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The Impact of Exchange Rate Volatility on The Inflation Rate: Evidence from Turkey

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Abstract

This study examines the relationship between exchange rate, inflation, and M1 money supply in the Turkish economy using VAR modeling with data from January 2003 to May 2024. The cointegration test reveals that these variables move together in the long run. Granger causality analysis indicates that, at the 1% significance level, the M1 money supply affects both the exchange rate and inflation, while inflation exhibits a one-way causality towards the exchange rate. According to the variance decomposition results, the primary determinant of inflation in Turkey is the fluctuations in the M1 money supply. The impulse response functions indicate that inflation's impact on the exchange rate lasts for eight periods, while its response to the M1 money supply continues for ten periods. These findings demonstrate that the dynamics of money supply and exchange rate play a critical role in influencing inflation. Therefore, the management of exchange rate stability and money supply should be prioritized in the design of macroeconomic policies

Key Words: Exchange Rate, Inflation, M1 Money Supply, VAR Model

Döviz Kuru Oynaklığının Enflasyon Oranı Üzerindeki Etkisi: Türkiye'den Kanıtlar

Öz

Bu çalışma, Türkiye ekonomisinde döviz kuru, enflasyon ve M1 para arzı arasındaki ilişkiyi Ocak 2003-Mayıs 2024 dönemi verileriyle VAR modeli çerçevesinde incelemektedir. Eşbütünleşme testi, bu değişkenlerin uzun dönemde birlikte hareket ettiğini ortaya koymuştur. Granger nedensellik analizi, %1 anlamlılık düzeyinde M1 para arzının hem döviz kurunu hem de enflasyonu etkilediğini; ayrıca enflasyonun döviz kuru üzerinde tek yönlü bir nedenselliğe sahip olduğunu göstermiştir. Varyans ayrıştırma sonuçlarına göre, Türkiye'de enflasyonun temel belirleyicisi M1 para arzındaki dalgalanmalardır. Etki-tepki fonksiyonları, enflasyonun döviz kuruna etkisinin sekiz dönem sürdüğünü, M1 para arzına tepkisinin ise on dönem boyunca devam ettiğini göstermektedir. Bu bulgular, para arzı ve döviz kuru dinamiklerinin enflasyon üzerinde kritik bir rol oynadığını göstermektedir. Dolayısıyla, makroekonomik politikaların tasarımında döviz kuru istikrarı ve para arzının yönetimi öncelikli olarak ele alınmalıdır.

Anahtar Kelimeler: Döviz Kuru, Enflasyon, M1 Para Arzı, VAR Modeli

1. Introduction

The relationship between inflation and exchange rates is a critical area of study, particularly for emerging economies where exchange rate fluctuations directly impact price stability and economic performance. Since the 1970s, price volatility has posed significant challenges globally, with developing economies especially vulnerable to "imported inflation," which undermines the effectiveness of domestic policies. The persistent currency devaluations and rising inflation of the 1980s further highlight the need for effective management of this relationship (Madesha et al., 2013).

In import-dependent economies like Turkey, exchange rate movements play a key role in shaping inflation dynamics. Currency depreciation increases the cost of imported goods and production inputs, raising

domestic prices through multiple channels: higher input costs, increased uncertainty, and inflationary pressures in dollarized sectors such as wages and rents (Alkan and Dağdır, 2020).

Exchange rates not only drive inflation but also affect trade competitiveness. While depreciation raises import costs, it can enhance export performance, suggesting that exchange rate adjustments may serve as a policy tool under certain conditions. However, their broader economic effects must be carefully evaluated (Aytekin et al., 2023).

In inflation-targeting regimes, understanding the exchange rate-inflation relationship is essential. Forward-looking policies rely on accurate assessments of exchange rate impacts, supported by macroeconomic models and market indicators, to guide monetary interventions (Dereli, 2018).

This study examines the impact of exchange rate volatility on inflation in Turkey, using monthly data from January 2003 to May 2024. Given Turkey's open economy and reliance on imports, understanding this relationship is crucial for ensuring price stability. The study is structured as follows: the introduction outlines the research context, followed by sections on the conceptual framework, literature review, methodology, findings, and conclusions.

2. The Effect of Exchange Rate Volatility on Inflation

The exchange rate is the price of a country's currency expressed in terms of another country's currency. It is a relative price that measures the value of the domestic currency against the foreign currency. Generally, the exchange rate between currency X and currency Y shows the number of units of currency Y needed to purchase one unit of currency X. For example, the exchange rate between Turkey and the United Kingdom indicates the price of the pound in terms of Turkish lira (TL).

Exchange rate volatility has a significant pass-through effect on price inflation, particularly in developing countries. Developing countries often play a crucial role in supply chains for advanced economies and are dependent on these economies for the supply of capital goods and certain consumer goods. Therefore, fluctuations in exchange rates can directly impact costs and, consequently, price levels in these countries. Exchange rate volatility can trigger inflationary pressures by increasing import costs, which in turn can threaten overall economic stability. Developing countries, being more vulnerable to such fluctuations, find exchange rate stability to be crucial in their economic policies. A depreciation of the local currency typically results in higher costs for imported goods. This occurs because more local currency is needed to purchase the same product. For example, if the local currency depreciates against the dollar, a product that previously cost 100 local units might now cost 120 or more local units. This increase in the cost of imported goods raises local consumer prices and creates inflationary pressures. Therefore, exchange rate stability is critical, especially for economies that are heavily reliant on imports. Developing countries often adjust their economies to align with the global framework shaped by advanced economies. In contrast, advanced economies typically use exchange rate policies to achieve economic expansion and control inflation. These countries view devaluation as a part of their economic growth strategies and adjust their exchange rate policies to achieve these goals. Developing countries, on the other hand, often struggle to adapt to the effects of such policies, leading to more complex and gradual manifestations of exchange rate volatility impacts. These differences can explain why the pass-through effects of exchange rate changes occur at varying speeds and in different ways across economies. (Gidigbi et al., 2018:22-23).

The relationship between exchange rates and inflation is explained by the concept of exchange rate pass-through. This effect is defined as the change in domestic import prices and export prices due to a

one-unit change in the nominal exchange rate. In other words, it can be described as the percentage change in the prices of imported goods in terms of the local currency resulting from a specific percentage change in exchange rates between countries engaged in international trade. The indirect effect of exchange rates on prices occurs through exports. A depreciation of the local currency makes domestic products more competitive in international markets, which increases export demand while making imports more expensive, thus reducing import demand. Consequently, domestic demand shifts towards exported goods and import-substituting products. This process can lead to an increase in the prices of local goods. Additionally, rising costs of imported inputs can increase the costs of exported goods, which in turn affects local prices. As a result, fluctuations in exchange rates can influence local prices through changes in aggregate demand. The theoretical basis of the relationship between exchange rates and prices is based on the law of one price. According to this law, in markets with free foreign trade there is a single price for traded goods. Where this law is valid, the relationship between the exchange rate and prices is perfectly reflected. In this case, prices are determined by the currency of the producer. However, for this to be the case, the goods produced in different countries must be homogeneous and there must be no extra factors such as transport costs. When a single price cannot be applied for each good, that is, in cases that are not in accordance with the law, incomplete reflection is experienced. In the short run, exchange rate changes do not affect prices in the same way (Kaygısız, 2018:118-119)

2.1. Inflation

Inflation is defined as a continuous increase in the general price level of goods and services in an economy. It can be defined as a periodic or continuous increase in the general price level. However, in order for price increases to be considered inflationary, they must be widespread and continuous throughout the economy. A price increase alone may not

necessarily have an inflationary effect. Inflation can be classified into two types: creeping inflation and hyperinflation. Creeping inflation is characterized by a slow but steady increase in the general price level over an extended period. In other words, it refers to a situation where price increases continue at a moderate and stable rate over a long duration. This type of inflation exhibits a gradual but consistent rise and tends to worsen over time. This type of inflation can threaten economic stability because its prolonged nature can lead to increased pressure on prices and a reduction in the purchasing power of the public. Additionally, the tendency of creeping inflation to worsen over time can complicate economic planning and decision-making processes. This situation may create economic uncertainty and a lack of confidence, affecting investment and consumption decisions. Hyperinflation, also known as runaway or galloping inflation, is characterized by monthly price increases of 50% or more. This results in rapid and substantial price hikes. Hyperinflation can lead to a swift depreciation of a country's currency and severely undermine public confidence in money. This type of inflation threatens economic stability and can cause people's savings to erode quickly. Hyperinflation emerges when prices increase at an extremely rapid rate, often in double or triple digits, causing inflation rates to spiral out of control. Prices can escalate so quickly that they tend to double almost daily. This scenario leads to a collapse of the monetary system due to the continuous erosion of the purchasing power of money. Unlike creeping inflation, hyperinflation is typically short-lived but has devastating effects. The Consumer Price Index (CPI) is used to measure the inflation rate, reflecting how price changes affect the cost of living for consumers. Hyperinflation can lead to economic and social chaos, rapidly devaluing the public's savings and incomes (Nuhu, 2021:28).

Macroeconomists commonly use two primary measures to evaluate price levels: the Gross Domestic Product (GDP) deflator and the Consumer Price Index (CPI). These indicators are crucial for

understanding the magnitude and impact of inflation within an economy. The GDP deflator, used to measure the general price level, can be defined as follows:

$$P_t = \frac{\text{Nominal GDP}_t}{\text{Real GDP}_t} \quad (1)$$

The GDP deflator is a measure of the level of prices of all new, domestically produced, final goods and services in an economy. It reflects the ratio of nominal GDP to real GDP and captures the average change in prices across the entire economy. The GDP deflator provides the average price of final goods produced in the economy. Since consumers are more concerned with the average price of the goods they consume, macroeconomists also refer to another index, the Consumer Price Index (CPI). The CPI is used to define the inflation rate as the percentage increase in the Consumer Price Index over a one-year period. In other words, the GDP deflator is an index that reflects changes in the price levels of all final goods and services produced within an economy. This index is calculated by dividing nominal GDP (measured at current prices) by real GDP (measured at constant prices), thus reflecting the general increase or decrease in prices over time. The GDP deflator is an important indicator for analyzing broad price movements within the economy. The persistence of increases in the general price level can be either anticipated or unexpected. If the increase is fully anticipated, all sectors and individuals in the economy may be prepared and can take measures accordingly. In this case, people and businesses can plan with the price increases in mind and mitigate the adverse effects of inflation. However, unexpected inflation creates uncertainty, complicating economic decisions and leading to unforeseen costs. Inflation can be unexpected for the following three possible reasons:

- ✓ A general failure of the economy as a whole to forecast inflation accurately, so that the actual inflation rate exceeds the expected rate.
- ✓ Some groups or individuals in the economy fail to forecast inflation accurately and thus demand lower wage increases than are actually necessary to maintain real wages.
- ✓ Where some groups or individuals are not fully compensated even if they correctly forecast inflation, e.g. if they are members of weak trade unions or receive contractually fixed incomes

When inflation is not accurately predicted by groups or individuals within the economy, redistributive effects occur this can result in some individuals benefiting, while others suffer economically (Sesan, 2013:3).

2.1.1. Theories of Inflation.

Inflation literature had been widely discussed by theorists. Three main types of inflation, namely demand-side inflation, cost-side inflation and structural inflation are widely used in the literature.

2.1.2. Demand-Pull Inflation

Demand-pull inflation occurs when aggregate demand increases at a rate faster than aggregate supply. This type of inflation arises when total demand exceeds the total supply of goods and services. It is often observed during periods of economic recovery when unemployment rates are decreasing and the economy is growing. An increase in aggregate demand can be driven by both monetary and real factors. Monetary factors, such as an increase in the money supply, are significant contributors to demand-pull inflation. When the money supply grows faster than production, it can lead to inflationary

pressures. Additionally, real factors contributing to inflation include changes in taxes and government (public) spending. These factors can stimulate aggregate demand, thereby contributing to demand-pull inflation (Lado, 2015:35)

2.1.3. Cost-Push Inflation

Cost inflation is caused by increases in the cost of production, such as increases in the prices of commodities such as oil and food or increases in the cost of production caused by natural disasters. In such periods, aggregate supply decreases and the general level of prices rises as a result. Cost-push inflation is often triggered by trade unions and monopolistic groups, such as firms operating in monopolistic or oligopolistic markets. Strong labor unions usually raise wages, leading to higher prices. Such price increases are referred to as **wage-push inflation**. Additionally, when firms with monopoly power use their market dominance to raise prices, it leads to an increase in the general price level. This type of inflation is known as **profit-push inflation.** Another type of cost-push inflation arises from supply shocks, known as **supply shock inflation.** This occurs when a decrease in aggregate supply leads to inflation, often associated with shortages in agricultural products that drive up food prices and increases in the prices of key industrial inputs. Such price increases can result from internal supply constraints or international events that restrict the movement of trade goods and cause supply shortages, such as wars (Lado, 2015:35)

2.1.4. Structural Inflation

Structural Inflation: Inflation caused by structural problems and bottlenecks in the economy is called structural inflation. The main causes of structural inflation are inelastic supply of agricultural products, rapid population growth, incompatibility of demand structure with production structure, continuous deficit in foreign trade balance,

imbalance between factors of production, monopolistic tendencies, market failures and institutional disorders (Büyükakın, 1995:20).

Structural inflation theories are based on the work of structural economists, particularly contributions from Myrdal, Streeten, and some Latin American economists. According to the structuralist perspective, inflation in developing countries often arises as a natural consequence of ambitious development programs and primarily results from structural imbalances within these economies. Structural imbalances in developing countries' economies are as follows:

- ✓ Food scarcity: imbalance between food demand and supply.
- ✓ Input imbalance: shortage of capital and surplus labour, shortage of fuel and oil,
- ✓ Foreign exchange bottlenecks: imbalances between exports and imports and balance of payments deficits,
- ✓ Infrastructure bottlenecks: inadequate supply of electricity, transport and communications and telecommunications
- ✓ Social and political restrictions.

The greatest threat from inflation is the erosion of the purchasing power of money. Inflation discourages investment, reduces the value of savings and can lead to a fall in real wages. In addition, inflation can have adverse effects on low-income segments of society and the elderly. (Lado, 2015:36).

2.2. Exchange Rate

The exchange rate plays an important role in achieving the Central Bank's macroeconomic objectives. The exchange rate is one of the monetary aggregates through which monetary policy is directed in

order to achieve set policy objectives such as the ideal unemployment rate, inflation rate and economic growth. At the same time, the exchange rate is an intermediate policy variable through which monetary policy is transmitted to the economy through its impact on the value of domestic currency, domestic inflation (pass-through effect), external sector, macroeconomic credibility, capital flows and financial stability (Gidigbi et al, 2018:22).

The national currency is used by economic actors for making and receiving payments within a country. However, in international trade, residents of countries use foreign currencies. The exchange rate facilitates the conversion of domestic currencies into foreign currencies, and vice versa. It gains significance due to the cross-border flows of goods, services, financial assets, and fund transfers. The exchange rate is the price of one currency in terms of another, representing the current market price at which a national currency can be exchanged for another currency. It is typically expressed as either the number of units of domestic currency needed to purchase one unit of foreign currency or the number of units of foreign currency obtained for one unit of domestic currency. For example, Lira per United States (US) dollar (TL/US$) or US dollar per TL (US$/TL). If 1 USD can be exchanged for 32,300, then one TL can be exchanged for 0.03096 USD. The exchange rate plays a critical role in an economy because imports and exports constitute a large part of the economy. Essentially, exchange rate changes affect the price of imported goods, services and our exports. For example, when the value of a currency like the Turkish Lira (TL) decreases, imported goods become more expensive, which tends to reduce the volume of imports. At the same time, other countries will pay less for some of the exported products, which can increase export sales, foreign exchange earnings, and the competitiveness of the country's export industries in international markets (URL1,2016).

Economists argue that macroeconomic fundamentals play a crucial role in determining exchange rates in the long run. It is believed that the value of a country's currency responds positively to fundamental factors such as an increase in economic growth, improvements in the trade balance, reductions in inflation rates, or increases in real interest rates. A simple model for determining the long-term equilibrium exchange rate is based on the Quantity Theory of Money. The domestic version of this theory suggests that a one-time increase in the money supply will result in a proportional increase in the domestic price level in the short term. The international version posits that an increase in the money supply will also be reflected proportionally in the exchange rate (Sesan, 2013:3).

2.2.1. Foreign Exchange Rate Regimes

Foreign exchange rate regimes refer to the various systems through which the value of a country's currency is determined relative to other currencies. The choice of exchange rate regime can significantly impact a country's economic stability, trade balance, and monetary policy. The main types of foreign exchange rate regimes include:

2.2.1.1. Fixed Exchange Rate System

In a fixed exchange rate system, a country's currency value is pegged to another major currency or a basket of currencies. The central bank or monetary authority intervenes in the foreign exchange market to maintain the currency's value within a narrow band around the peg. This system aims to provide stability and predictability in international trade and investment. For example, the Hong Kong dollar is pegged to the U.S. dollar. In a fixed exchange rate system, the exchange rate is determined by an authority such as the government or the Central Bank, which limits transactions in the foreign exchange market. In this system, the Central Bank must have sufficient gold and foreign

exchange reserves to intervene in the market as a buyer and seller. (Alkan and Dagdır,2020:271).

In a fixed exchange rate regime, the local currency is typically pegged to widely used currencies such as the U.S. dollar, the Euro, or the British pound or to a basket of currencies. In this system, the government or the central bank acting on its behalf intervenes in the foreign exchange market to maintain the exchange rate close to a predetermined target. This intervention aims to ensure exchange rate stability. However, if the exchange rate is fixed at an inappropriate level, it can jeopardize local economic stability. The fixed exchange rate system has the advantages of price stability, promoting international trade, reducing exchange rate risk and the risk of creating speculative bubbles of the type that raise the exchange rate (Labonte, 2004:9-11; Frankel, 2003:9-10).

The fixed exchange rate system provides less uncertainty and prevents destabilizing fluctuations for international trade and investment. In this system, destabilizing speculation is lower than in the flexible exchange rate system. Due to the reduction in fluctuations in exchange rate movements, lower interest rates are generally anticipated. A fixed exchange rate system not only aids in maintaining price stability and keeping inflation at low levels but also plays a supportive role in preserving balance sheets and reserves. Consequently, proponents of the fixed exchange rate system argue that it should be preferred as an exchange rate regime that provides stability in economic policies (Alkan and Dağıdır, 2020:272).

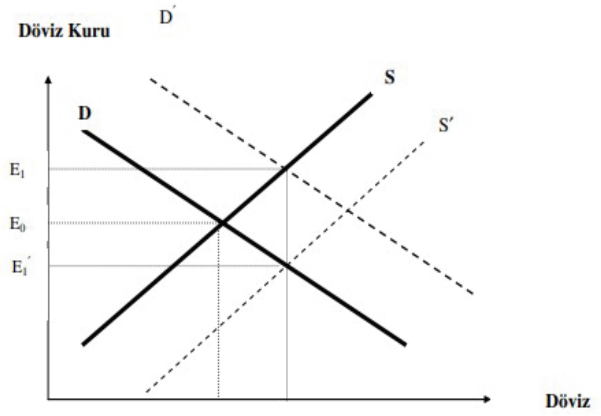
2.2.1.2. Flexible Exchange Rate

In the floating exchange rate system, also known as the flexible exchange rate system, exchange rates are determined by the supply and demand in the market without government intervention. In this system, unlike the fixed exchange rate system, there is no need to use

foreign reserves in the medium term to ensure exchange rate stability; external balance is achieved naturally. In this system, central banks do not directly intervene, and the exchange rate is determined based on supply and demand conditions. Flexible exchange rates are viewed as a natural corrector of economic imbalances, as the exchange rate can serve as an automatic stabilizer for external trade and balance of payments. However, fluctuations in exchange rates based on free capital movements can lead to economic uncertainty and speculation (Alkan and Dağıdır, 2020:271-272).

In a flexible exchange rate system, the currency's value is determined by market forces of supply and demand relative to other currencies, without direct government or central bank intervention. The exchange rate fluctuates freely based on economic conditions, trade balances, and capital flows. For instance, the U.S. dollar and the Euro operate under a floating exchange rate system. In other words, the currency's value is determined by market forces of supply and demand relative to other currencies, without direct government or central bank intervention. The exchange rate fluctuates freely based on economic conditions, trade balances, and capital flows. For instance, the U.S. dollar and the Euro operate under a floating exchange rate system. In countries with a flexible exchange rate regime, central banks usually intervene in the market to limit or minimize short-term exchange rate volatility by buying or selling foreign currency against the local currency. Flexible exchange rate regimes offer countries the advantage of an independent monetary policy. Foreign exchange and other financial markets in countries adopting a flexible exchange rate system should be deep enough to absorb shocks without large exchange rate volatility. They should also have effective financial instruments to hedge against the potential risks of a flexible exchange rate (Stone et al, 2008:42).

Figure 1 Flexible Exchange Rate System



Source, (Demir, 2007:19)

In the case where the demand and supply curves for foreign exchange are labeled as D and S, respectively, the exchange rate is determined at E0. At this price level, the supply and demand for foreign exchange are equal. When the supply is held constant, an increase in demand for foreign exchange due to factors such as a rise in imports will shift the demand curve from D to D′. As a result, the exchange rate will rise correspondingly to E1. Under an unlimited free floating exchange rate system, since there would be no government intervention in the foreign exchange market, the exchange rate can change instantly and without being subject to a limit. At the point where excessive demand for foreign exchange is eliminated, exchange rate equilibrium is restored. In case of an increase in foreign exchange supply, the supply curve will shift to the right in the form of S′ and the exchange rate will be E1′. A fall in the exchange rate would, on the one hand, increase the demand for foreign exchange by encouraging imports and, on the other hand, discourage exports and reduce foreign exchange revenues. As a result, the exchange rate equilibrium is restored at E0, where the excess in foreign exchange supply is eliminated (Demir, 2007:19).

3. Literature Review

The relationship between inflation and exchange rates holds significant importance in both theoretical and empirical literature. Advances in the field of econometrics enable more reliable analyses. The findings obtained vary from country to country, depending on the analysis methods used and the characteristics of the variables. Studies examining the impact of exchange rate volatility on inflation in Turkey and other countries are summarized in the table below.

Table 1. Domestic and International literature Studies on the Subject

Author or Authors	Period, Data Type and Variables	Method	Findings
Akdemir and Özdemir (2018)	2003:M1 and 2017:M6 (Monthly Data) Exchange Rate, Imports, Manufacturing and Consumer Price Index	SVAR Model	It had been also found that there is a non-complete transition effect in Turkey and that manufacturing industry prices are more affected by the exchange rate than the CPI.
Aksoy et al (2023)	2004-2021 (Monthly Data) Consumer Price Index, Producer Price Index and Real Effective Exchange Rate	ARDL Boundary Test Tado Yamamoto Causality Test	It has been found that in Turkey, the variables of exchange rate, inflation, and producer prices affect each other in the long run. Additionally, the Toda-Yamamoto causality test has determined that there is a bidirectional causality relationship between the exchange rate and producer prices and a unidirectional causality relationship from producer prices to inflation.
Alkan and Dağıdır (2020)	2005:M1-2019:M7 (Monthly Data) Average Dollar Exchange Rate, Average Euro Exchange Rate, Consumer Price Index and Producer Price Index	Maki (2012) Cointegration Test with Multiple Structural Breaks and Granger Causality Test	There is a bidirectional causality relationship between exchange rates and inflation indices.

Author or Authors	Period, Data Type and Variables	Method	Findings
Asad et al (2012)	1973 - 2007 (Annual Data) Growth Rate of Inflation, Growth Rate of Output, Growth Rate of Real Effective Exchange Rate, Growth Rate of Money Supply and Growth Rate of Money Velocity in The Economy	The Ordinary Least Square (OLS) Method	It is concluded that the real effective exchange rate has an impact on inflation in Pakistan.
Asafo (2019)	2006Q3 to 2017Q4 (Qarterly Data) Foreign Exchange Inflows (Forex), Nominal Effective Exchange Rate (NEER), Consumer Price Index (CPI), Government Bond Yield (LGBY) and Monetary Policy Rate (MPR)	Bayesian VAR Method	In the impulse response analysis, it is found that the depreciation of the exchange rate leads to an increase in prices in Ghana, and in the variance decomposition, it is found that monetary expansion is the most dominant factor in explaining inflationary pressures in Ghana
Baidoo et all (2023)	2002:M1 to 2018:M12 (Monthly Data) Inflation, Inflation Gap, Monetary Policy Rate, Exchange Rate, Output, Output Rate	The Threshold Autoregressive (TAR) Method	The study found that the exchange rate has a significant positive effect on inflation and monetary policy rate

Author or Authors	Period, Data Type and Variables	Method	Findings
Bozdağlıoğlu and Yılmaz (2015)	1994:M1 – 2014:M12 (Monthly Data) Nominal Exchange Rate and Inflation	VAR Analysis	In the study, it had been found that increases in the nominal exchange rate affect inflation, but shocks in inflation variables do not affect the nominal exchange rate.
Cabral et al (2020)	2000Q1 to 2015Q2 (Quarterly Data) Interest Rate and Exchange Rate	Dynamic Panel Methods	In the study after the 2008 global financial crisis, it was found that central banks in developing countries responded only to inflation movements in their interest rate reaction functions.
Çelkan (2023)	2013:M1to 2021:M12 (Monthly Data) Consumer Price Index, Weighted Exchange Rate, Trade-Weighted Consumer Price Index, Time Series of The Sum of The Log Difference of The Trade-Weighted Consumer Price Index and The Log Difference of The Weighted Exchange Rate	Regression Analysis	The study finds that the exchange rate pass-through to general consumer prices is 1.92% in the short run and 5.71% in the long run.

Author or Authors	Period, Data Type and Variables	Method	Findings
Duman (2019)	2003: Q1–2017: Q3 (Quarterly Data) Real Effective Exchange Rate, Consumer Price Index and GDP	VAR Analysis Granger Causality	According to Granger causality analysis, it had been determined that the real effective exchange rate affects inflation, and inflation in turn influences economic growth
Emikönel and Orhan (2023)	1990:M1-2020:M12 (Monthly Data) The Exchange Rate and Inflation	ARDL Model	In the countries included in the study, it has been determined that the exchange rate and inflation variables are cointegrated. Additionally, it has been found that the exchange rate does not have a significant long-term effect on inflation in Brazil, Turkey, and India, whereas it does have a significant effect on inflation in Indonesia and South Africa.
Gidigbi et al (2018)	1981 to 2015 (Annual Data) Inflation, Imports, Money Supply, Interest Rate, Public Expenditure, Foreign Direct Investment, Exchange Rate, Trade Openness	VECM: Error Correction Model	The Vector Error Correction Model (VECM) estimates indicate that all variables specified in the model are long-term Granger causes of inflation. However, no short-term relationship was found among the variables

Author or Authors	Period, Data Type and Variables	Method	Findings
Güneş. (2013)	2008M1-2012M11 (Monthly Data) Cnsumer Price Index, USD Dollar and Euro	Vector Error Correction Model (VECM) Analysis	The study has identified a long-term relationship between the price level and the exchange rates of the US dollar (USD/TRY) and Euro (EUR/TRY) in Turkey. The direction of this relationship has been determined to be from exchange rates to the price level. Consequently, it has been observed that as exchange rates increase, inflation also rises
Imimole and Enoma (2011)	1986–2008 (Annual Data) GDP, Exchange Rate, Money Supply and Inflation Rate	ARDL Boundary Test	They found that exchange rate depreciation, money supply and real gross domestic product are the main determinants of inflation in Nigeria and have a significant long-run impact on inflation in Nigeria.
Kaya (2018)	2003:M1-2016:M12 (Monthly Data) Crude Oil Prices, Exchange Rate and Inflation	VAR Model	In the study, it was found that in the medium term, import prices of crude oil have a more significant impact on inflation, accounting for approximately 28% of inflationary movements. Conversely, in the short term, exchange rates were found to be more influential, explaining approximately 15% of inflation.

Author or Authors	Period, Data Type and Variables	Method	Findings
Kaygısız (2018)	2002M1-2016M4 (Monthly Data) Producer Price Index, Nominal Exchange Rate, Industrial Production Index, M1 Money Supply and Imported Crude Oil Prices	VAR Model	It has been determined that inflation's response to the exchange rate ends after 16 periods, and that 20% of the changes in inflation are due to the exchange rate. Additionally, the exchange rate has been found to affect inflation to the same extent in both the short term and the long term.
Keefe (2020)	2002: Q1 to 2016: Q4 (Quarterly Data) Interest Rate and inflation Gap, Output Gap and Exchange Rate	Dynamic Panel Threshold Regression Model	Both developing and developed economies have been found to adhere to their inflation targeting commitments when exchange rate volatility is below 1%. However, it has been observed that once volatility surpasses this threshold, central banks are either unable or unwilling to respond to deviations in inflation gaps.
Kennedy and Nourizad (2016)	1999:M1 – 2010:M1 (Weekly Data) Fed_Surprise, Bear Market, VIX, Nine_ Eleven, M2 Growth, Negatif_Return, Real_Sector, Crisis	GARCH (1,1) Model	The study found that the September 11 terrorist attacks, bear markets, fluctuations in unemployment claims, and negative stock market returns increased financial volatility

Author or Authors	Period, Data Type and Variables	Method	Findings
Korkmaz and Bayır (2015)	2003:M1-2014:M11 (Monthly Data) Nominal Effective Exchange Rate, Producer Price Index and Consumer Price Index	VAR Model Granger Causality Test	A unidirectional causality relationship has been identified from the exchange rate to the producer price index and from the consumer price index to the exchange rate
Lado (2015)	2011M8 - 2014M11 (Monthly Data) Exchange Rate and Consumer Price Index	Granger-Causality Test	In the study, a unidirectional causality from the exchange rate to the CPI was found without feedback.
Madesha et al (2013)	1980 - 2007 (Annual Data) Exchange Rate and Inflation	Granger Causality Test	In the study, a long-term relationship between the exchange rate and inflation has been identified. Additionally, it has been found that during the examined period, inflation and the exchange rate Granger-cause each other
Mignon and Villavicencio (2017)	1994Q1 to 2015Q3 (Qarterly Data) Import Price Index, Consumer Price Index, Nominal Effective Exchange Rate	Fixed Effect and Dynamic Generalized Method of Moments (GMM) Panel-Data Estimators	The study finds that inflation targeting, and transparent implementation of monetary policy decisions significantly reduce the exchange rate pass-through to consumer prices.

Author or Authors	Period, Data Type and Variables	Method	Findings
Monfared and Akın (2017)	1976-2012 (Annual data) 1997: Q3 - 2011: Q4 (Quarterly Data) Money Supply, Inflation and Exchange Rate	Hendry Method VAR Model	In the study, the Hendry model identified a direct relationship between the exchange rate and inflation. In the VAR model, it was found that both money supply and the exchange rate positively influence inflation, with the impact of money supply on inflation being greater than that of the exchange rate.
Mugambi et all (2024)	2005:M1 to 2023:M11 Monthly Data Inflation Exchange Rate Monetary Policy Rate Broad Money Supply M2 Global Oil price	The Non-Linear Threshold Autoregressive (TAR) Model	The study finds that the relationship between exchange rate depreciation, inflation and monetary policy is non-linear and that there is a larger pass-through effect when exchange rate depreciation is high
Nuhu (2021)	1986-2019 (Annual Data) Consumer Price Index, Nominal Exchange Rate, Money Supply, Imports and Exports	Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Vector Error Correction Model (VECM)	The study has found a long-term relationship among the variables, and additionally, it has been observed that money supply and nominal exchange rate have a positive and significant effect on the consumer price index. Therefore, it is concluded that inflation in Nigeria is driven not only by exchange rate fluctuations but also by increases in money supply.

Author or Authors	Period, Data Type and Variables	Method	Findings
Olamide et al (2022)	2000 – 2018 (Monthly Data) Inflation, Oil Prices, Economic Growth and Exchange Rate	Panel Data Analysis	The study found that exchange rate instability and inflation have a negative relationship with the economic growth of the region.
Özen et al (2020)	2016:M7 - 2019:M6 (Monthly Data) Producer Price Index, PPI Consumer Price Index, CPI Dollar Selling Rate USD, CBRT Overnight Interest Rates and Interest Rates of the Commercial Banks Credit IRBC	Fully Modified Least Squares (FMOLS) Estimation Method Johansen Co-integration Test Granger Causality Test.	According to the results of the FMOLS regression model, it had been determined that the effect of the USD exchange rate on the Producer Price Index was larger than that of the bank loan interest rates. Moreover, Granger causality analysis had revealed a unidirectional causality relationship from loan interest rates to PPI, overnight interest rates to PPI and USD exchange rates to PPI.
Özçiçek (2010)	1994:M1 to 2007:M3 (Monthly Data) Nominal Exchange Rate, Consumer Price Index, Producer Price Index and M1-Money Supply	ARCH Model	In Turkey, the pass-through effect of the exchange rate on inflation has been found to be quite low. This effect is stronger in trade-related sectors, whereas in non-trade-related sectors, such as the services sector, the pass-through effect is weaker.

Author or Authors	Period, Data Type and Variables	Method	Findings
Sesan (2013)	1986 – 2012 (Annual Data) Inflation, Exchange Rate, Money supply, Fiscal Deficit, GDP	Johansen Julius Cointegration Test, VAR Model, Granger Causality Test	Cointegration test detected a long-run relationship between the variables. VECM analysis revealed a positive relationship between inflation, exchange rate, money supply and fiscal deficit and a negative relationship with gross domestic product. Granger causality test revealed a bidirectional relationship between all variables.
Shaari et al (2012)	2005 – 2011 (Monthly Data) Oil Price Shock, Exchange Rate and Inflation	VECM and Granger Causality Test	Long-term cointegration has been found among all variables at a significance level of 5%. However, in the short-term analysis, only the inflation rate was found to be influenced by crude oil prices. The Granger causality test indicated that inflation does not Granger-cause the exchange rate, but it Granger-causes the price of crude oil.
Şeker (2022)	2004Q1to 2021Q4 (Qarterly Data) Consumer Price Index (CPI), Producer Price Index (PPI) and Real Exchange Rate	VAR Model	In the study, unidirectional causality was found from exchange rate to producer and consumer price indices and from producer price index to consumer price index

Author or Authors	Period, Data Type and Variables	Method	Findings
Şen et all (2020)	2013:M1 to 2018:M12 (Monthly Data) Inflation, Interest Rate and Exchange Rate	ADL Tests for Threshold Cointegration	For the countries analyzed in the study, a positive long-run relationship was found between inflation rates and nominal interest rates. Moreover, a cointegrated relationship between interest rates and exchange rates was found for Brazil, India and Turkey.
Timothy et al (2016)	1970:1-2014:4 (Quarterly Data) Inflation Rate, Imported Inflation, Large Money Supply and Nominal Exchange Rate	Granger Causality in Vector Auto-Regressive Environment GARCH (1,1)	According to the results of the Granger causality test, there is a one-way causality from inflation to real exchange rate volatility, and a one-way causality from all sample variables to imported inflation. Moreover, the analysis of the GARCH (1,1) model reveals that the conditional variance of real exchange rate volatility is sensitive to the inflation rate, imported inflation, broad money supply, and lagged nominal exchange rate.
Tümtürk (2017)	1994:M1 to 2016:M9 (Monthly Data) Producer Price Index for Turkey Producer Price Index for the USA GDP for Turkey Nominal Exchange Rate (USD	Least Squares Method (OLS)	The study finds that the pass-through effect of exchange rate changes on domestic prices tends to decrease with inflation targeting.

Author or Authors	Period, Data Type and Variables	Method	Findings
Türk (2016)	1987- 2013 (Annual Data) Consumer Price Index (CPI), Wholesale Price Index (WPI) and Nominal Exchange Rate	Vector Autoregressive (VAR) Model Granger Causality Test	In the study, the effect of exchange rate on inflation was found to be significant, while the effect of inflation on exchange rate was found to be insignificant.
Yüksel and Baycan (2022)	1985 to 2019 (Annual Data) Exchange Rate, Inflation and GDP	Propensity Score Matching Methods	The study finds that the adoption of the inflation targeting policy leads to lower exchange rate volatility in all economies included in the analysis.

4. Data Set and Methodology

The study analyses the causality, cointegration and short-run relationship between inflation, exchange rate and M1 money supply. The aim of the study is to support the presumed relationship among the variables examined with empirical findings. Therefore, the study aims to investigate the impact of exchange rates and M1 money supply on inflation by adopting a quantitative analysis technique and utilizing the monthly logarithmic data of the variables examined. This study employs empirical analysis and focuses solely on the three parameters under examination. The parameters used in the study are the consumer price index representing inflation, the nominal exchange rate, and the M1 money supply. The following equation is the estimation equation to be used in this study:

$$\mathrm{Inf}_t = \alpha_0 + \alpha_1 \mathrm{Exc}_t + \alpha_2 \mathrm{M1}_t + \varepsilon_t \quad (2)$$

In the equation, Inf_t represents the consumer price index at time t, Exc_t represents the nominal exchange rate at time t and $M1_t$ represents the M1 money supply at time t, ε_t ; represents the error term at time t

In this study, the impact of exchange rate volatility on inflation in Turkey had been analyzed within the framework of the VAR model. The nominal dollar exchange rate had been used to represent the exchange rate, while the consumer price index (CPI) is used to represent inflation. Additionally, based on the approach that inflation is caused by monetary factors, the money supply defined by M1 had been used to indicate the impact of monetary policy.

In the study, the presumed relationship between the exchange rate and inflation was modeled by using variance decomposition based on the VAR model. The sources of shocks in the exchange rate and money supply, which are considered to affect the general price level

and the degree to which these variables influence each other, has been analyzed using variance decomposition obtained from the VAR model. The duration of the impact of these shocks had been analyzed using impulse response functions. The study utilized the logarithmic values of monthly data for a total of three variables inflation, exchange rate and M1 money supply covering the period from January 2003 to May 2024. The monthly data for the analysis period, comprising a total of 257 observations, was obtained from the Central Bank of Turkey's Electronic Data Distribution System (EVDS).

In the study, unit roots of the time series had been examined using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Causality relationships had been determined using the Granger causality test. Additionally, cointegration and short-term relationships within the VAR model framework had been evaluated using the EViews 10 software package. The variables used in the study and their sources had been shown in Table 2 below:

Table 2. Variables and Dataset Used in The Study

Symbol	Descriptions of Abbreviations	Analysis Period	Data Source
Inf	TUIK Price Index (Consumer) (2003=100)	January 2003-May 2024	TCMB
Exc	Nominal Exchange Rate (Buying Foreign Currency TL/$)	January 2003-May 2024	TCMB
M1	Money Supply Defined by M1 (Thousand TRY)	January 2003-May 2024	TCMB

In this study, the logarithms of all variables were taken for analysis. The money supply, defined as M1, was used in the study to emphasize the role of money supply as an important cause of inflation. Besides, nominal exchange rates were employed instead of real exchange rates to better illustrate the exchange rate-inflation relationship. The

Consumer Price Index (CPI) was used to represent inflation, aiming to observe changes in other variables without delay.

The null and alternative hypotheses for the research are formulated as follows.

H_0: Exchange rate and M1 money supply have no statistically significant effect on inflation in Turkey.

H_1: Exchange rate and M1 money supply have a statistically significant effect on inflation in Turkey.

4.1. VAR Model (Vector Autoregressive) Method)

The VAR model, developed by Sims (1980), had been designed to model the relationships between variables without distinguishing which variables are endogenous and which are exogenous. VAR models are systems of equations in which each endogenous variable is expressed as a function of its own lagged values as well as the lagged values of all other variables in the system. In this model, all variables are considered endogenous. The VAR model is typically used to analyze the dynamic effects of changes in one variable on the other variables in the system (Türk, 2016:94)

The VAR model allows all parameters to be predicted mutually and consistently in a single model. For parameters to predict each other effectively, there should be a meaningful relationship among them. Therefore, in the VAR model, keeping the number of variables as low as possible enhances the accuracy of forecasts. Otherwise, the inclusion of an irrelevant variable in the VAR model leads to prediction and forecasting errors. The VAR model, widely used in economic time series analysis, distinguishes itself from other simultaneous equation systems by its ability to model both endogenous and

exogenous variables together without distinction. VAR models are used primarily to analyze the relationships between macroeconomic variables and the dynamic effects of random shocks on the system of variables. VAR models are systems where each variable is linearly related to its own lagged values and the lagged values of all other variables in the system. In other words, it is a dynamic framework that encompasses the relationships of each variable within the system with its own past values and the past values of all other variables. In this structure, without any restrictions, it means that the same variables will appear on the right-hand side of each equation in the VAR model. Additionally, in VAR models, including lagged values of dependent variables allows for more robust predictions in the future (Monfared and Akın, 2017:332-333).

In this context, the three-variable VAR model that we will use to analyze the effect of exchange rate on inflation in Turkey can be presented as follows.

$$Inf_t = \theta + \sum_{i=1}^{k} \beta_i \, Inf_{t-1} + \sum_{j=1}^{k} \vartheta_j \, Exc_{t-j} + \sum_{m=1}^{k} \varphi_m \, M1_{t-m} + \mu_{1t} \quad (3)$$

$$Exc_t = \theta + \sum_{i=1}^{k} \beta_i \, Inf_{t-1} + \sum_{j=1}^{k} \vartheta_j \, Exc_{t-j} + \sum_{m=1}^{k} \varphi_m \, M1_{t-m} + \mu_{2t} \quad (4)$$

$$M1_t = \theta + \sum_{i=1}^{k} \beta_i \, Inf_{t-1} + \sum_{j=1}^{k} \vartheta_j \, Exc_{t-j} + \sum_{m=1}^{k} \varphi_m \, M1_{t-m} + \mu_{3t} \quad (5)$$

In the equations, θ is the constant term, β, φ and ϑ are the coefficients to be estimated; μ_{1t}, μ_{2t} and μ_{3t} are the error terms.

In VAR models, the relationships between variables are examined using Impulse-Response Functions based on Variance Decomposition and Granger causality tests. VAR modeling is highly sensitive to the choice of lag length. Therefore, in VAR analysis, the lag length of variables included in the model should be chosen to accurately reflect the dynamic relationships between variables.

4.2. Descriptive Statistics

Before estimating the variables analyzed in the study, descriptive statistics were first calculated in order to have information about the general characteristics of the time series of the variables. The findings obtained had been presented in Table 3 below.

Table 3. Descriptive Statistics

	INF	EXC	M1
Mean	5.573238	1.083247	19.26164
Median	5.411244	0.670239	19.17961
Maximum	7.732742	3.474179	22.43092
Minimum	4.551453	0.157377	16.48732
Std Deviation	0.747426	0.896014	1.483616
Skewness	1.003680	1.118902	0.290807
Kurtosis	3.500548	3.177937	2.427197
Jarque-Bera	45.83211	53.96387	7.135799
Probability	(0.0000000)	(0.000000)	(0.000000)
Observation	**257**	**257**	**257**

Table 3 illustrates that the performance of the variables measured by the average return is higher for M1 money supply. In addition, M1 money supply has a higher volatility than the other variables analyzed with a value of 1.48 standard deviation, while the lowest standard deviation, i.e. volatility, belongs to inflation with a value of 0.74 standard deviation. In general, it can be said that the volatility of the variables is high. For all variables, Jarque-Berra statistics probability values less than 0.05 means that the time series do not show a normal distribution. Moreover, all variables have positive skewness. However, money supply defined by M1 has a lower skewness of 0.29 compared to the others. It is observed that the kurtosis value is relatively lower in M1 money supply compared to other variables. it can be said that the kurtosis values of the variables in general are close to the accepted values.

4.3. The Correlation Matrix Between Variables

The correlation matrix results for the variables analyzed in the study are presented below in Table 4

Table 4. Correlation Matrix Results Between Variables

	INF	EXC	M1
INF	1		
EXC	0.97552386	1	
M1	0.97620801	0.932823490	1

When the results of the correlation matrix in Table x are analyzed, it is noteworthy that there is a very strong relationship of 0.97 between the variables. This indicates that the variables affect each other significantly in the short term.

5 Findings of the Study

In this section, the results of unit root, Granger causality, cointegration, and VAR tests obtained through econometric techniques used in the study had been presented.

5.1. Unit Root Test Results

In the study, the extended Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, which are commonly used unit root tests, were chosen to examine whether the time series are stationary. These tests help to determine whether the time series is stationary by evaluating whether the time series contains a unit root. The hypotheses for these tests had been formulated as follows:

H0: The time series contains a unit root.

H1: The time series does not contain a unit root.

Table 5. Unit Root Test Results

	Augmented Dickey Fuller (ADF)					
	With Constant		**With Constant & Trend**		**Without Constant & Trend**	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*
Inf	4.9824 1.0000	-3.2267 0.0196	4.1704 1.0000	-4.3070 0.0036	2.9051 0.9992	-1.5763 0.1081
Exc	3.6098 1.0000	-11.0445 0.0000	-0.1914 0.9930	-12.1435 0.0000	5.1206 1.0000	-7.2323 0.0000
M1	0.8529 0.9948	-18.9434 0.0000	-0.4032 0.9870	-18.9625 0.0000	7.6359 1.0000	-3.4613 0.0006
	Phillips Perron (PP)					
	With Constant		**With Constant & Trend**		**Without Constant & Trend**	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*	t-Statistic *Prob*
Inf	6.5930 1.0000	-7.2370 0.0000	5.3876 1.0000	-8.2893 0.0000	6.2082 1.0000	-5.1126 0.0000
Exc	4.0762 1.0000	-10.1602 0.0000	-0.0421 0.9956	-10.5824 0.0000	6.0123 1.0000	-9.9280 0.0000
M1	0.7383 1.0000	-18.7832 0.0000	-0.6546 0.9745	-18.8410 0.0000	8.0143 1.0000	-17.1543 0.0000

When Table 5 is analyzed, it had been found that the exchange rate (Exc) variable is stationary in the Phillips Perron (PP) test in the model with constant & trend and does not contain unit root with its level value. The other variables had been determined to have a unit root at their level values and therefore were non-stationary. When the first order differences of the time series were taken, it had been found that they became stationary at 1% significance level and became suitable for the test.

5.2. Granger Causality Tests

In the study, the causal relationship between the variables was analyzed using Granger causality tests based on monthly logarithmic data for the variables under investigation. Granger causality test is used to determine whether there is a causal relationship between time series data. For example, if variable X is the Granger cause of Y, and variable Y is the Granger cause of X, this implies that the future values of X can help in predicting Y, and the future values of Y can help in predicting X. The following equations represent the Granger Causality Regression Test Formulas for a bidirectional relationship between variable X and variable Y:

$$Y_t = \alpha + \sum_{i=1}^{p} \varphi_i \, Y_{t-1} + \sum_{i=1}^{q} \alpha_j \, X_{t-j} + \varepsilon_{1t} \quad (6)$$

$$X_t = \delta + \sum_{i=1}^{p} \vartheta_i \, X_{t-1} + \sum_{i=1}^{q} \theta_i \, Y_{t-j} + \varepsilon_{2t} \quad (7)$$

The Granger causality test is used to test the relationship between the current value of the first parameter and the past values of the second parameter. In this test, if the F-statistic is smaller than the critical F-value, it indicates that there is no Granger causality between the variables. In the study, the results of the Granger causality test had been evaluated at a significance level of 5%. The findings from the Granger causality test had been presented in Table 6 below.

Table 6. Granger Causality Tests Results

Null Hypothesis	Observation	F-Statistic	Prob	Causality
EXC does not Granger Cause INF	255	0.32029	0.7262	No
INF does not Granger Cause EXC		22.6279	0.0000	Yes
M1 does not Granger Cause INF	255	19.6581	0.0000	Yes
INF does not Granger Cause M1		0.92917	0.3962	No
M1 does not Granger Cause EXC	255	22.7804	0.0000	Yes
EXC does not Granger Cause M1		0.81082	0.4457	No

Table 6 indicates that there is a unidirectional causality relationship from M1 money supply to both exchange rate and inflation, and from inflation to exchange rate at 1% significance level. In this case, it can be stated that M1 money supply is the important indicator to be taken into account for inflation.

5.3. Cointegration Test

The main focus of this study is to analyze how inflation reacts to changes in the exchange rate and M1 money supply in the long run. Hence, co-integration test had been used to determine the relationship or long-run equilibrium between the variables. In this study, the Johansen procedure had also been applied to determine the long-term coefficients of the model Table 7 presents the results of the cointegration test. The results indicate that both the maximum-Eigen statistic and the trace statistic are significant at the 5% level among the three variables in the Turkish economy. This implies that there is a long-term equilibrium relationship between the variables.

Table 7. Cointegration Test Results

Null hypothesis	Max-Eigen Statistic	Critical value (Eigen) at 5%	Trace Statistic	Critical value (Trace) at 5%	Prob
r=0*	44.97241	21.13162	81.12669	29.79707	0.0000
r≤1*	29.60323	14.26460	36.15428	15.49471	0.0000
r≤2*	6.551053	3.841466	6.551053	3.841466	0.0105

When the table is analyzed according to the null hypothesis, the value of the trace statistic is 81.12669, which is above the critical value of 29.7971 at 5% significance level. This result indicates that there is a long-term relationship between the variables in this model at 5% significance level. The results for the maximum Eigen statistic indicate that there is a long-term relationship between the variables since the maximum Eigen statistic is 44.97241, which is higher than the

critical value of 21.1316 at 5% significance level. When the Trace and Maximum Eigenvalue statistics are compared to the critical values, the null hypothesis stating that there is no cointegrated vector between the variables had been rejected at 5% significance level. In other words, since the test statistics estimated for the variables are higher than the critical values at 5% significance level, the null hypothesis that there is no cointegration between the variables is rejected. Hence, it had been determined that the variables are cointegrated in the long run. A significant cointegration relationship between the variables means that the variables do not move independently of each other in the long run.

5.4. VAR Analysis Results

The VAR model has been extensively used in applied econometrics, particularly in macroeconomics and finance research, following Sims' (1980) pioneering work. The VAR model is a simple multivariate time series forecasting model based on the lagged values of all variables included in the model. Additionally, all variables in this model are defined as endogenous (Selim and Güven, 2014:138). In this section of the study, the results obtained from the VAR model had been presented.

5.4.1.VAR Model Lag Length Determination

In order to accurately forecast a VAR analysis, it is essential to first determine the appropriate lag lengths. For these lag lengths to be correctly identified, it is crucial that the series are stationary. The LR, FPE, AIC, SC, and HQ information criteria are methods used to determine lag lengths in VAR analysis. The results of these criteria for determining the appropriate lag length had been presented in the following Table 8

Table 8. VAR Lag Order Selection Criteria

Lag	logL	LR	FPE	AIC	SC	HQ
0	1515.330	NA	1.06e-09	-12.14723	-12.10485	-12.13017
1	1625.883	217.5551	4.71e-10	-12.96292	-12.79340	-12.89468
2	1654.332	55.29858	4.03e-10	-13.11914	-12.82248*	-12.99973*
3	1667.705	25.67115	3.89e-10*	-13.15426	-12.73047	-12.98367
4	1672.780	9.619839	4.01e-10	-13.12273	-12.57180	-12.90097
5	1685.735	24.24589*	3.89e-10	-13.15450*	-12.47644	-12.88157
6	1690.280	8.395446	4.03e-10	-13.11871	-12.31351	-12.79461
7	1699.346	16.53106	4.03e-10	13.11925	-12.18691	-12.74397
8	1704.279	8.875102	4.17e-10	13.08658	-12.02711	-12.66012

Note: LR denotes Lagrange Criterion, AIC denotes Akaike Information Criterion, FPE denotes Final Prediction Error Criterion, SC denotes Schwarz Criterion, and HQ denotes Hannan-Quinn Criterion. * Indicates the optimal lag length according to the criterion at a 5% significance level.

The lag length with the highest number of asterisks (*) is considered as the optimum lag length.

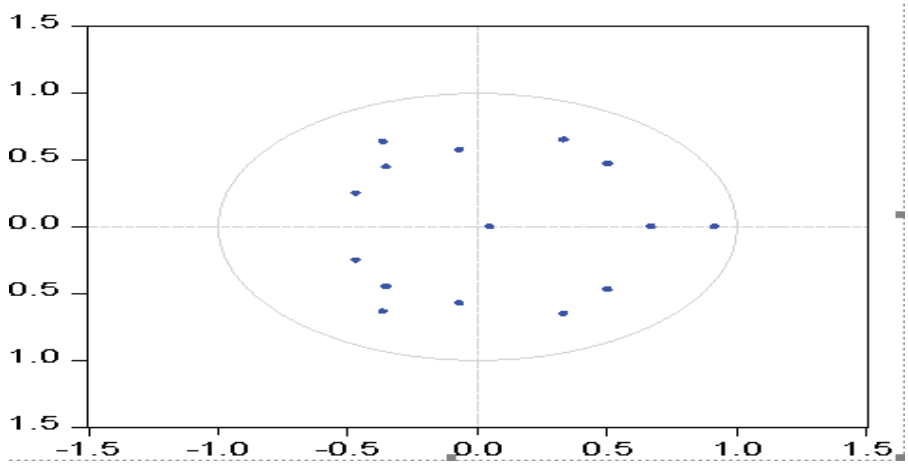
However, in case of autocorrelation problem in the VAR model estimated with this lag length, one of the later lag lengths should be selected (Kaygısız,2018:128).

According to Table 8, based on information criteria, the 2nd, 3rd, and 5th lags were deemed appropriate, and autocorrelation tests were conducted accordingly. Test results indicated the presence of autocorrelation issues at the 2nd and 3rd lags. Consequently, it was decided to estimate the VAR model with a 5-lag structure (VAR (5)). The results of the relevant autocorrelation analysis had been shown in Table 9 below.

Table 9. Autocorrelation Table

Lag Lenght	LM Test Statistic	Probability
1	19.52689	0.0290
2	18.26875	0.0422
3	14.07048	0.1198
4	8.611604	0.4739
5	8.949297	0.4420
6	4.211963	0.8969

Figure 2. Inverse Roots of AR Characteristic Polynomial



As can be understood from Table 9, the characteristic roots of the model estimated as VAR (5) are within the unit circle. This indicates that the model is stationary and stable. Besides, the results of the White test for heteroscedasticity in the model are as follows: the Chi-square value is 882.2748 with 810 degrees of freedom, and the obtained p-value is 0.0391. Therefore, it can be stated that there is no heteroscedasticity issue at the 1% significance level. Additionally, the test statistic of the Jarque-Bera normality test is estimated to be 141.19003 with 6 degrees of freedom, and the calculated p-value is 0.00000. Since the

p-value of the Jarque-Bera normality test is less than 0.05, it indicates that the series do not follow a normal distribution. In time series analyses, autocorrelation issues are generally more prominent, whereas heteroscedasticity problems are more significant in cross-sectional analyses. Since this study involves time series data, a 1% significance level had been considered sufficient for the heteroscedasticity test result.

5.4.2. Variance Decomposition

Variance decomposition is a commonly used statistical method for understanding complex structures within a wide range of variables. This method aims to explain the impact of one variable on others and trace its origins by analyzing relationships among internal variables. Variance decomposition analysis examines the causes of variations in the variance of a variable. In this way, it can be determined how much of the changes in a variable are due to its own internal factors and how much are due to other variables. In other words, the variance decomposition table shows how the forecast error variance of each variable is influenced by shocks to other variables in the system as well as by its own shocks. Fundamentally, variance decomposition is used to understand differences between variables and examine how internal factors respond to external influences (Akkaya, 2021: 213).

Using this method, the sources of changes in a variable can be identified. The variance decomposition results obtained from the estimated VAR model are presented in Table 10 below.

Table 10. Variance Decomposition of INF

Variance Decomposition of INF				
Period	**S. E**	**INF**	**EXC**	**M1**
1	0.011671	100.0000	0.000000	0.000000
2	0.014739	92.19168	0.611728	7.196592
3	0.015139	90.38608	0.592578	9.021341
4	0.015394	90.57657	0.592827	8.830608
5	0.015675	88.13388	0.571983	11.29414
6	0.016043	86.03074	1.241925	12.72734
7	0.016529	86.14559	1.422014	12.43240
8	0.016860	85.66145	1.392867	12.94569
9	0.017035	85.27001	1.466402	13.26359
10	0.017172	85.04621	1.488418	13.46537

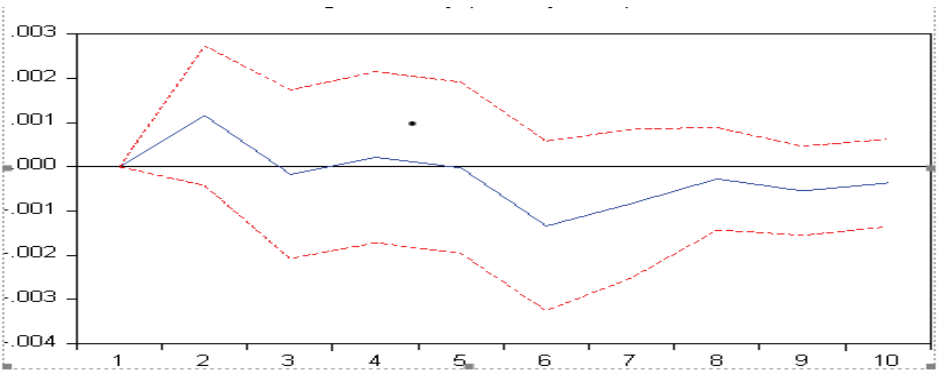
Note: The variance decomposition results were obtained using Cholesky decomposition.

The primary source of variance for all variables is their own internal shocks. Accordingly, in the medium and long term, M1 money supply is the most significant factor in forecasting inflation variance errors. As seen in Table 10, a substantial portion of inflation variations stem from M1 money supply. Table 10 illustrates the sources of deviations in inflation. In variance decomposition, shocks are applied to variables, and subsequently, it is determined which independent variables influence the dependent variable more. The Table shows that the deviation in inflation at the end of 10 periods is mostly caused by itself with 85.04, followed by M1 money supply with 13.46 and exchange rate with 1.48. According to this result, it is understood that the main cause of inflation in Turkey is the changes in M1 money supply. Therefore, the impact of M1 money supply on inflation appears to be significantly higher compared to the exchange rate. Based on this situation, it can be said that M1 money supply should be considered as an important policy variable to explain the causes of inflation in Turkey and to control inflation.

5.4.3. Impulse Response Analysis

In this section of the study, graphs illustrating the response of inflation to a standard error shock in exchange rates and M1 money supply had been presented. Monte Carlo simulation techniques were employed to derive the standard errors. Impulse-response analysis is a frequently used method for interpreting coefficients in VAR models. This methodology is used to understand how and to what extent variables respond when exposed to error terms in a VAR model. In the study analyzing the relationship between exchange rate and inflation in Turkey, the impulse-response functions obtained by using a trivariate VAR model had been presented in Figure 3 for a ten-period time horizon.

Figure 3: Response to INF to EXC Innovation Using Cholesky (d.f.adjusted) Factors

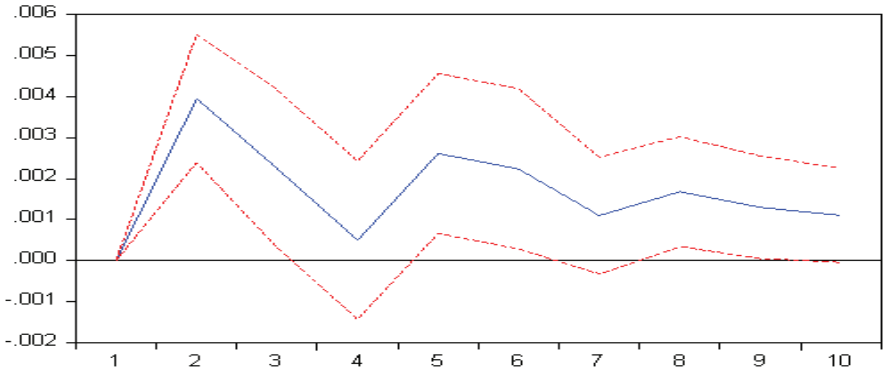


Note: The vertical axis represents the change in the response to a 1% exchange rate shock. The horizontal axis represents the time period (1 to 10 periods). The red dotted line represents the two standard error confidence bands around the prediction.

Figure 3 illustrates that changes in inflation vary across periods following a shock to the exchange rate. Following the exchange

rate shock, inflation shows a rapid increase until the second period. Between the second and third periods, a significant decline in inflation is observed, followed by a mildly fluctuating trend from the third to the fifth period. A sharp decrease in inflation occurs between the fifth and sixth periods, while an upward trend is seen from the sixth to the eighth periods. After the eighth period, inflation appears to follow a slightly fluctuating trend. Thus, the graph indicates that the response of inflation to the exchange rate shock lasts for eight periods and ends by the eighth period.

Figure 4. Response of INF to M1 Innovation Using Cholesky (d.f.adjusted) Factors



Note: The vertical axis represents the change in the response to a 1% exchange rate shock. The horizontal axis represents the time period (1 to 10 periods). The red dotted line represents the two standard error confidence bands around the prediction.

Figure 4 indicates that when a shock is applied to the M1 variable, inflation initially responds positively, rising rapidly until the second period. Following the second period, inflation declines sharply, reaching its lowest point by the fourth period. A decreasing trend in inflation is observed between the fifth and seventh periods, after

which it exhibits a mildly fluctuating pattern. In the inflation impulse response graph, it is observed that inflation's response to the M1 money supply persists for ten periods, exhibiting a slightly increasing and decreasing trend after the seventh period.

6. Conclusion

In countries like Turkey, a significant portion of raw materials and intermediate goods used in the manufacturing industry are imported. An increase in the exchange rate leads to a depreciation of the Turkish Lira against foreign currencies, thereby raising import costs. This rise in costs is directly reflected in consumer prices. Since energy prices are particularly tied to foreign currencies, an increase in the exchange rate triggers inflation and drives up the prices of essential consumer goods. Additionally, exchange rate fluctuations create economic uncertainty, which undermines consumer and investor confidence. This lack of confidence prompts firms to pass on cost increases to their prices more rapidly. This study empirically analyzes the effects of changes in the exchange rate and M1 money supply on the general price level in Turkey over the period from January 2003 to May 2024. The cointegration test results indicate that the variables move together in the long run. The Granger Causality test has identified the impacts of M1 money supply on both the exchange rate and inflation. These findings suggest that the M1 money supply is a significant determinant of inflation. According to the results obtained from the VAR model, variance decomposition analysis shows that, at the end of 10 periods, 85.04% of the deviation in inflation is explained by inflation itself, 13.46% by the M1 money supply, and 1.48% by the exchange rate. These findings indicate that the primary driver of inflation in Turkey is changes in the M1 money supply. The impulse response functions reveal that inflation's response to the exchange rate lasts for eight periods, while its response to the M1 money supply continues for ten

periods. Thus, it is concluded that both the exchange rate and the M1 money supply have a significant impact on inflation.

This study adds an original case study to the literature by empirically examining the relationship between exchange rate volatility and inflation in a developing economy such as Turkey. Given the distinct macroeconomic dynamics of developing countries, this research can fill a gap in the literature by providing regional and country-specific insights that go beyond the findings derived from developed nations. In this study, the interaction between the exchange rate and inflation is examined in the context of money supply, contributing to the literature by illustrating how these factors work together. The impact of monetary indicators, such as the M1 money supply, on inflation, especially when analyzed alongside exchange rate volatility, is believed to provide policymakers and economists with a more comprehensive macroeconomic framework. The study also illustrates how exchange rate volatility and changes in the money supply affect inflation in the context of Turkey, providing significant strategic insights for central banks and policymakers. By adding concrete results regarding the impact of exchange rate policies on inflation targeting to the literature, it is anticipated that this research will contribute to the policy-making process.

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