Macro dynamics of inflation in the Turkish economy

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Abstract

This study analyzes the macroeconomic determinants of inflation, a significant economic issue in national economies, using monthly data from January 2006 to January 2023 for the Turkish economy. Understanding inflation and its influencing factors is crucial for enhancing the effectiveness of disinflationary measures due to their adverse impacts on economic units. In this context, the relationship between inflation and selected macroeconomic variables was investigated for the Turkish economy. Based on the cointegration test results, it was established that the series are cointegrated. In the long term, money supply and interest rate variables positively impact inflation. Conversely, inflation is negatively impacted by the Industrial Production Index (IPI), which measures economic growth. This result indicates that increases in production capacity and economic growth reduce inflation. These findings suggest that the Turkish economy operates with underemployment and that monetary factors significantly impact inflation. The outcomes of the Granger causality analysis indicate a reciprocal causal relationship between inflation, money supply, and exchange rate.

Keywords: Inflation, Money Supply, Cointegration, Turkish Economy   **JEL Codes:** E31, E51, C22

Türkiye ekonomisinde enflasyonun makro dinamikleri

Öz

Bu çalışma kapsamında son dönemlerde ülke ekonomilerinde en önemli ekonomik sorun olarak göze çarpan enflasyon olgusunun makroekonomik belirleyicileri 2006:1 ile 2023:1 arası dönemde aylık frekanslı veriler yardımıyla Türkiye ekonomisi için incelenmiştir. Ekonomik birimler üzerindeki doğrudan negatif etkilerinden dolayı enflasyonu ve belirleyen faktörlerin doğru bir şekilde anlaşılmasını geliştirilecek politikaların başarısını artıracaktır. Bu kapsamda enflasyon oranı ile seçilmiş makroekonomik değişkenler arasındaki ilişki Türkiye ekonomisi bağlamında araştırılmıştır. Düzeyde durağan olmayan seriler arasında yapılan eş bütünleşme test sonucuna göre seriler eşbütünleşik çıkmıştır. Uzun dönemde para arzı ve faiz oranı değişkenlerinin enflasyon üzerinde pozitif etkiler oluşturduğu, ekonomik büyümeyi temsilen modele dâhil edilen Sanayi Üretim Endeksinin ise enflasyon üzerinde negatif etkisinin olduğu sonucuna varılmıştır. Bu sonuç, üretim kapasitesinde dolayısıyla ekonomik büyümede meydana gelen artışların enflasyonu azalttığına işaret etmektedir. Bu bağlamda Türkiye ekonomisinin eksik istihdamla çalıştığını ve parasal faktörlerin enflasyon üzerinde daha fazla etkiler taşıdığını göstermektedir. Granger nedensellik analizi sonuçlarına göre ise enflasyon, para arzı ve döviz kuru değişkenleri arasında çift yönlü Granger nedensellik ilişkisinin olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Enflasyon, Para Arzı, Eşbütünleşme, Türkiye Ekonomisi   **JEL Kodları:** E31, E51, C22

Introduction

The recent pandemic, conflicts, and increases in producer input prices, especially in energy, have led to significant increases in inflation rates across all countries, including advanced economies. According to World Bank data, the inflation rates in 2020 were 1%, 1.23%, and 12.27% in the UK, the US, and Türkiye, respectively. By 2022, these rates had risen to 7.92%, 8.0%, and 72.30% for the same countries. Inflation, defined as continual increases in the general price level, negatively impacts real earnings, unemployment, consumption, savings, investment, and household purchasing power (Duodu et al., 2022). Rising price levels cause economic uncertainty, weaken investors' confidence in the market, and negatively affect financial and public sector balance sheets (Durguti et al., 2021, p. 2). Since inflation reduces the purchasing power of money, it redistributes income and wealth from fixed-income earners to higher-income groups, leading to inequality in wealth and income distribution (Kolcu, 2023, p. 32).

As stated by Abel et al. (2021), inflation, often referred to as one of the "twin evils" along with unemployment in the economy, is considered the most sensitive and important issue faced by policymakers due to its direct effects on economic units. Given these facts, it appears that the inflation rate has recently become a major problem, even in developed countries where it has been

hovering at very low levels. Reducing the rising general level of prices has become a priority policy in all economies. Price stability, where inflation is not palpable, is the most fundamental macroeconomic objective. With a stable general price level, confidence among economic agents will be strengthened, and economic growth and welfare will accelerate through investment, production, savings, and consumption in an economic environment with minimal uncertainty (Deluna et al., 2021, p. 1).

This study analyzes the macroeconomic dynamics of inflation in Türkiye, where inflation has been persistently high for a long time, using monthly data from 2006 to 2023, the year of transition to explicit inflation targeting. In the literature, the determinants of inflation are generally analyzed with macroeconomic variables such as money supply (MS), exchange rate (ER), and interest rate (IR), among others. To the best of our knowledge, this is the first study analyzing the effect of the Industrial Production Index (IPI) on inflation, which is added to the model to represent the economy's production capacity and GDP. The anticipated contributions of the study are outlined as follows. After discussing inflation within a theoretical framework, the trend of inflation in the Turkish economy will be analyzed. In the applied part of the study, the macroeconomic determinants of inflation will be tested using the Fourier KPSS unit root test (URT) and the Fourier-SHIN cointegration approach, both of which are recent econometric methods. Furthermore, the study will investigate the coefficients for both the long and short term, along with the results of causality analysis. For robustness, long-run coefficients will also be analyzed using the FMOLS method. Following the introduction, the study will proceed with a theoretical framework section, examining the approaches that determine the causes of inflation, and a section discussing the course of inflation in the Turkish economy. The literature review will cover the results of selected studies on inflation. In the Data Set, Methodology, and Results section, the dataset, econometric methods, and analysis results will be discussed. The study will conclude with a section on conclusion and policy recommendations.

1. The Theoretical Concept of Inflation

Due to its direct negative effects on the economy, numerous approaches have been developed to explain inflation and its determinants. The success of policymakers' efforts to reduce inflation and achieve a stable price level can only be realized with a proper understanding of its causes. In this context, various economic schools have developed theories to explain inflation. One of the primary theories is the Quantity Theory of Money (QTM), a proposition of the Classical school. This theory separates the real and monetary aspects of the economy by utilizing Irving Fisher's exchange equation:

$$M \times V = P \times Y$$

In this equation, M represents the MS, V denotes the velocity of money circulation, P signifies the general price level, and Y stands for output. According to the Classical view, since the economy operates at full employment, the level of output Y is constant. Additionally, because money is demanded solely for transaction purposes, the velocity of circulation (V) is also considered constant.

Assuming flexible wages and prices, the QTM asserts that the price level and the MS are proportional. According to this theory, a rise in the MS is expected to result in a proportional increase in the inflation rate (Mankiw, 2022; Tolasa et al., 2022). In the QTM, sustained inflation is regarded as a consequence of monetary expansion (Kandil & Morsy, 2011, p. 146).

The Neo-Classical school, an extension of the Classical approach, posits that the economic structure consists of two sectors: real and monetary (nominal). The Classical dichotomy, which states that nominal factors have no effect on real variables, is considered valid in this framework. The Neo-Classical perspective, acknowledging full employment in the economy, asserts that nominal prices are contingent on the MS, whereas real wages are determined in the real sector (labor market). Consequently, according to this view, increases in the MS will solely elevate the overall price level without influencing the output (Kibritçioğlu, 2002, pp. 47-48).

Monetarists, led by Milton Friedman, defined inflation as a "monetary" phenomenon everywhere and always. They asserted that monetary policy holds greater efficacy than fiscal policy in economic strategies, particularly those aimed at achieving price stability. They further posited that inflation ensues when increments in the MS surpass those in the supply of goods and services within the real sector of the economy (Demirgil, 2019, p. 14; Tolasa et al., 2022).

The New Classical Economists assert that individuals in the economy have rational expectations, do not make systematic mistakes, have full information, and can quickly adapt to market changes. New Classical economists contend that only unforeseen policy adjustments influence real variables in the short term. They emphasize that an anticipated monetary expansion would not affect output levels but would solely contribute to inflation by elevating overall price levels (Ağayev, 2012, p. 61). In conclusion, theories based on money contend that the primary factor behind inflation is the rise in the MS exceeding the increase in real money demand (Elbahnasawy & Ellis, 2022, p. 59).

Rejecting the classical school's premises of full employment, flexible wages, and prices, John M. Keynes emphasized the demand side of the economy by asserting that the economy would not consistently operate at full employment. Keynes argued that an

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increase in the money supply (MS) in an economy experiencing underemployment would lead to growth in output, income, and employment. Rising aggregate demand (AD) would then lead to inflation once the economy reaches full employment (Tolasa et al., 2022; Kolcu, 2023, p. 34). Keynes stated that when there is an increase in AD at full employment, firms increase their profits under fixed nominal wages. To meet the increased demand, firms will hire more labor, which will push up nominal wages due to competition among firms in the labor market. This process continues until real wages are reduced to their initial level, resulting in higher prices and an inflation spiral (Kibritçioğlu, 2002, p. 48; Duodu et al., 2022).

In both Classical and Keynesian schools, a rise in AD exceeding the increase in aggregate supply (AS), results in an elevation of the overall price level. According to both economic theories, an increase in public expenditures and a deficit resulting from lower taxes reduce planned savings and shift the IS curve up and to the right, leading to an increase in AD. This increase in AD leads to inflation (Abel et al., 2021).

In contrast to monetary approaches, the Structuralist approach attributes the causes of inflation to a country's structural characteristics (economic and social structure) (Çatalbaş, 2007, p. 199). In the Structuralist approach, the main factors determining inflation are the policies, consumption-saving tendencies, the social and demographic structure, and expectations of economic agents.

The traditional viewpoint in inflation research classifies the origins of inflation into two main categories: demand-pull inflation and cost-push inflation. In demand-pull inflation, economic agents tend to increase their expenditures as the economy enters an expansionary phase, production capacity increases, unemployment rates decrease, and the associated uncertainty in the economy diminishes. The failure of AS to adapt to the rise in AD results in a demand surplus, causing an increase in the overall price level. In this framework, the excess demand over the production capacity of the economy puts pressure on resources, leading to demand-driven inflation (TRCB, 2014, p. 3). Policymakers can stimulate AD through monetary and fiscal policies, such as increasing the MS, lowering IR, increasing public expenditures, and lowering tax rates. These actions could cause 'demand-pull' inflation by exerting demand pressure once the economy reaches its full capacity (Kibritçioğlu, 2002, pp. 45-46; Kolcu, 2023, p. 32).

In cost-push inflation, changes in cost (supply) conditions lead to inflation. Increases in the costs of production factors, such as labor and capital, cause cost-push inflation by increasing the general price level (Çelik, 2021, p. 136). Changes in factors affecting the supply and the cost of goods and services, such as wage increases, energy price hikes, and droughts, will also raise the general price level and lead to 'cost-push' inflation (TRCB, 2014, p. 4).

In today's economic environment, where international flows of goods and services are accelerating, ER significantly impacts inflation. An increase in the ER raises the cost of imports by elevating the relative price of imported goods. Fluctuations in the ER can alter the overall domestic price level, particularly in nations with a substantial reliance on imported production and high energy dependence, as is the case with the Turkish economy (Demirgil, 2019, p. 19). The impact of the ER on the general domestic price level is known as the pass-through effect.

1.1. Inflation In Turkish Economy

The Turkish economy exhibits significant fluctuations in inflation rates, similar to growth rates, from period to period and even from year to year (Şenses, 2021, p. 215). During the 1920s and 1930s, inflation in the Turkish economy remained relatively stable. However, following World War II, supply shocks and monetary expansion led to rapid inflation, with consumer prices increasing by more than 50% annually (Pamuk, 2022, p. 200). Figure 1 illustrates the trend of inflation in the Turkish economy from 1960 to 2022.

The period between 1960 and 1970 saw relative price stability (Şenses, 2021, p. 215). However, the 1970s were marked by macroeconomic imbalances and high inflation caused by the oil crisis. Prices began to rise sharply, accelerating in the latter half of the decade, reaching 101.4% in 1980. In response to these challenges, 1980 became a year of significant economic policy changes. Barriers to imports were removed, and an export-incentivized growth model was adopted. Additionally, the Turkish lira was devalued, leading to the abandonment of the fixed exchange rate regime in favor of a floating parity system.

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Figure 1. Inflation in the Turkish Economy (1960-2022)
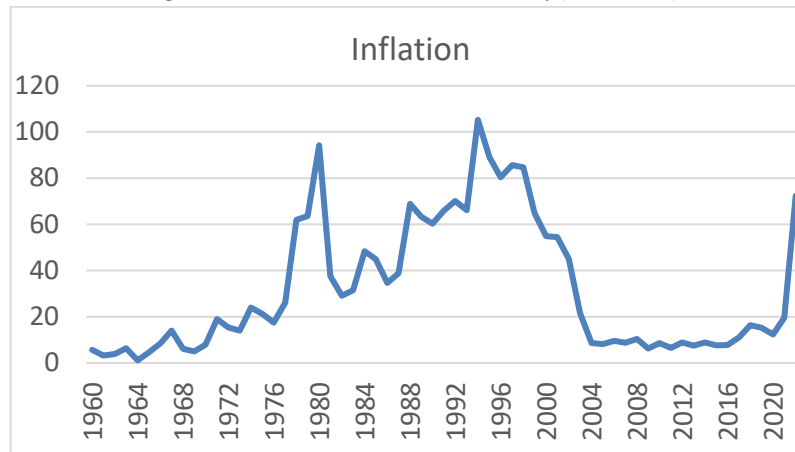
Source: Central Bank of the Turkish Electronic Data Delivery System (EVDS)

Pamuk (2022) argues that the liberalization of capital movements and the implementation of export-oriented policies without ensuring balance in public finances in the 1980s made the Turkish economy open and fragile against external shocks. This period was marked by political crises and price instability. The 1990s were the most volatile and unstable period for the Turkish economy, with public deficits continuing to increase. As public sector balances deteriorated, real IR rose, further exacerbating budget deficits. The Turkish economy experienced four crises during this period, two of which were externally driven. Budget deficits and public borrowing reached unsustainable levels, leading to an inflation rate of 105.2% in 1994, the highest in its history (Pamuk, 2022, p. 281). After the 2001 crisis, the Central Bank made substantial progress in reducing inflation by prioritizing price stability and using monetary policy to achieve this goal (TRCB, 2014). The ER-based stabilization program was replaced by a floating ER. The 'Transition to a Strong Economy Program' aimed to reduce uncertainty in financial markets through various banking sector reforms. The objective was to maintain stability in IRs and ERs and to effectively use macroeconomic policies during the disinflation process (TRCB, 2014, p. 16). From 2002 to 2005, the Central Bank of Türkiye implemented monetary policies under an implicit inflation-targeting regime, switching to an explicit inflation-targeting regime in 2006 (Kılavuz & Altınöz, 2020, p. 243). As a result of these monetary and fiscal policies, Turkey achieved monetary and fiscal discipline, leading to relative price stability and single-digit inflation from 2004 to 2017. However, starting in 2018, Türkiye entered a period of rising inflation, primarily due to increases in the ER. Policymakers' failure to establish stable IRs and monetary policies led to a return to double-digit inflation rates.

From 2020 onward, both endogenous factors, such as unstable monetary and fiscal policies, and exogenous factors, such as the COVID-19 pandemic, the global energy crisis, and the global grain crisis, contributed to the rise in inflation. As Demirgil (2019) points out, the Turkish economy has historically faced inflation and price instability. Therefore, the success of disinflation policies in Turkey depends on accurately identifying and addressing the causes of inflation.

2. Literature Review

The inflation rate is a frequently studied topic in the literature, as it closely relates to all segments of the economy and directly influences household consumption, savings, investment, and purchasing power. As Deluna Jr. et al. (2021) highlighted, while the examination of factors influencing inflation is well-established, there remain areas that require continuous study due to the ongoing development of econometric methods. In the literature, the determinants of inflation and its relationship with economic variables are generally investigated using various econometric methods for specific countries and/or country groups with different data frequencies. This section will group studies on inflation by country, country groups, and the Turkish economy—the focus of this study—and summarize their results.

In their 1994 study, Dhakal et al. examined the factors influencing inflation in the United States from 1957 to 1991. The findings indicated that variations in MS, wage rates, budget deficits, and energy prices significantly influence the inflation rate. Mohanty & John (2015) and Deluna Jr et al. (2021) share a common finding that global oil prices serve as the primary determinant of inflation. Additionally, they observe asymmetric effects of IRs on inflation in the economies of India and the Philippines. In separate studies, Salma (2021) for Bangladesh and Tolasa et al. (2022) for the Ethiopian economy used OLS and ARDL bounds test approaches, respectively. They concluded that MS, ER, IR, real GDP, foreign direct investment, and foreign trade are determinants of inflation. Duodu et al. (2022) investigated the determinants of inflation in the Ghanaian economy using causality analysis. The results of the Granger causality analysis showed a unidirectional causality relationship between MS, budget deficit, real income, and inflation.

The results of country-group-based studies on inflation are summarized as follows. First, in their 2011 study, Kandil & Morsy

examined the factors influencing inflation in the Gulf countries from 1970 to 2007. They emphasized that inflation in trading partners is a crucial external factor, discovering that a rise in ERs (reflecting the depreciation of the domestic currency) and oil revenues contribute to increased inflationary pressures. Additionally, they observed that an increase in MS leads to inflation in Bahrain and the United Arab Emirates. Conversely, Agayev (2012) examined the impact of ERs, wages, and MS on inflation in twenty-three transition economies from 1998 to 2008 using the panel data method. The researcher found that although ER and wages have significant positive relationships with inflation, MS does not have a significant effect. Lim & Sek conducted an analysis of the determinants of inflation from 1970 to 2011, categorizing countries into two groups based on their inflation rates: low and high inflation. Their primary findings indicate that GDP growth and imports of goods and services have notable long-term impacts on inflation in both groups of countries. In nations with high inflation rates, national expenditures have positive effects on inflation, while MS has negative effects. Jongwanich et al. (2019) analyzed the impact of food, oil prices, and ER on consumer and producer prices in ten Asian developing countries from 2000 to 2015 using the VAR method. They found that demand-pull factors significantly explain changes in consumer prices, while the effect of ER on domestic prices is more pronounced in countries with a flexible ER system. Durguti et al. (2021) examined the relationship between economic growth, remittances, export-import levels, foreign direct investments, and inflation in six Balkan countries with similar economic and social structures from 2003 to 2019. Their findings indicate that economic growth, imports, and foreign direct investments positively contribute to inflation, whereas remittances and exports negatively influence the inflation rate. Elbahnasawy & Ellis (2022) investigated the determinants of inflation from a different perspective, examining the effects of natural resource revenues (oil, natural gas, etc.), shadow economy, and political system on inflation in 156 economies from 1970 to 2009 using the GMM method. They concluded that higher natural resource income, shadow economy, political instability, and less democratic governance positively and significantly affect inflation. Citci & Kaya (2023) studied the impact of ER uncertainty on inflation across 149 countries from 1980 to 2017, revealing a non-linear, positive, and statistically significant relationship between ER uncertainty and inflation. Using the VAR method, Hall et al. (2023) examined the causes of the recent rise in inflation in the US, Euro area, and UK economies. They asserted that inflation increases in the US can be attributed to shocks in MS, public spending, and supply chain constraints. In contrast, the principal drivers of inflation in the UK include expansionary monetary policy, wages, and supply chain constraints.

The Turkish economy, which is the focus of this study, is generally characterized by high inflation. Consequently, policymakers are striving to develop policies to reduce inflation and achieve a stable economic structure. The effectiveness of these disinflation policies relies on accurately identifying the factors influencing inflation dynamics. The literature includes numerous studies examining the determinants of inflation in the Turkish economy. The results of some of these studies are summarized as follows.

Lim & Papi (1997) investigated inflation determinants using quarterly data from 1970 to 1995. Their findings suggest that the primary factors influencing inflation are MS and ERs, with public budget deficits also exerting significant effects on inflation. In her study in 2010, Oktayer analyzed the connection between inflation, budget deficit, and MS using a cointegration approach for the period between 1987 and 2009. The author determined that the series exhibits a long-term relationship, and budget deficits directly influence inflation. Alev (2019) employed the ARDL approach to analyze the determinants of inflation, utilizing quarterly data spanning from the first quarter of 2006 to the second quarter of 2018. The analysis results reveal that the series exhibits co-movements in the long run, with the IR on loans, M1 MS, and budget deficit exhibiting substantial positive effects on inflation, while GDP and ER have negative but statistically insignificant effects. Using the Johansen cointegration method, Demirgil (2019) examined the relationship among inflation, IR, ER, MS, and oil prices for the period 2009-2018. The conclusion is that, in the long run, all series, except for the IR, exhibit substantial positive effects on inflation.

Yenisu (2019) examined the macroeconomic factors influencing inflation in the Turkish economy during the period from 2010 to 2018 using the Toda-Yamamoto causality test. The study concluded that MS and oil prices are the primary causes of short-run inflation. Kılavuz & Altınöz (2020) investigated the relationship between M1, M2, and M3 money supplies (MSs), ER, IR, and inflation using quarterly data from 2006 to 2018 with the ARDL bounds test. Their findings indicate that among the series exhibiting long-term co-movement, only IR and M2 MS have notable positive effects on inflation. Celik (2021) analyzed the relationship between PPI, credit volume, real ER, MS, short-term external debt stock, IR, energy prices, and inflation using the cointegration method for the period from 2008 to 2019. The analysis results show that the series exhibits cointegration in the long run, with PPI, MS, short-term external debt stock, and energy prices having positive effects on inflation. Karabacak (2023) investigated the pass-through effect of ER on domestic prices using the ARDL bounds test approach, with quarterly data from 2003 to 2022. The study found that ER, GDP, oil prices, and producer prices are interrelated in the long term. Increases in GDP, ER, and producer prices were shown to elevate inflation, confirming the validity of the pass-through effect in the Turkish economy. In a separate 2023 study, Kolcu analyzed the cointegration relationship between the inflation rate and variables such as ER, IR, real MS, budget deficit, and current account deficit over the period from 2006 to 2021. Using quarterly data and employing Stepwise regression, VAR, and ARDL bounds test approaches, the results indicated long-term cointegration among the series. Additionally, the analysis revealed that ER positively impacts inflation, MS negatively affects inflation, and other variables did not exhibit significant effects.

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A thorough examination of the implications and outcomes of inflation studies reveals that inflation and the variables included in the model as determinants exhibit long-term cointegration. Notably, variables such as ER, MS, energy prices, GDP, budget deficit, and IR significantly impact inflation.

3. Dataset and Methodology

This study examines the macro determinants of the inflation rate, a chronic and current issue in the Turkish economy, covering the period from January 2006 to January 2023. Table 1 presents the descriptive statistics of the variables used. The series are sourced from the Central Bank Data Delivery System. Given the monthly nature of the series, their seasonality properties are analyzed. Seasonality in the Industrial Production Index (IPI) is adjusted using the Tramo/Seats method, while no seasonality is detected in other series. Before proceeding with the analysis, logarithmic transformations are applied to the relevant series. In this context, the macro determinants of inflation are analyzed using the model specified in Equation 1. IPI is commonly used to represent economic growth in monthly frequency studies (Yılancı, 2017, p. 60). In this study, the inclusion of IPI aims to examine both the output level and the influences of the real sector of the economy on inflation. A dummy variable is incorporated into the model to account for the structural breaks that occurred during the study period.

$$linf = \beta_0 + \beta_1 lms + \beta_2 lex + \beta_3 lint + \beta_4 lipi + \beta_5 dum + \varepsilon_t \qquad (1)$$

Table 1. Descriptive Statistics

Variable	Description	Mean	Max.	Min.	Standard D.
linf	Inflation Rate Calculated by Consumer Price Index	313.8405	1203.480	123.57	214.7891
lms	M2 MS	1.60E+09	8.43E+09	2.37E+08	1.71E+09
lex	Nominal dollar rate sales price	4.0153	18.7913	1.1760	4.0143
lint	CB policy rate	12.6365	24.11	5.94	4.3714
lipi	Industrial Production Index	95.2261	165.5610	50.4538	26.1461

Source: Authors.

Granger & Newbold (1974) termed the relationship between variables in analyses conducted with non-stationary series as a 'spurious regression' despite obtaining a significant relationship, a significant t-statistic, and a high R2 between the variables. This study revealed that the stationarity of the series needs to be investigated in empirical studies. Indeed, if the series has a unit root, random shocks have a long-run permanent effect, and the fluctuations in the series are highly persistent (Yılancı, 2017, p. 54). Therefore, ensuring the stationarity of variables in time series analysis is essential for the robustness, consistency, and predictive utility of the results. Fundamentally, a series is considered to be covariance (weakly) stationary if its mean and variance remain constant, and the covariance depends on the time intervals between two periods (Baltagi, 2021, p. 448). Accordingly, the stationarity of the series will be tested using the conventional ADF unit root test (URT). However, structural breaks could not be modeled within the scope of this test. During the period under study, the Turkish economy has experienced numerous economic, political, and governmental crises. To account for these structural breaks, the Fourier-KPSS URT, developed by Becker, Enders & Lee (BEL) in 2006, will be employed. This method endogenizes breaks using the Fourier term. BEL (2006) observed that major macroeconomic variables display a diverse range of structural breaks characterized by an unknown number, duration, and form. To address this complexity, BEL (2006) devised a URT that uses a chosen frequency of the Fourier function to model breaks with unknown characteristics.

In Fourier-KPSS, the stationarity of a y_t series is tested by estimating the following equation as a first step;

$$y_t = \alpha_0 + \beta_t + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_t \qquad (2)$$

In this equation, π, k, t, and T denote the number of constant pi, the number of frequencies that minimize the sum of squares of the residual, t denotes the trend, and T denotes the number of observations, respectively. The test statistic is obtained by applying the KPSS URT to the residuals obtained from this equation. The test statistic is calculated using Equation 3.

$$\tau_k = \frac{1}{T^2} \frac{\sum_{t=1}^{T} S_t(k^2)}{\sigma^2} \qquad (3)$$

If the test statistic is below the critical value, the null hypothesis cannot be rejected, indicating that the series is stationary. In the final step, the significance of the trigonometric terms must be assessed. This is done through an F test; if the F test statistic exceeds the critical F value, it confirms the significance of the Fourier terms. BEL (2006) noted that while their test could detect sharp breaks, it is more effective at identifying gradual and soft breaks. In this test, rather than selecting the date, shape, number, and form of the break, it is sufficient to choose the appropriate frequency (k) to include in the equation (Becker et al. 2006, p. 382).

Non-stationary series can become stationary through differencing. However, analyses involving unit root series often experience information loss due to the differencing process. At this point, cointegration, initially introduced by Granger (1986) and formally tested by Engle & Granger (1987), offers a method to explore long-run relationships between series with unit roots. If the

combined effects of two or more non-stationary variables result in stationary outcomes, the series is considered to be cointegrated (Pesaran, 2015, p. 523).

Tsong et al. (2016) developed a test that integrates the unknown number and form of structural breaks in the deterministic terms by incorporating the Fourier component. The null hypothesis of this test is cointegration. Similar to the Fourier KPSS URT, this test produces robust and stable results regardless of the number, form, and shape of the breaks (Yılancı, 2017, p. 58). To examine the presence of long-run relationships between y_t and x'_t;

Equation 4 is used to estimate the test statistic. In this context, the null hypothesis postulates the cointegration of the series, while the alternative hypothesis asserts the absence of cointegration.

$$y_t = \delta_0 + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_2 \cos\left(\frac{2\pi kt}{T}\right) + x'_t\beta + \upsilon_{1t} \qquad (4)$$

In this equation, k is the frequencies (the number of frequencies that minimize the sum of residual squares), t is the trend, T is the number of observations. π denotes the constant pi.

From this equation, the Fourier SHİN statistic is derived using Equation 5

$$CI_f^m = T^{-2}\varpi_1^{-2}\sum_{t=1}^{T}S_t^2 \qquad (5)$$

Here, ϖ_1 is a robust estimator of the long-run variance of υ_{1t} (Yılancı et al., 2017, p. 3).

4. Findings

The findings of the empirical analyses will be discussed in this section. First, the results of the ADF URT for the series are presented in Table 2.

Table 1. ADF URT Results

Variables	Constant	Constant+Trend
linf	3.2019	2.9503
Δlinf	-3.8534***	-4.7073
lms	3.8822	2.7607
Δlms	-11.8146***	-12.4077***
lex	2.5379	-0.4855
Δlex	-10.0841***	-10.6697***
lint	-2.4147	2.5008
Δlint	-7.1662***	-7.5732***
lipi	0.0875	-2.4613
Δlipi	-5.4312***	-5.4642***

*Note: *** denotes a 1% significance level.*
Source: Authors.

The ADF URT, under the assumption of the null hypothesis that there is a unit root in the series, suggests that all series have a unit root when examined at their original levels. However, when the first difference is applied, all series become stationary at a 1% level of significance. The results of the Fourier-KPSS URT are detailed in Table 3. In contrast to the ADF URT, this test, which assumes the null hypothesis that the series is stationary, finds that all series are non-stationary at their level values. Since the F statistic for the trigonometric terms significantly exceeds the critical value of 4.972, the Fourier terms are deemed significant.

Table 2. Fourier KPSS URT Results

Fourier-KPSS Results (Model with Constant and Trend)				
Variables	Frekans	Min. SSR	Test Statistik	F Test Sts.
linf	1.0000	30.6796	0.2146	93.4197
lms	1.0000	79.9229	0.2217	105.7422
lex	1.0000	47.1436	0.2118	144.5694
lint	1.0000	10.1078	0.0546	138.4398
lipi	1.0000	6.6006	0.2075	135.0336

Note: 5% statistic value for k=1: 0.0546. F statistic 5% critical value: 4.972. (Critical values are from Becker et al., (2006).
Source: Authors

The Fourier-SHIN cointegration test is used to evaluate the presence of long-run relationships among series. The results, including the cointegration test, long-run coefficients, short-run dynamics, and the error correction term are presented in Table 4.

Table 3. Fourier-SHİN Results

Cointegration Test Statistic	Frequency	Min SSR.	5% critical value	F Statistic
0.02419	3.0000	0.01313	0.065	15.83983
Long-run Coefficients				
Variables	**Coefficient**	**Standard Deviation**	**t statistic**	**Probability**
lms	0.8358	0.0579	14.4221	0.0000
lex	-0.0608	0.0448	-1.3562	0.1776
lint	0.0979	0.0222	4.3935	0.0000
lipi	-0.2323	0.0155	-3.7693	0.0000
Short Run Coefficients and Error Correction Term				
Variables	**Coefficient**	**Standard Deviation**	**t statistic**	**Probability**
linf(-1)	0.4514	0.0632	7.1422	0.0000
lms(-1)	0.1579	0.0489	-3.0904	0.0023
lex(-1)	-0.0092	0.0242	-0.3813	0.7033
lint(-1)	-0.0178	0.0139	-1.2813	0.2017
lipi(-1)	0.0162	0.0068	2.3602	0.0193
ECT	-0.1188	0.0376	-3.1593	0.0018

Source: Authors.

The Fourier SHIN cointegration test, which posits a cointegration relationship as the null hypothesis, shows that the null hypothesis cannot be rejected because the test statistic is lower than the critical value. Thus, it is concluded that the variables of inflation, MS, ER, IR, and IPI are cointegrated in the long run in the Turkish economy. This result is in line with the studies by Demirgil (2019), Kılavuz & Altınoz (2020), Celik (2021), and Kolcu (2023), which examine the relationship between inflation and selected variables in the Turkish economy. After identifying the cointegration relationship in the Fourier-SHIN test, it is necessary to evaluate the significance of the trigonometric terms. Since the F statistic exceeds the critical value of 4.019, the null hypothesis is rejected, indicating that the Fourier terms are significant. Based on the results of the DOLS analysis, it is observed that in the long term, both MS and IR variables positively affect inflation. Specifically, a 1% increase in MS corresponds to a 0.83% increase in inflation, providing evidence that partial QTM is valid in the Turkish economy. This finding is consistent with the results of Kandil & Morsy (2011), Alev (2019), Kılavuz & Altınoz (2020) and Tolasa et al. (2022). The effect of the ER on inflation is negative but statistically insignificant. This result is in line with Deluna Jr., Loanzon & Tatlonghari (2021) but different from Karabacak (2023). Increases in IRs lead to higher inflation. Although the coefficient is relatively low, it is suggested that higher IRs raise costs, resulting in cost-push inflation. This conclusion is also supported by Alev (2019) and Tolasa et al. (2022). The inclusion of the IPI variable in the model, representing economic growth, shows a negative impact on inflation. Specifically, a 1% increase in the corresponding variable leads to a decrease in inflation by 0.23%. To ensure the robustness of these results, the long-run coefficients are also analyzed using the FMOLS method. The findings indicate that the impacts of MS and IR on inflation align with the DOLS analysis. However, unlike the DOLS analysis, the ER positively affects inflation, which is statistically significant at the 10% level.

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Table 4. FMOLS Results

Variables	Coefficient	Standard Dev.	t statistic	Probability
lms	0.8209	0.0624	13.1398	0.0000
lex	0.0789	0.0461	1.7099	0.0888
lint	0.0405	0.0202	2.0086	0.0459
lipi	0.0241	0.0441	0.5464	0.5854

Source: Authors.

In the short run, inflation is positively affected by its own lagged value, indicating that inflation is a self-sustaining process. In this period, both the ER and IR variables have no significant effect on inflation. Conversely, the MS variable significantly and positively impacts inflation in the short run. The Error Correction Term (ECT) coefficient, which indicates the extent to which deviations from equilibrium in the short run are corrected, is expected to be negative and statistically significant. This coefficient suggests that approximately 12% of the deviations from equilibrium are corrected after a single period. The coefficient's statistical significance confirms the effectiveness of the ECT mechanism.

Granger causality analysis is employed to examine the causal relationships between the series. The results of the causality test are presented in Table 6.

Table 6. Granger Causality Analysis

Direction of Causality	F statistic.	Probability	Conclusion
lms $\Longrightarrow$ linf	13.4070	0.0000	Causality.
lex $\Longrightarrow$ linf	11.7125	0.0000	Causality.
lint $\Longrightarrow$ linf	0.9974	0.3708	No causality
lipi $\Longrightarrow$ linf	2.7968	0.0637	No causality
linf $\Longrightarrow$ lms	5.6959	0.0040	Causality.
linf $\Longrightarrow$ lex	13.9002	0.0000	Causality.
linf $\Longrightarrow$ lint	0.2235	0.7999	No causality.
linf $\Longrightarrow$ lipi	1.0645	0.3470	No causality.

Source: Authors.

The Granger causality analysis reveals a bidirectional causality relationship between both MS and ER with inflation. However, no causality relationship is identified between the IR and IPI variables and inflation. This result is in line with Yenisu (2019). Finally, Cusum and Cusum Square analyses are used to test the long-term stability of the coefficients. The results show that the coefficients are stable, indicating that the model is robust and suitable for forecasting and prediction purposes.

Figure 2. Cusum and Cusum Square Results
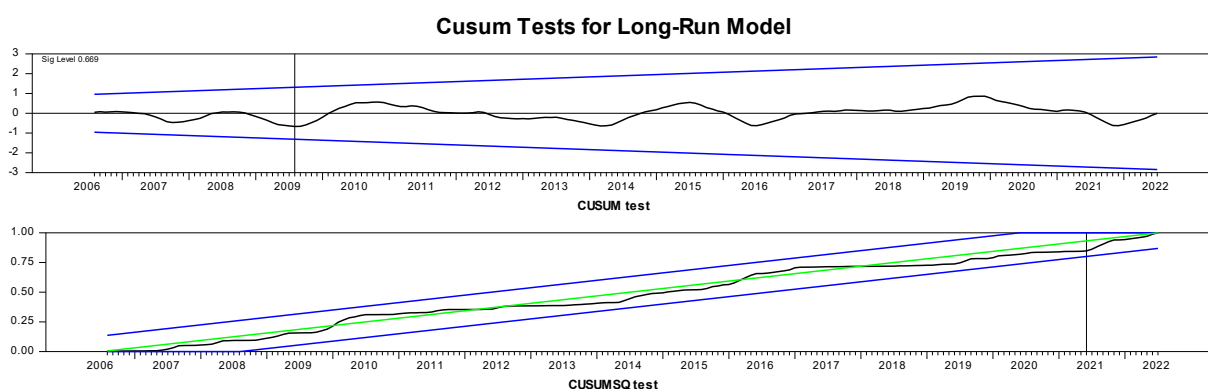
Source: Authors.

Conclusion and Policy Recommendations

Inflation has recently emerged as the most critical economic issue, even in developed countries. The recent surge in inflation across global economies is primarily driven by pandemic conditions and rising global input prices, particularly energy costs. Inflation heightens economic uncertainty and influences the decisions of economic agents regarding consumption, saving, and investment. By diminishing purchasing power, inflation effectively acts as a tax on income. Inflation, which redistributes income and wealth, causes firms to delay or cancel their investment decisions. Therefore, stabilizing the general price level has become the primary policy goal for policymakers due to its adverse effects on economic agents. Since its inception, the Turkish economy has struggled to maintain a stable price level, except for brief periods, and has often experienced double-digit and, in some years, triple-digit inflation rates. The inflation rate in the Turkish economy, which was relatively low between 2004 and 2017, has recently begun to rise again due to the ER and external factors such as the pandemic and the Russia-Ukraine war. This study aims to investigate the impact of the main macroeconomic variables on inflation in the period between January 2006 and January 2023, the year of transition to explicit inflation targeting in the Turkish economy. An accurate determination of whether inflation is demand- and/or supply-driven, as well as identifying its determinants, will enhance the effectiveness of monetary and fiscal policies aimed at reducing inflation. In the empirical part of the study, the stationarity properties of the series are examined, revealing that the variables are non-stationary at their level values. The existence of long-run relationships between the variables is investigated with the Fourier-SHIN cointegration test. The study concludes that the inflation rate, MS, ER, IR, and IPI variables are cointegrated in the Turkish economy during the relevant period. In the long term, MS and IR variables positively impact inflation, partially validating the QTM in Turkish economy. Conversely, the IPI negatively impacts inflation, indicating that increases in production capacity and economic growth reduce inflation. In this context, the findings indicate that the Turkish economy operates with underemployment, and monetary factors have a greater impact on inflation. Granger causality analysis indicates a bidirectional Granger causality relationship between MS and ER and inflation. No causality relationship was found between other variables and inflation. The investigation into the macro determinants of inflation in the Turkish economy concludes that the MS is the primary determinant of inflation, while the IR has a notable but moderate impact. Additionally, the IPI demonstrates negative effects on inflation. Since policies to increase the production capacity of the economy will suppress, inflation and strict

Sarı (2024).

monetary policy will have long-run disinflationary effects, fiscal policies that will increase the productivity and capacity of the real sector and monetary policies that include tightening of the MS are recommended to policymakers.

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