J. H., 2025)). Economists see inflation as the cause and interest rates as the effect. The disagreement between economists and policymakers is one of the motivators that reveal the need for new research. This study examines the short- and long-term relationships between variables and examines the direction of causality. This study is based on the assumption that inflation is the cause of interest rates and that there is a long-term and short-term relationship between inflation and interest rates. The study organizes its parts as follows. The second part sorts out the literature and puts forward research hypotheses. Chapter 3 describes the data and methods. The fourth chapter evaluates the empirical results. The study ends with a conclusion.

2. Literature Review And Hypothesis Formation

The relationship between inflation and interest rates is one of the most studied and discussed topics in the literature. The research results vary depending on the period and the country.

Some studies have found that the relationship between inflation and interest rates varies by country. Moreover, reducing inflation depends on reducing nominal interest rates. According to the research results of Tsong and Hachicha (2014), it was found that nominal interest rates in Indonesia, Malaysia, Russia, and South Africa are less responsive to changes in inflation. Based on their findings,

the researchers argued that nominal interest rates should be increased to lower inflation in a hyperinflationary environment.

The validity of Fisher's hypothesis, showing a long-run relationship between inflation and interest rates, was supported by later evidence. Yenice and Yenisu (2019) show the pass-through effect of exchange rates on interest rates and inflation in their study of Türkiye for the period 2003-2018. The results support Fisher's hypothesis and indicate a long-term relationship between the variables. According to Şen et al. (2019), evidence is found for the Fisher hypothesis in the Fragile Five (India, Brazil, South Africa, Indonesia, and Türkiye) during their study period from January 2013 to December 2018. Their result suggests that there is a positive relationship between inflation and nominal interest rates, particularly when it comes to long-term inflation. While there is a cointegration relationship between interest rates and exchange rates in Brazil, India, and Türkiye, no significant results are found in Indonesia and South Africa.

Results from some studies have not revealed any long-term relationship between inflation and interest rates. Gök (2018) found no cointegration relationship in Türkiye's 2009: M01-2017: M10 period research. On the other hand, the results of Tsong and Hachicha's (2014) study covering Indonesia, Malaysia, Russia, and South Africa did not provide evidence of a long-run relationship between demand credit and interbank overnight interest rates.

According to some studies, there is a causal relationship between the inflation variable and interest rates. According to Asari et al. (2013), Malaysian research shows that the relationship between interest rates and inflation is positive, while exchange rate volatility is negative, which is consistent with the assumption that there is a long-run relationship. Syzdykova (2018) analyzed the Kazakhstan Stock Exchange Index (KASE) using five macroeconomic variables (mining and industrial production index, exchange rate, CPI, and oil price interest rate). The results showed the existence of bidirectional causality between the variable CPI and the exchange rate. The results also showed a causal relationship between CPI and interest rates. Gök (2018), 2009: M01-2017: Examining the period M10, he could not find evidence of a long-run relationship between inflation and interest rates in Türkiye. However, the results of the study showed the existence of a one-way causality relationship between PPI and CPI and interest rates. According to the results of the study, the Fisher hypothesis is invalid in Türkiye. The relationship between the series is also short-term.

Altunöz (2018), in his study on the Chinese economy using monthly data between 1996:01 and 2015:03, could not find evidence for the validity of the Fisher hypothesis. According to Altunöz (2018), the monetary policy implemented in China is not very effective against the long-term real interest rates. Economic units allocate re-

sources for investment according to inflation expectations. Moreover, it is not possible to adjust interest rates to prevent inflationary pressures on the Chinese economy. Samırkaş (2019) found a causal relationship between inflation and interest rates in a study conducted in Türkiye for the period 2003 to 2019. İşcan and Kaygısız (2019) studied the relationship between exchange rates, inflation, and interest rates in Türkiye during the period 2009: 01 and 2017: 12. The results showed that the exchange rate is the cause of both inflation and interest rates. The results provided evidence that inflation was the cause of interest rates.

Some results of the studies on the relationship between inflation and interest rates show that the change in interest rates affects inflation. Ogbonna (2014) found that the results of Nigerian research for the period 1970Q1 and 2012Q4 show a causal relationship between inflation and interest rates from interest rates to prices in the long run. The researcher estimates that inflation in Nigeria is supply-driven.

To examine the relationship between inflation and interest rates, Rehman (2015) used seven interest rates, namely the central bank policy rate, government bond rate, government bond rate, discount rate, lending rate, market rate, and deposit rate. In his interest-rate-based research, he concluded that the relationship between the price level and nominal interest rates is positive and statistically significant in many countries. The results obtained by Yıldız and Başar (2018) in Türkiye between 1984 and 2017 demonstrate a unidirectional causal relationship between interest rates and inflation. Similarly, Kılıcı (2019)'s study of Türkiye for the period 2005-2017 found a one-way causal relationship between central bank overnight rates and inflation. Berument and Froyen (2021) examined interest rates and inflation in the Fisher equation using data from England from 1844 to 2018. According to the analysis, interest rates were ineffective against inflation from 1944, when the gold standard was introduced, until 1913. During the World Wars, the effect of interest rates on inflation was weak. The results of

the analysis show that the effect of interest rates on inflation disappeared between 1952-1992, the Bretton Woods period, and 1992-2008, but after the 2008 global crisis, interest rates increased inflation. Dogan et al. (2016) Türkiye study, parametric and non-parametric Granger causality analysis results from the January 2002-February 2018 period data show the existence of a causal relationship between inflation and interest rates.

An important result of inflation and interest rate research is that it reveals the bilateral relationship between the variables. Çiğdem (2019) examined the relationship between CBRT's weighted average cost of capital (WACF) and CPI in the period 2012:01-2019:06. The researcher found evidence showing a bilateral causal relationship between inflation and short-term interest rates. In other words, the results showed that the variable of inflation was the cause of interest rates, and the variable of interest rates was the cause of inflation. Yıldırım and Sarı (2020), Türkiye, 2004:01-2020:04 period research revealed a non-linear, latent cointegration relationship between inflation and interest rates in the long run, but did not reveal any evidence showing a linear relationship. According to Akgül and Özdemir (2018), in Türkiye's research, a non-linear causality relationship has been determined from the interest rate variable to inflation and from inflation to interest rate. In addition, the research also reveals a one-way non-linear causality relationship between the exchange rate and inflation. Škare and Škare (2015) investigated the relationship between interest and inflation in the Netherlands using data for the period 1800-2012. According to the results, long-term interest rates and the price level are cointegrated non-linearly. In addition, there is a linear and non-linear bidirectional causality relationship between the variables. According to the researchers, the relationship between interest rates and prices is related to all variables in the economy. For this reason, it is not possible to explain the Gibson Paradox with a single factor.

Table 1 provides a summary of research and findings in the literature.

Table 1. Research on the relationship between inflation and interest rates and their results

Author(s)	Method	Period	Country	Results
Asari et al. (2013)	VECM-Granger	1999-2009	Malaysia	Inflation affects interest rate volatility negatively. Inflation affects the interest rate.
Tsong and Hachicha (2014)	Engle-Granger	January 1995-June 2011	Indonesia, Malaysia, Russia, and South Africa	Nominal interest rates have little effect on inflation. In the context of hyperinflation, nominal interest rates would have to be raised to reduce inflation.
Ogbonna (2014)	VECM-Granger	1970Q1-2012Q4	Nigeria	In the long run, there is a causal relationship between interest rates and prices. In the short run, no effects are found.
Rehman (2015)	Pearson Bivariate Correlation, Cross-Series Pearson Correlation	1966-1980, 1965-1984	Pakistan	Inflation and the nominal interest rate are positively related. The efficiency of monetary policy, as measured by the relationship between interest rates and inflation, is negative.
Nchor and Darkwah (2015)	ARDL	1991- 2013	Ghana	Interest rates and exchange rates impact inflation over the short and long term.
Škare and Škare (2015)	Gregory-Hansen	1800-2012	Netherlands	There are interest rates and fluctuating and nonlinear bidirectionalities.
Altunöz (2018)	ARDL Bound Test	1996:01- 2015:03	China	The Fisher hypothesis is valid.

Gök (2018)	Symmetric and asymmetric causality	2009:M01-2017:M10	Türkiye	There is a unidirectional causal relationship between PPIs and CPI, and interest rates. There is a short-term relation between these series.
Syzdykova (2018)	OLS and Johansen cointegration test	2000-2016	Kazakhstan	TÜFE'den döviz kuruna doğru çift yönlü ve faize ise tek yönlü nedensellik ilişkisi vardır.
Sağlam (2018)	Fourier Approach, Gradual Break Unit Root Test	1995-2016	11 Countries	In other countries, except for Indonesia and the Philippines, the Fisher hypothesis is valid.
Demirgil and Türkay (2018)	ARDL Bound Test, Toda Yamamoto Causality Test	2003:01- 2017:01	Türkiye	The 1 percent increase in the inflation rate raises interest rates by 0.48 percent.
Şen et al. (2019)	ARDL	2013-2018	Brazil, India, Indonesia, S. Africa, Türkiye	There is a positive relationship between inflation and interest rates.
Samırkaş (2019)	VAR/ Toda-Yamamoto	2003-2019/ monthly data	Türkiye	We have a cause-and-effect relationship between inflation and interest.
Yenice and Yeni-su (2019)	ARDL and causality test	2003-2018	Türkiye	There is a long-term relationship between inflation and interest; Fisher's premise is valid.
Kılıcı (2019),	Fourier Granger causality test	2005-2017	Türkiye	There is a one-way correlation between the overnight rate and inflation.
Berument and Froyen (2021)	ARDL Bound Test	1844-2018	United Kingdom	Between 1992 and 2008, the interest rate had no effect on inflation. After 2008, however, the interest rate rises with inflation.
Doğan et al. (2020)	Non-Linear Granger Test	2002:01- 2018:02	Türkiye	Inflation has a one-way relationship with interest rates. The Fisher assumption applies to Türkiye.
Yıldırım and Sarı (2020)	NARDL	2004:01-2020:04	Türkiye	There is hidden cointegration between the variables.
İşçan and Kaygısız (2019)	VAR Analysis	2009-2017	Türkiye	Interest is not the cause of inflation; inflation is the cause of interest.
Akgül and Özdemir (2018)	Diks-Panchenko nonlinear causality test	2003-2016	Türkiye	There is a nonlinear causal relationship between interest rates and inflation and between inflation and interest rates.
Yıldız and Başar (2018)	OLS and Toda-Yamamoto(TY) Causality	1984- 2017	Türkiye	There is a causal relationship from interest rate to inflation.
Yenice and Yeni-su (2019)	ARDL	2003-2018	Türkiye	The exchange rate has a pass-through effect on interest rates and inflation. There is a long-term relationship between inflation and interest.
Çiğdem (2019)	Engle-Granger, VECM-Granger Causality	2011: 01-2019: 06	Türkiye	In the short run, there is a bilateral causal relationship between inflation and interest rates.

3. Data and Method

3.1. Data

This study examines the relationship between inflation and interest rates in Türkiye using monthly data for the period 2012M01-2024M12 obtained from the website CBRT-EVDS. The equation established to determine the relationship between inflation and interest rates can also

be presented as follows:

$$\text{LNTUFE} = \alpha_0 + \alpha_1 \text{FAIZ} + \varepsilon_t$$

(1)
Both variables are seasonally adjusted, and the natural logarithm of the variable CPI data is used. Descriptive information on the data included in the study is summarized in Table 2.

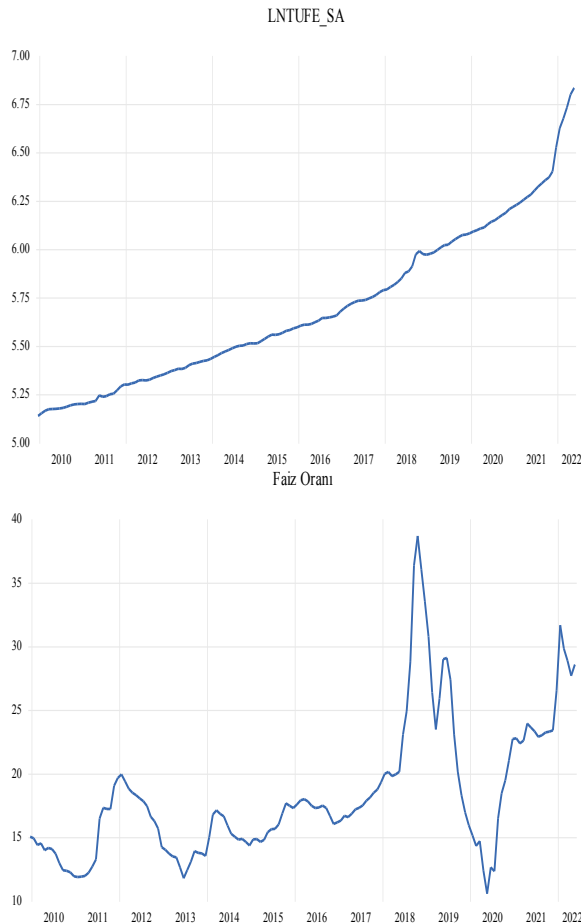
Table 2. Data and identifiers

Variable	Symbol	Identifying Information	Source
Inflation	LNTUFE	Consumer Price Index-Level	TCMB-EVDS
Interest rate	FAIZ	Weighted Average Interest Rates Applied to Banks' Loans in TL (Flow Data, %) Commercial Loans (opened in TL) (Excluding Legal Entity Overdraft and Corporate Credit Cards)	TCMB-EVDS

Analyzing the seasonally adjusted and log inflation (TUFE) data in Figure 1, we see that there is an increasing trend over the years. However, from October 2021 onward, a sudden increase in inflation is observed, which can be attributed to global and local economic and political developments.

The interest rate variable, on the other hand, follows a

fluctuating trend over the years. It is worth noting that the interest rate was highest in May 2018 at 38.7 and lowest in May 2020 at 10.6. It can be observed that interest rates increase again in the following period, reaching 28.6 in May 2022.



3.2. Method

In this study, ADF and PP unit root tests were used to test the stationarity and level values of the series. After controlling for unit roots, Lee and Strazicich's (2003) double structural break LM unit root test was used to examine the effects of a structural break in the series. With this test, Lee and Strazicich consider two breaks, assuming that the break is uncertain and unknown. Model A, which shows the structural break, allows for a double break at constant, and Model C for a break at fixed and trend (Damar et al., 2021: 669). The data generation process in this test is as follows:

$$Y_t = \delta' z_t + e_t$$

(1)

In the equation, z_t is an exogenous variable vector and $e_t = \beta_1 e_{t-1} + \varepsilon_t$, $\varepsilon_t \sim \text{NIID}(0, \sigma^2)$.

Considering the two breakpoints, z_t is defined as:

$$z_t = [1, t, D_{1t}, D_{2t}]'$$

(2)

In equality, $t \geq T\beta_j + 1$, $j=1, 2$ and $D_{jt} = 1$.

Otherwise, the value will be zero. $T\beta_j$ indicates the breakage that has occurred. The two-break LM unit root test statistic is obtained from the regression estimates based on the LM, and the LM is as follows:

$$\Delta Y_t = \delta' \Delta z_t + \phi \tilde{\varepsilon}_{t-1} + u_t$$

(3)

is the coefficient obtained from the regression and is defined as $y_1 - z_1 \tilde{\delta}$.

It is expressed as Δz_t and $\tilde{\varepsilon}_t$ on ΔY_t . In the equation, y_1 and z_1 represent the first observation of y_t and z_t , respectively. The null hypothesis is also tested by applying $\phi=0$ and related t-statistics. The structural breakpoint, which considers all possible breaks, is chosen when the t-statistic has a minimum value (Iranmanesh and Jalaei, 2021).

The long-term relationships of variables were examined using VECM-based Engle-Granger, Phillips-Ouliaris, and Johansen cointegration tests (trace and maximum eigenvalue). In a two-stage estimation process, Engle-Granger tests the null hypothesis that there is no cointegration between variables and addresses this concern by using OLS and applying the known unit root to estimate the economic variables. In this way, the coefficients are estimated by performing the stationarity test on the residuals. The unit root's rejection of the null hypothesis proves the existence of cointegration. Phillips-Ouliaris uses residual-based variance tests and multivariate tracking statistics. These residual-based tests are used in the similar way as unit root tests, but the data are residuals from cointegration regression (Ssekuma, 2011). Johansen's test is used in the multivariate framework. To determine the cointegration relationship between the dependent and independent variables, we first need to determine whether the variable is $I(0)$ or $I(1)$. If all variables are $I(1)$ variables, Johansen's test can be used to determine the number of cointegration relationships between dependent and independent variables.

The basic equations that capture Johansen's cointegration are shown below (Johansen, 1991, 1995):

$$Z_t = AZ_{t-1} + \dots + A_n Z_{t-n} + \beta x_t + \varepsilon_t$$

(4)

where Z_t is the vector of independent and dependent variables of $I(1)$, the vector of non-random variables, and the error correction term (Naidu et al., 2017: 143).

In this study, long-term coefficients were investigated by FMOLS, DOLS, and CCR methods. The fully modified least squares method (FMOLS) used in the analysis is a non-parametric analysis proposed by Phillips-Hansen (1990). The dynamic least squares (DOLS) method proposed by Saikkonen (1991) and Stock-Watson (1993) is a parametric test and takes into account internality (Cergibozan, 2017: 85). The CCR method developed by Park (1992), on the other hand, is based on canonical regression and the highest correlation between the series. In addition, this method takes into account the coefficients and the cointegration vector between the series. The canonical regression analysis method is also an estimation method resistant to varying variance and autocorrelation (Uslu, 2022: 208). In this way, it is aimed to take into account the details and to make the study stronger with the analysis to be made with all three tests. In addition, it is aimed to determine an effect that cannot be detected by

such a method by using other methods.

Because cointegration relationships between series were found in this study, short- and long-term Granger causality analyses were performed as a function of VECM to determine the direction of relationships between series. Granger causality is based on the standard conditioning concepts of probability theory, but approaches based on the concepts of causal explanation and intervention have also been developed. Intervention in this sense is closer to experimental science and shows, for example, that we can freeze a system and measure the effectiveness of that action on another process. It is well known that causal relationships between random variables can only be inferred unambiguously in limited situations, such as in directed acyclic models. In the context of Granger causality, there are no such uncertainties or limitations (Amblard and Michel, 2013: 116).

The Granger causality test was originally proposed by Granger (1969) and is commonly used to test causality between two time series variables. It is a statistical acceptance test used to determine whether one variable influences another. Technically, both x and y are time series variables. If " x causes y " is pointed out by a set of statistics showing that current y can be pointed out by past values of x , adding lagged values of x to the model improves the explanation. As for the relationship between inflation and interest rates, inflation is affected not only by historical inflation but also by interest rates, and vice versa (Jiang and Bai, 2017). The analysis of Granger's causality test is as follows:

$$LNTUFE_t = \sum_{i=1}^n \alpha_i LNFAIZ_{t-i} + \sum_{j=1}^n \beta_j LNTUFE_{t-j} + \mu_{1t} \quad (5)$$

$$LNFAIZ_t = \sum_{i=1}^m \lambda_i LNTUFE_{t-i} + \sum_{j=1}^n \delta_j LNTUFE_{t-j} + \mu_{2t} \quad (6)$$

The Granger causality test was first proposed by Granger and is commonly used to test causality between two time series variables. The statistical hypothesis used to determine whether one variable affects another is the null hypothesis of the first regression " x does not cause Granger y ." Similarly, the null hypothesis in the second equation tests the hypothesis that y is not the cause of Granger x :

$$H_0: \beta_1 = \beta_2 = \dots = \beta_p = 0. \quad (7)$$

The null hypothesis in the first regression is " x does not cause Granger y ." Similarly, the null hypothesis in the second equation tests the hypothesis " y does not cause Granger x ". Technically, the null hypothesis is as follows:

$$H_0: \beta_1 = \beta_2 = \dots = \beta_p = 0. \quad (8)$$

The alternative hypothesis, on the other hand, is that at least one estimation parameter is nonzero and can be

represented as follows:

$$H_1: \text{At least one } \beta_j \neq 0. \quad (9)$$

So, the effects of shocks originating from the individual variables of the model itself and from other variables were analyzed using the variance decomposition method.

4. Results

In the study, first of all, the correlation coefficient between the series was examined, and the series were seasonally adjusted. Moreover, the natural logarithmic transformation was applied to the series. Examination of the correlation coefficients between the series reveals a strong positive relationship between variable inflation rates and interest rates (Table 3). However, the presence of a correlation does not imply that a causal relationship exists. The results may contain spurious regressions and lead to misleading estimates. To determine a healthy relationship between the series, unit roots should first be examined, long- and short-term relationships should be determined, and a causality analysis should be performed.

Table 3. Correlation coefficient

Correlation	LNTUFE_SA	LNFAIZ_SA
LNTUFE_SA	1.000000	
LNFAIZ_SA	0.672666	1.000000

For econometric analyses to be valid and reliable, it is essential that the variables be stationary. Therefore, the unit root of each variable was tested using Augmented Dickey-Fuller (ADF) and Phillips-Perron tests, which are generally preferred in the literature. Since the null hypothesis for the variables cannot be rejected, the differences between the variables are assumed to reach stationarity at the first difference.

As can be seen in Table 4, the ADF and PP t-statistics show that the null hypothesis can be rejected at the 1% and 5% levels for each variable. This result shows that the stationarity hypothesis is accepted at the first difference and the variables are integrated in the first order.

Table 4. Determination of stationarity of series

Variables		ADF		PP	
		S	S-T	S	S-T
Level	FAIZ	-1.9720	-2.9886	-1.7188	-2.6808
	TUFE	2.5837	2.1757	4.1292	4.5323
First Difference	FAIZ	-7.7799***	-7.7751***	-7.7872**	-7.7807***
	TUFE	-2.8945**	-3.7145**	-5.1908***	-5.9896***

The results of the LM unit root test, computed in accordance with the critical values in the article by Lee and Strazicich (2003, 2004), show that inflation and interest rates contain structural breaks. When evaluated in this framework, the variable CPI faced the effects of a structural break in the periods 2012M05, 2012M06, 2016M10, and 2020M12. This result shows that the disinflation in the analyzed period started in June 2012. On the other hand, the FAIZ variable was also subject to a structural break in the periods 2020M06, 2020M08, 2018M04, and 2019M11 (Table 5). The break in the rate emerged in line with the economic and social developments that emerged in 2019. Structural break test results show that the effects of various problems occurring in the economy

in addition to internal and external security in Türkiye negatively affect the economy. In particular, it points to the structural breaks that occurred due to the shocks in 2020. In this context, it is observed that a serious shock has occurred in the global economic environment since the first half of 2020. As a result of the epidemic exceeding the borders of China, economic activity in the European economies, especially in Italy, England, France, and Spain, and subsequently in the USA, came to a standstill. Among the decisions taken within this framework, especially the measures such as quarantine and economic shutdown, have had intensely restrictive results on economic activity (SBB, 2020: 18).

Table 5. Lee Strazicich LM Unit Root test results

	Model	Lag	t-stat	Critical Values			Breakpoints
				%1	%5	%10	
TUFE	A	3	-1.953961	-4.093	-3.585	-3.331	2012M05-2012M06
	C	6	-7.720537	-6.159	-5.610	-5.306	2016M10-2020M12
FAIZ	A	8	-4.697504	-4.093	-3.585	-3.331	2020M06-2020M08
	C	8	-7.640729	-6.308	-5.607	-5.246	2018M04-2019M11

The stationarity of the first-order series I (1) means that the necessary conditions for the analysis are satisfied. Therefore, to determine the relationship between the series, the optimal delay criterion of VAR was first determined by testing it over 8 periods. When examining the test results for the delay criteria of VAR, SC (Schwarz

information criterion) recommends two delays, while the test result of HQ (Hannan-Quinn) suggests using one lag (Table 6). On the other hand, the results of LR, the FPE, and the AIC tests all recommend using three lags. Three lags suggested by LR, FPE, and Akaike (AIC) were used in the study.

Table 6. Selecting Var Lag criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	572.7685	NA	1.04e-06	-8.096007	-8.054181	-8.079010
1	628.1209	108.3494	5.04e-07	-8.824410	-8.698931*	-8.773419*
2	630.6504	4.879624	5.15e-07	-8.803552	-8.594420	-8.718568
3	639.6451	17.09629*	4.80e-07*	-8.874398*	-8.581614	-8.755421
4	643.2478	6.745564	4.83e-07	-8.868764	-8.492326	-8.715792
5	645.5968	4.331502	4.94e-07	-8.845345	-8.385255	-8.658381
6	648.4125	5.112143	5.03e-07	-8.828546	-8.284803	-8.607588
7	650.1574	3.118502	5.19e-07	-8.796559	-8.169163	-8.541607
8	651.5672	2.479628	5.39e-07	-8.759818	-8.048770	-8.470873

After determining the optimal lag criterion, we examined whether the stationarity of the model VAR was stable before performing the Granger causality test. The results presented in Figure 2 show that all roots are less than 1 and are inside the circle. This result shows that the model created is stable. Moreover, the fact that the unit roots are not close to the circle indicates that the shocks are not permanent.

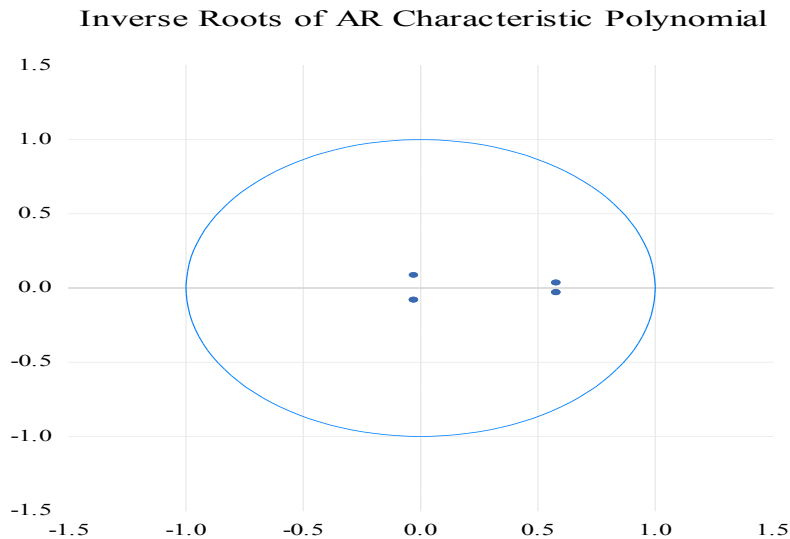


Figure 2. AR characteristic inverse roots of series

Table 7 shows the results of the cointegration test. DOLS and VECM-based cointegration (Engle-Granger, Phillips-Ouliaris, and Johansen) analysis results reject the H_0 hypothesis at the 1% significance level and accept the alternative hypothesis. Accordingly, the results of the co-

integration analyses confirm the long-term relationship between the variables. The results reveal that policymakers need to set long-term strategic plans and goals, depending on the long-term relationship.

Table 7. Co-integration test results

Panel A: DOLS-Based Test Results					Panel B: VECM Based				
Engle-Granger			Phillips-Ouliaris		r=0	Trace		Maks. Eigenvalues	
Test	Prob.		Test	Prob.		Test	Critical Values	Test	Critical Values
Tau-stat	-7.950776	0.0000***	-7.983740	0.0000***		38.77 (0.00)***	15.49	31.24 (0.00)***	14.26
Z Stat	-89.08308	0.0000***	-89.31629	0.0000***	r ≤ 1	6.17 (0.00)***	3.84	7.52 (0.00)***	3.84

Note: (*) 10%; Significant at (**) 5% and (***) 1% levels.

The FMOLS, DOLS, and CCR methods were used to estimate the long-run coefficients of the FAIZ variables concerning the TUF variables, which were found to be positive and significant at the 1% level of significance. Moreover, the effect of a one-unit increase in interest

rates on inflation is 0.054% for the FMOLS approach, 0.051% for the DOLS approach, and 0.055% for the CCR approach. The fact that the coefficients obtained with all three methods are close to each other is an important indication of a positive relationship between the series.

Table 8. Long-Run coefficient estimations

Dependent Variables: D(LNTUFE_SA)			
Variables	FMOLS	DOLS	CCR
D(LNFAIZ_SA)	0.054673 (0.0000)***	0.051833 (0.0000)***	0.054614 (0.0000)***
R ²	0.433016	0.455126	0.433136
Adjusted R ²	0.429159	0.439778	0.429280

Note: (*) 10%; Significant at (**) 5% and (***) 1% levels.

The Granger analysis based on the VECM rejects the hypothesis that the variable LNTUFE is not responsible for the short-term significance level of the variable FAIZ. On the other hand, we cannot reject the hypothesis that the variable LNTUFE does not cause the variable FAIZ. In other words, Granger's results show that inflation causes interest rates in the short run, but they do not show that interest rates cause inflation. His H_0 hypothesis that inflation does not cause interest rates and that interest rates

do not cause inflation, in the long run, is rejected, and the alternative hypothesis is adopted. In other words, Granger provides evidence for a two-way causal relationship between inflation and long-term interest rates.

Table 9. VECM Long- and Short-Run Causality Results

	Short Run		Long Run
	LNTUFE_SA	LNFAIZ_SA	ECM (-1)
LNTUFE_SA	-	4.58276 (0.0118) **	-0.004916 [-2.08488]
LNFAIZ_SA	0.46215 (0.6309)	-	-0.068100 [-5.69860]

Note: (*) 10%; Significant at (**) 5% and (***) 1% levels.

The variables in the model that affect economic or financial factors are analyzed by variance decomposition. How much of the variance is explained by their lag values and how much is explained by the other variables can be explained by the percentages obtained by variance decomposition analysis, and the effective rates can be revealed (Uslu, 2022). The results of variance decomposition show that when inflation is the dependent variable, the shock caused by it ranges from the first to the tenth period. On the other hand, it is observed that the shock caused by interest rates increases gradually. While the effect of inflation itself was 99.12% in the second period,

it gradually decreased to 91.42% in the tenth period. The effect of the interest rate variable was 0.87 in the second period, increased to 2.67% in the third period, and 8.58% in the tenth period.

When the interest rate is the dependent variable, the shock caused by the interest rate in the first period is about 84.6%, and the shock caused by inflation is 15.44%. However, the shock caused by the interest rate itself gradually decreased in the subsequent period, falling to 67.66% in the tenth period. In the tenth period, the effect of the inflation shock increased and reached about 32.34%.

Table 10. Variance Decomposition Results of Series

Variance Decomposition of D(LNTUFE_SA):			
Period	S.E.	D(LNTUFE_SA)	D(FAIZ_SA)
1	0.011262	100.0000	0.000000
2	0.014555	99.12105	0.878951
3	0.015038	97.33214	2.667862
4	0.015626	97.52534	2.474664
5	0.016454	96.60317	3.396826
6	0.017118	93.98146	6.018540
7	0.017836	92.94019	7.059806
8	0.018585	92.25176	7.748238
9	0.019102	91.62932	8.370680
10	0.019640	91.41988	8.580116
Variance Decomposition of D(FAIZ_SA):			
Period	S.E.	D(LNTUFE_SA)	D(FAIZ_SA)
1	1.163805	15.44395	84.55605
2	1.410556	31.06020	68.93980
3	1.431075	31.11162	68.88838
4	1.433059	31.26799	68.73201
5	1.438399	31.29178	68.70822
6	1.453835	31.85809	68.14191
7	1.459793	32.33285	67.66715
8	1.459909	32.33097	67.66903
9	1.460082	32.34307	67.65693
10	1.460244	32.33886	67.66114

5. Conclusions and Discussion

This study examines the relationship between inflation and interest rates using the latest data based on monthly central bank EVDS data for the period 2012M01-2024M12. In this paper, we examine the unit root of the series through the classical unit root test, ADF, and PP tests, and find that the series is stationary in the first

difference. In addition, the effects of a series of structural breaks due to shocks were investigated using the Lee-Strazich test on structural unit roots with double failure. According to the results, the inflation rate (TUFE) was affected by structural shocks in the periods 2012M05, 2012M06, 2016M10, and 2020M12. This result shows that inflation fluctuations started in June 2012 during the analysis period. Moreover, it is observed

that a structural break occurred in 2020M06, 2020M08, 2018M04, and 2019M11 years due to interest rate (FAIZ) shocks. The main reasons for the volatility and shocks observed in both series are the instability in the Turkish economy and supply and demand shocks due to the 2019 COVID-19 outbreak, an externally dependent economic structure, and policy changes in the Turkish economy. There is a need to carefully monitor the economic consequences of policy changes and to create policies that are resistant to shocks arising from supply and demand.

The Turkish economy demonstrates that policies that are resilient to fluctuations caused by supply and demand shocks need to be developed, and the economic consequences of policy changes need to be carefully monitored. For example, the Central Bank of the Republic of Türkiye's (CBRT) transition from low interest rate policies in 2021-2023 to high interest rate policies in 2023-2024 underscores this need. Although the low interest rate policy targeted economic growth, it increased inflation above 85%, while the increase in interest rates to 50% in 2023 was projected to reduce inflation to 36% in 2025. However, this transition slowed down economic growth and negatively affected sectors such as construction and consumption expenditures. The CBRT's Inflation Report 2025-I emphasizes that this policy change is being meticulously monitored through inflation expectations and economic activity indicators (CBRT, 2025). On the other hand, policies that are resilient to supply and demand shocks can be exemplified by energy diversification and financial support. Türkiye has reduced its energy dependency against global energy price volatility through renewable energy investments and new gas supply agreements, such as the Azerbaijan-Russia agreement. This has reduced energy inflation from 120% in 2022 to 50% in 2024 (Bloomberg HT, April 10, 2025). In addition, targeted subsidies for low-income households in 2024 prevented high inflation from collapsing consumer demand and provided protection against demand shocks (Ministry of Treasury and Finance, 2024). Academic literature confirms that such policies create resilience against supply shocks (e.g., energy prices) and demand shocks (e.g., decline in purchasing power) (Akçay, 2023; Yeldan and Özsan, 2024). These examples reveal that economic policies should be monitored carefully, and flexible strategies should be developed against shocks.

According to the results of DOLS and VECM-based cointegration (Engle-Granger, Phillips-Ouliaris, and Johansen) analysis, a long-term relationship was determined between the series. This result is consistent with Fisher's theory and makes sense. Thus, there is a long-term relationship between the series. In this context, strategic plans and goals must be established to ensure macroeconomic and long-term stability. According to the results obtained with FMOLS, DOLS, and CCR methods to estimate the long-term coefficient, the coefficient effect of a one-unit increase in interest rates on inflation was determined as 0.054% with the FMOLS approach, 0.051% with the DOLS approach, and 0.055% with the CCR approach.

ch. The fact that the coefficients obtained with all three methods are close to each other is important to show the positive relationship between the series. In our study, the effects of other factors were not considered when examining the relationship between inflation and interest rates. Given this situation, it is considered that it would not be appropriate to use the interest rate as the sole instrument of economic policy. Moreover, the risks arising from the interest rate, the results of our study should also be taken into account, as well as the instabilities arising from the exchange rate and the cost-related negative effects of an increase in inflation due to imported inputs.

Results from the VECM-based Granger analysis establish a causal relationship between inflation and interest rates in the short term. On the other hand, the results of our study show a short-term causal relationship between inflation and interest rates. This clarifies recent debates about causal currents and shows that the neo-Fisher approach will not work in Türkiye in the short term. Our study contributes to the literature by determining a bidirectional causal relationship between inflation and interest rates over time. To explore the details of causal relationships between variables, variance decomposition results show that making inflation the dependent variable reduces the shock of inflation itself and increases the shock of interest rates. However, when the interest rate is a dependent variable, the shock from the interest rate decreases while the shock from inflation increases. This result is important because a decrease in interest rates means an increase in inflation. The results of the analysis show that the recent increase in inflation is not associated with an increase in interest rates, but with a decrease.

In the literature, the relationship between inflation and interest rates is studied in two ways, in a linear and a non-linear framework. Akgül and Özdemir (2018) show a linear causality relationship between the interest rate variable and inflation and a nonlinear causality relationship between inflation and interest rates. This result, which completes our study, shows that the causality relationship between the variables is not only linear but also nonlinear. From this point of view, the relationship between the variables must be evaluated in two ways. Since our study investigates the relationship between inflation and interest rates, many factors such as exchange rate, population, growth rate, fixed income rate, GDP, imports, government debt, and money supply were not considered. Expanding the studies to include these factors is important to evaluate the relationship between inflation and interest rates and shed light on policymakers.

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BİLGİ

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