

e-ISSN: 2667-5773



# HALIÇ ÜNİVERSİTESİ SOSYAL BİLİMLER DERGİSİ

HALIÇ UNIVERSITY  
JOURNAL OF SOCIAL SCIENCES

**Cilt: 7 • Sayı: 2 • Eylül 2024**  
Volume: 7 • Issue: 2 • September 2024

---

**Haliç Üniversitesi Adına Sahibi** **Prof. Dr. Nihat İNANÇ**  
*Owner on behalf of Haliç University* Haliç Üniversitesi Rektörü / Rector of Haliç University

---

**Editörler** **Doç. Dr. G. Banu DAYANÇ KIYAT**  
*Editors* **Editör / Editor**  
**Arş. Gör. İlkay YURDAL**  
**Dergi Asistanı / Journal Assistant**

---

**Sorumlu Yazı İşleri Müdürü** **Yazgı Cihangir Aygün**  
*Publishing Manager*

---

**Yönetim Yeri** Haliç Üniversitesi  
*Head Office* Haliç University

---

**Yazışma Adresi** 5. Levent Mah.. 15 Temmuz Şehitler Cd. NO:14/12  
*Corresponding Address* 34060 Eyüpsultan – İstanbul  
Tel: 212 924 24 44  
E-posta: sosbd@halic.edu.tr

---

**İnternet Adresi** <https://dergipark.org.tr/tr/pub/husbd>  
*Web Address*

---

**Yayın Türü** Yerel Süreli / *Periodical*  
*Publication Type* Mart ve Eylül aylarında olmak üzere yılda iki sayı yayımlanır.  
09.08.2021 tarihi itibari ile online olarak yayım hayatına devam etmektedir.  
Published twice a year, in March and September  
e-ISSN: 2667-5773

---

**Asitsiz kâğıda basılmaktadır**  
*Printed on acid free paper*

---

**Baskı**  
*Printing Press*

---

**Basım Tarihi** 20.12.2024  
*Publication Date*

---

**Derginin Tarandığı Kaynaklar**  
*Index in*

**A S O S**  
**indeks**

---

---

**Yayın Kurulu**  
*Editorial Board*

Prof. Dr. Ahmet ERKUŞ (Bahçeşehir Üniversitesi)  
Prof. Dr. Cem Sefa SÜTÇÜ (Marmara Üniversitesi)  
Prof. Dr. Ekrem TUFAN (Çanakkale Onsekiz Mart Üniversitesi)  
Prof. Dr. Emel KARAYEL BİLBİL (Marmara Üniversitesi)  
Prof. Dr. Özgür ÇENGEL (İstanbul Galata Üniversitesi)  
Prof. Dr. R. Gülay ÖZTÜRK (İstanbul Ticaret Üniversitesi)  
Prof. Dr. Ramazan AKTAŞ (TOBB Üniversitesi)  
Prof. Dr. Z. Aslı ALICI (Haliç Üniversitesi)  
Doç. Dr. Aslı GÖKSOY (American University in Bulgaria)  
Doç. Dr. Aylin ÜNVER NOI (Haliç Üniversitesi)  
Doç. Dr. Banu DAYANÇ KIYAT (Haliç Üniversitesi)  
Doç. Dr. Selma ARIKAN (Medeniyet Üniversitesi)  
Dr. Öğr. Üyesi Furkan KAYA (Yeditepe Üniversitesi)  
Dr. Öğr. Üyesi Murat ÇAĞLAR (Akdeniz Üniversitesi)  
Dr. Öğr. Üyesi Nurdan GÜVEN TOKER (Haliç Üniversitesi)  
Dr. Öğr. Üyesi Şirin KARADENİZ (İstanbul Teknik Üniversitesi)  
Dr. Öğr. Üyesi Zerrin YANIKKAYA (Maltepe Üniversitesi)  
Öğr. Gör. Erdem AKGÜN (Haliç Üniversitesi)

---

**Danışma Kurulu**  
*Advisory Board*

Prof. Dr. Akın MARŞAP (İstanbul Aydın Üniversitesi)  
Prof. Dr. Atila YÜKSEL (Adnan Menderes Üniversitesi)  
Prof. Dr. Erdiç ÖZTÜRK (İstanbul Üniversitesi)  
Prof. Dr. Mehmet ARSLAN (Gazi Üniversitesi)  
Prof. Dr. Nuray TEZCAN (Haliç Üniversitesi)  
Doç. Dr. Erol DURAN (Çanakkale Onsekiz Mart Üniversitesi)  
Doç. Dr. Gözde ÖYMEN (İstanbul Ticaret Üniversitesi)  
Doç. Dr. Zelha ALTINKAYA (Yalova Üniversitesi)  
Dr. Öğr. Üyesi Atilla TEKİN (Adıyaman Üniversitesi)  
Dr. Öğr. Üyesi Birgül YEŞİLOĞLU GÜLER (Uludağ Üniversitesi)

---

---

**Cilt 7 Sayı 2**

Doç. Dr. Gökçe MARAŞ

**Hakem Listesi**

Doç. Dr. Merve KEKEÇ

*Volume 7 Issue 2*

Dr. Öğr. Üyesi Anıl Burcu ÖZYURT SERİM

*Reviewer List*

Dr. Öğr. Üyesi Gökçe KARAHAN ADALI

Dr. Öğr. Üyesi Melih ATALAY

---

## AMAÇ VE KAPSAM

---

Haliç Üniversitesi Sosyal Bilimler Dergisi Eylül 2018 tarihinden itibaren yılda iki kez yayınlamaktadır. Bu dergide sosyal bilimler, beşeri bilimler ve konservatuvar alanlarında araştırmaya dayalı Türkçe veya İngilizce dilinde özgün ve derleme makaleler yayınlamaktadır. Gönderilen makaleler hakemler tarafından incelenip değerlendirilir ve kabul edilen makaleler derginin web sayfasında online olarak yayınlamaktadır. 09.08.2021 tarihi itibari ile online olarak yayın hayatına devam etmektedir.

### Yayın Sıklığı

Haliç Üniversitesi Sosyal Bilimler Dergisi Mart ve Eylül aylarında olmak üzere yılda iki kez yayınlamaktadır.

### Yayın Koşulları

1. Gönderilecek makalelerde özet, abstract, şekil, tablo, metiniçi kaynak ve kaynakça gösterimi yazım kılavuzuna göre hazırlanmadığı durumda makale direkt reddedilmektedir.
2. Gönderilecek makalelerde alanında bir boşluğu dolduracak özgün bir araştırma sonuçlarını içermesi şartı aranır.
3. Yayın Kurulu, dergiye gönderilen makaleleri öncelikle yayın ilkeleri, dergi kapsamı, bilimsel içerik ve şekil açısından inceler. Ön incelemeden geçen makaleler değerlendirilmek üzere en az 2 hakeme gönderilir. Eserin dergiye kabul edilebilmesi için iki hakemden de olumlu değerlendirme alması gerekir. Gerektiği

durumlarda üçüncü hakemden de değerlendirme sürecine katkı sağlaması istenebilir. Son karar editöre aittir.

4. Yayınlanmak üzere gönderilen makalelerin daha önceden yayımlanmamış olduğu ve intihal içermediği iThenticate aracılığıyla teyit edilir. Benzerlik raporu dergi editörleri tarafından kontrol edildikten sonra sonucu referanslar hariç %20 ve altında çıkan makaleler değerlendirilmek üzere hakemlere gönderilir. Sonucu referanslar hariç %20 üzerinde çıkan makaleler için yazardan düzeltme talep edilir. Gerekli düzeltmelerin 20 gün içerisinde yapılmaması durumunda makale reddedilir. Süreç içinde son karar editöre aittir.
5. Makale yazarlarından değerlendirme ve yayın işlemleri için herhangi bir ücret talep edilmez.
6. Makalelerin tüm sorumluluğu ilgili yazarlara aittir. Makaleler uluslararası kabul görmüş bilimsel etik kurallarına uygun olarak hazırlanmalıdır. Gerekli hallerde Etik Kurul Raporu'nun bir kopyası eklenmelidir.
7. Bireysel kullanım dışında, Haliç Üniversitesi Sosyal Bilimler Dergisi'nde yayınlanan makaleler, şekiller ve tablolar yazılı izin olmaksızın çoğaltılamaz, bir sistemde arşivlenemez veya reklam ya da tanıtım amaçlı materyallerde kullanılamaz. Bilimsel makalelerde, uygun şekilde kaynak gösterilerek alıntılar yapılabilir.

### **Açık Erişim Politikası**

Haliç Üniversitesi Sosyal Bilimler Dergisi açık erişim politikasını benimsemiş bir dergidir.

## **Makale Yazım Kuralları**

“Yazar Rehberi”ni bilgisayarınıza derginin web sayfasından indirebilirsiniz.

## **Yazıların Bilimsel ve Hukuki Sorumluluęu**

Yayınlanan makalelerin bilimsel ve hukuki sorumluluęu yazarlarına aittir. Yazıların içerięinden ve kaynakların doęruluęundan yazarlar sorumludur. Editör, Yardımcı Editör, Yayın ve Danıřma Kurulu Üyeleri ve Yayımcı, dergideki hatalardan veya bilgilerin kullanımından doęacak olan sonuçlardan dolayı sorumluluk kabul etmez.

## **Yayın İzni**

Bireysel kullanım dıřında, Haliç Üniversitesi Sosyal Bilimler Dergisi’nde yayınlanan makaleler, řekiller ve tablolar yazılı izin olmaksızın çoęaltılamaz, bir sistemde arřivlenemez veya reklam ya da tanıtım amaçlı materyallerde kullanılamaz. Bilimsel makalelerde, uygun řekilde kaynak gösterilerek alıntılar yapılabilir.

## **Telif Hakkı Düzenlemesi**

Telif hakkı devir formu doldurulmalıdır.





## EDİTÖRDEN MEKTUP

---

Değerli okurlar,

Haliç Üniversitesi Sosyal Bilimler Dergisinin 2024 Yılı Eylül sayısını sizlere sunmaktan büyük mutluluk duyuyoruz. Yılda iki kez elektronik baskı halinde yayınlanan dergimizin bu baskısında iki iktisat ve bir yönetim bilişim alanında olmak üzere toplamda üç araştırma makalesini sizler ile buluşturuyoruz. Başlangıçtan itibaren kalitemizi ve okuyucu sayımızı yükselmeyi hedef edindik. Dergimizin bu sayısının da siz okurlarımıza yararlı olmasını dileriz.

Dergimize makale göndererek bilimsel katkı sunan tüm yazarlarımıza, bu makaleleri kıymetli zamanlarını ayırarak değerlendiren hakemlerimize ve derginin hazırlanmasında emeği geçen adanmışlık içerisinde çalışan tüm akademik ve idari çalışma arkadaşlarımıza içten teşekkürlerimizi sunarız.

Doç Dr. Gül Banu DAYANÇ KIYAT  
Editör



## İçindekiler / Contents

---

### Araştırma Makaleleri / Research Articles

#### İktisat

##### **Covid-19 Pandemisi Sırasında Küresel Piyasalarda Para Politikalarının ve Finansal İstikrar Tedbirlerinin Etkisinin Analizi**

Analyzing The Effect of Monetary Policies and Financial Stability Measures Across Global Markets amid Covid-19 Pandemics

**Rabia ÖZKAYA** ..... 111-141

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

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

**İbrahim Halil UÇAR** ..... 143-191

#### Yönetim Bilişim

##### **Makine Öğrenme Yöntemleri Kullanılarak EEG Tabanlı Duygu Sınıflandırma Araştırmaları Üzerine Bibliyometrik Analiz**

Bibliometric Analysis on EEG-Based Emotion Classification Research Using Machine Learning

**Selma İlknur UĞUR, Nesibe MANAV MUTLU,**

**Kübra EROĞLU** ..... 193-212



## Analyzing The Effect of Monetary Policies and Financial Stability Measures Across Global Markets amid Covid-19 Pandemics

Rabia ÖZKAYA<sup>1\*</sup>

<sup>1</sup>Haliç Üniversitesi, İstanbul  
Orcid Numarası: 0000-0002-0132-8441

\*Sorumlu Yazar e mail: rabiaozkaya@yahoo.com Geliş Tarihi: 01.08.2024  
Kabul Tarihi: 18.11.2024

Atf/Citation: Özkaya , R. (2024). "Analyzing The Effect of Monetary Policies and Financial Stability Measures Across Global Markets amid Covid-19 Pandemics", *Haliç Üniversitesi Sosyal Bilimler Dergisi* 2024, 7(2): 111-141.

### Abstract

This study investigates causal relationships among financial stability measures and monetary policies implemented in the US, the EU, and Türkiye. Selected variables from stock markets, money markets, and bond markets are tested. The set of macrofinancial process covers S&P500 stock market, BIST-100 stock market; Volatility index; German, the US and Türkiye 10-year treasury bond interest data, the European Union 27 average CPI, US CPI, Turkey CPI, ECB policy rate, FED policy rate, CBRT policy rate data. Initially, the Granger causality analysis is applied for the each dataset of the US, the EU and the Turkish economy, separately. Secondly, mutual impact of stock markets, money markets and bond markets are examined. Finally, CBOE Volatility index (VIX) is taken into account. It is aimed to observe spillover effects from developed economies to emerging markets amid pandemics. The dataset covers the monthly period of 2019M1 to 2023M6.

**Keywords:** Granger Causality, Monetary Policy, Financial Stability, Volatility Index, Stock Market, European Central Bank

# Covid-19 Pandemisi Sırasında Küresel Piyasalarda Para Politikalarının ve Finansal İstikrar Tedbirlerinin Etkisinin Analizi

## Öz

Bu çalışma, ABD, AB ve Türkiye’de uygulanan para politikaları ile finansal istikrar tedbirleri arasındaki nedensel ilişkileri araştırmaktadır. Hisse senedi piyasaları, para piyasaları ve tahvil piyasalarından seçilen değişkenler test edilmiştir. Makrofinansal süreç seti S&P500 hisse senedi piyasası, BIST-100 hisse senedi piyasası; Volatilite endeksi; Almanya, ABD ve Türkiye 10 yıllık hazine bonosu faiz verileri, Avrupa Birliği 27 ortalama TÜFE, ABD TÜFE, Türkiye TÜFE, ECB politika faizi, FED politika faizi, TCMB politika faizi verilerini kapsamaktadır. Granger nedensellik analizi ilk olarak; ABD, AB ve Türkiye ekonomisine ait her bir veri seti için ayrı ayrı uygulanmıştır. İkinci olarak, hisse senedi piyasaları, para piyasaları ve tahvil piyasalarının karşılıklı etkisi incelenmiştir. Son olarak CBOE Volatilite endeksi (VIX) dikkate alınmıştır. Salgınlar sırasında gelişmiş ekonomilerden gelişmekte olan piyasalara yayılma etkilerinin gözlemlenmesi amaçlanmaktadır. Veri seti 2019M1 ile 2023M6 arasındaki aylık dönemi kapsamaktadır.

**Anahtar Kelimeler:** Granger Nedensellik, Para Politikası, Finansal İstikrar, Volatilite Endeksi, Borsa, Avrupa Merkez Bankası

## 1. Introduction

The global pandemic that began in 2019 has profoundly reshaped economies worldwide, influencing financial and monetary policies in ways never before seen. The crisis has led to dramatic shifts in how countries manage their economies, with significant implications for financial stability, inflation, and economic growth. As the pandemic unfolded, governments and central banks implemented a range of financial and monetary measures to mitigate the economic fallout. These responses included substantial fiscal stimulus packages, changes in interest rate policies, and modifications to inflation-targeting strategies with macroprudential measures. Such measures were designed to cushion the impact on businesses and consumers,

stabilize financial markets, and ensure economic recovery. The effects of these policies are particularly evident in emerging market economies, which faced unique challenges during the crisis. Many of these economies grappled with increased financial risks, such as currency volatility and capital flight, while simultaneously striving to control inflation and manage debt levels. The interplay between global financial strategies and local economic conditions created a complex landscape for policymakers.

To better understand the broad impacts of the pandemic and the effectiveness of various policy responses, we analyzed monthly data from 2019M1 to 2023M6. This period encompasses the onset of the pandemic, its peak disruptions, and the subsequent phases of recovery. By examining this data, we can gain insights into how financial and monetary policies have influenced global and local economies, the behavior of financial markets, and the overall economic environment.

We select the US, EU and Turkish economies to examine the interaction between the global economy and emerging market economies. The US economy and EU economies also differ in terms of the price instability problems they face and hence their reactions to them. (Lutkepohl and Netsunajev, 2018:6-36). While supply chain disruptions and supply constraints, especially during the pandemic period, created inflationary pressure in the US economy. And the Ukraine crisis and rising energy prices contributed to inflation in the EU economies. Changing consumption behavior and increased saving surplus, wealth effect in both developed economies also impacted services price level. As an emerging market, the Turkish economy, faced external financing problems and turned to an expansionary fiscal policy and loose monetary policy. This also yields a powerful rise in inflation. While it was a less costly process for the US and EU economies to control inflation in terms of normalization processes. The same is not the case for Turkey.

This study investigates causal relationships among selected variables from stock markets, money markets, and bond markets. Selected variables are tested. The set of macrofinancial process covers S&P500 stock market, BIST-100 stock market; Volatility index; German, US and Turkey 10-year treasury bond interest data, European Union 27 average CPI index, US CPI index, Turkey CPI index, ECB policy rate, FED policy rate, CBRT policy rate data as shown in Table 3.

The Granger causality analysis is applied for first; each dataset of US, EU and the Turkish economy, separately. Second, mutual impact of stock markets, money markets and bond markets are examined. Finally CBOE Volatility index (VIX) is taken into account. It is aimed to observe spillover effects from developed economies to emerging markets amid pandemics. The dataset covers the monthly period of 2019M1 to 2023M6.

The foreign share in BIST100 stock market has been gradually decreased after 2019 and fell below 1%. The fact that the causality between VIX and BIST100 can be interpreted through the weight of the emerging markets index and the Banking index. However, we can observe that the causality coefficient is decreasing.

The increase in FED policy rate (FEDR) beginning from 2021 and the inflationary process of both the US and the EU economies explain why FEDR may affect DAX stock market. This effect is due to the ECB's policy rate path following the FED in the policy interest rate process. This follow-up still continues and shows itself in the EUR/USD parity process.

Although the data for the 2019-2023 period show that the macroeconomic variables of the US and the EU continue to interact, central bank of Turkey monetary policy moved away from the global financial system. Many of the causalities we observe in the



2008-2010 period were disappeared in this period and only Turkey's own macrofinancial variables themselves, they continue their causality with. This was due to the fact that the transaction volume of Turkish Lira with US dollars in the London interbank market decreased from 3% to 0.5%. In rival developing countries, such as Brasil and South Korea this level remains above 3%. The economic and political reason for this is the government's reaction to the exchange rate speculative attack that repeated several times after 2018. The fear that it would affect general elections and voting behavior led to the reduction of Turkey's financial openness. This is why the causality set is narrowing. Since protectionism is not as prominent in global financial markets as it is in the real economy, we did not observe this causality narrowing in US and EU macrofinancial variables.

## **2. Literature Review**

The method to be followed for this study involves several steps. First, we will examine and explain the relevant economic and financial theories. Next, we will research the main topics that have been determined and selected. This research will be conducted in a way that enables the evaluation of the subject. We will interpret the research and analyses made in previous years (see Table 1) to fully evaluate the main headings we are researching. Additionally, we will look at policy practices that have developed and updated over time. The aim of the study is to examine the effects of the current Central Banks. We will also analyze the applications of existing Central Banks. Finally, we will reach our conclusions by empirically analyzing the data we will examine.

Although many different ways of measuring volatility (Engle et.al.,2013:776-797) and causality have been mentioned in the literature different opinions have been put forward as to which measurement model is the best.

The relationship between inflation and stock market returns is controversial. Fama and Schwert (1977:115-146); Schwert G.W. (1989:1115-1456); Geske and Roll (1983:1-33) and Fama et al. (1989:23-49) found in their study that the relationship between inflation and stock returns is negative. It has supported international trade developments in studies carried out with developing stock exchanges. In these stock markets, the cause and effect relationship between macroeconomic data and stock returns is better understood. In studies conducted on developing stock markets, the majority of studies are conducted by countries using data from their own countries.

In their study, (You K. et al.2024:1-24) premises and undertakes a comprehensive analysis on the impact of the international trade aspect of the real economy on stock-market connectedness with both system-wide and pairwise directional evidence. They captured both export and import perspective between two economies in the latter analysis and examined whether imports induce stronger stock market spillover than exports. Consider a group of eleven economies: ASEAN 5 (Indonesia, Malaysia, the Philippines, Singapore, and Thailand), Australia, Brazil, China, Euro Area, Hong Kong (China), India, Japan, South Africa, UK and the US for period 2000 M1-2021 M6.

In their study, (Aytüre S. and Keskin M.2024:345-355) analysed the direction and degree of mutual impact of Türkiye's exports and imports on Borsa Istanbul. For this purpose, the relationship level between the periods 2013:01-2023:12 was examined with Causality and Cointegration tests in the BIST 100 index used in Borsa Istanbul, and its code is XU100, in the context of the stocks that are among the top hundred in terms of capital structure of Türkiye. It has been seen that foreign purchases and sales in both the short and long term are related to the BIST 100 performance and also cause the BIST 100 performance. However, it was determined that exports had a significant

positive effect on BIST 100 performance in the short and long term, while imports had a significant negative effect.

Sekula (2019:74-93) in his study; It examined the return rates of CAC 40, DAX 30, FTS 100, S&P 500, BUX (Budapest), PX (Prague), WIG (Warsaw) stock market indices with 4925 data between 31.12.1997-30.12.2016. Small stock markets have unstable economy, high risk and high returns. This means a lower return rate in developed stock exchanges such as Western Europe and the USA compared to the Central European Stock Exchanges. Granger causality uses VAR and Vector Error Correction (VECM) models. It is based on cointegration and stationarity analyzes of time variables. The VAR model is used to determine whether there is Granger causality in stationary variables.

Molnár A. and Csiszárík-Kocsir Á. (2022; 205-227), in their study they use the Johansen cointegration test; and assert that there exists a long-run relationship between the BUX composite stock indexes and the Hungarian GDP. From the ADL regression, based on the constructed models, it was determined that past values of Hungarian stock prices do in fact lead Hungarian economic growth, but they said this does not mean that stock prices Granger cause the economy. The Granger causality tests showed that there exists a causality between the BUX composite stock indexes and the Hungarian GDP.

Baker S.R. et. al. (2020:1-22) in their study; The Covid-19 pandemic, which spread from China's Hubei province, has caused volatility values to increase around the world. In the US, volatility levels in mid-March 2020 were last seen in October 1987 and December 2008, and before that in late 1929. It is difficult to explain the major stock market movements in 2020 with disruptions in cross-border supply chains. Since 1900, volatility from the coronavirus pandemic has peaked in an unusual way in history.

In his study, Özkaya and Altun (2024:1-14) found that the data except the central bank interest rates had a positive slope. It was shown that the kurtosis values of all data showed a sharp peak, and only the credit default swap (CDS) data was found to be stationary. It has been determined that the power over the volatility in the exchange rate is the lagged volatility. In the GARCH model (Engle, 1987:251-276), (Tsay,1987:590-604; 2002:81-110), testing the durable and long-term effects of variance and shocks is interpreted as the sum of these coefficients. A large sum of these coefficients indicates that large and negative shocks that can be predicted in the future will have large variance. It has been shown that exchange rate volatility is affected by past volatility and shocks. In the study, it was said that macroeconomic developments, politics and financial choices made by the government were the reason for the chaotic behavior in the exchange rate in Turkey. It has been said that these reasons increase the frequency of central bank intervention (Bernanke, 2005:1057-1592). This situation is observed by financial agents, and it is stated that the problem of trust in Turkish assets causes an increase in the risk premium in the global financial market and fluctuations in portfolios. Similarly, it has been shown that local financial agents choose dollarization, causing their savings in foreign currency to increase. It was stated that during this period, foreign currency investment in banks increased to the range of 60%-40% compared to Turkish Lira, and in developing economies, financial agents invested in foreign currency to protect their investments from financial loss, future fluctuations and high inflation. It has been stated that during the Covid-19 pandemic crisis, due to the expanding monetary and financial policies in the world, there was an increase in inflation and fluctuations in prices, which was seen in the decline in the VIX index and portfolio.

**Table 1.** Summary of Literature Review

Author	Method	Subject	Sample Info	Results
Lutkepohl and Netsunajev (2018:6-36)	VECM	Eurozone Monetary Policy and Stock Exchange Data	1999-2014	The long-term effect of a monetary policy shock on stock prices is limited to being neutral, and such a shock has a long-term negative effect on the stock market.
Sekula (2019:74-93)	Granger Causality	CAC 40, DAX 30, FTS 100, S&P 500, BUX, PX ve WIG indexes	1997-2016	Granger causality between indexes
Meher et al.(2020:422-431)	EGARCH	Crude oil and natural gas price volatility and Indian commodity exchange data during the pandemic period were examined.	2017-2020	The Covid-19 pandemic did not have a leverage effect on natural gas volatility, but it affected crude oil volatility.
You et al. (2024:1-24)	DYCI (Diebold-Yilmaz Connectedness Index) VAR	International trade and stock market connection. Composite Index, S&P500, STOXX, FTSE 100, UK, Hang Seng Composite, Nikkei 225, SASX 200, Africa All Share, Bovespa Index & Nifty 50 index	2000-2021	Imports and exports affect stock markets.
Farokhnia and Osterrieder (2020:1-15)	VIX Correlation and Granger Causality	S&P 500, VIX indexes	Ocak 2018-Şubat 2018	Granger causality between VIX and S&P 500 index

Author	Method	Subject	Sample Info	Results
Baek et al. (2020:1-10)	Markov Switching model-AR	VIX index, Covid-19 cases S&P 500 index, fiscal policy	Ocak 2020-Nisan 2020	The relationship between VIX index and mortality percentages and their impact on risk perception in the stock market
Ohmura (2020:1-7)	VAR-LINGAM	Japanese fiscal policy and financial processes	1980-2018	Causality relationship between stock returns and consumer behavior
Ünal (2020:772-789)	ARDL, CUSUM, ECM	Money supply/GDP; Budget Balance/GDP and Bist 100	2006-2019	Budget Balance/GDP and Bist 100 has reverse relationship; Money supply/GDP and has same direction
Trivedi (2021:63-72)	GARCH	Belgian and Indonesian stock exchanges were examined.	2018-2021	No significant correlation was found between the stock exchanges. The Jakarta stock exchange exhibited low volatility and suffered less losses than the Belgian stock exchange.
Aytekin and Uçan (2022:460-475)	Johanssen Coentegration, Granger Causality	Inflation, exchange rate, import-export	2004-2019	Causality relationship between exchange rate and inflation; causality between import and export

Author	Method	Subject	Sample Info	Results
Ozkaya (2022:1365-1380)	GARCH, Maximal Lyapunov exponent	Nonlinear stochastic analysis of USD Dolar/TL exchange rate	2019-2021	Volatility measurement was carried out
Ozkaya and Altun (2024:1-14)	GARCH, Maximal Lyapunov exponent	Exchange Rate Volatility of Turkish Lira	2019-2021	Exchange Rate Volatility of Turkish Lira is effected VIX and CDS
Vega et al. (2023:1-33)	VEC, Granger Causality, VAR	CPI, M2, imports price	2004-2022	Granger causality between indexes
Coşkuner and Özer (2024:15-24)	Johansen Coentegration, Granger Causality, VAR	Dollar/TL, Euro/TL, TUFE, Bist-100	2010-2021	Causality relationship between Bist-100 and Dollar/TL; Bist-100 and TUFE.
Yeboah and Lamin (2024:94-112)	ARDL, Granger Casuality	Foreign Direct Investment (FDI), GDP, Trade Openness, unemployment	1991-2022	Granger causality between FDI-GDP; External Debt-GDP; GDP-Trade openness; GDP-unemployment

**Source:** Author

## 2. Material and Method

The diversity of the selected data and the fact that the date range is up-to-date add a different perspective to the literature. The economic breaks caused by the uncertainty during the 2020 pandemic process are examined within the scope of the interest and monetary policies implemented by the selected central banks. We believe that this will make a significant contribution to the existing literature.

The aim of the research is to affect the stock market and economic data in line with the interest and monetary policies implemented by our own country's central bank and the world's two other largest central banks. In the study, data for the period 2019M1-2023M6 were used. In the analysis phase of the study, firstly, descriptive statistics of the existing data were determined and interpreted. Then, ADF (Dickey, D. A. and Fuller, W. A. (1979:427-431),(1981:1057-1072)), PP and KPSS unit-root tests were performed to determine whether the data were stationary or not and whether they contained unit root. The non-stationary ones were made stationary at the level and Granger Causality tests (Granger, 1987:251-276) were performed on the variables. VAR model was created.

In this part of the study, conceptual descriptions of the data, variables and econometric methods used for empirical application are included.

Mathematical models can be grouped into four main groups. This grouping is related to the certainty of the knowledge we have about the concept we observe. Depending on the rationality of financial market decision makers and economic agents, this information can often become less certain. From this perspective, these models can be considered as a test of the Efficient Market Hypothesis (Fama, 1970:383-417). Efficiency in financial markets depends on the availability of information (Mishkin, 2013:612).



As examples of hypotheses to be established for the models to be created for time variables analysis can be tabulated as follows: interaction between VIX and BIST 100 index, the effect between the implemented monetary policies and the BIST 100 index, the interaction of inflation rate and stock prices, the impact of policy rates on stock prices, the reaction of stock prices to short-term interest rate increases, the policy rate and financial asset prices. We can measure the success of the applied interest policy in controlling the exchange rate. Hypothesis testing is applied as given below:

“ $H_0$ : Dollar/TL exchange rate is not the Granger cause for the CBRT interest rate increase (CBR).

$H_1$ : Dollar/TL exchange rate is the Granger cause for the CBRT interest rate increase (CBR). The appropriate test statistic can be determined by performing hypothesis testing.

Examining the long-term relationship between two variables can be done with Granger causality analysis, and it can be determined whether the dependent and independent variables affect each other. In order to apply causality analysis, the variables must be stationary. Therefore, stationarity tests of the variables to be used must be performed before analysis (Granger and Newbold, 1977:687). A unit root test should be performed to determine whether the variables are stationary or not. Differentiation is also applied to make non-stationary variables stationary.

The empirical study part of the study has been prepared with the modeling and the statistical computer programs determined in Table 2 (Eviews 12, RStudio, Stata18) to be used according to the selected modeling in the time variables analysis. The data examined in the study are obtained from various databases. These are Republic of Turkey Presidency Budget Directorate, Central Bank of the Republic

of Turkey (CBRT), OECD database, ECB, investing.com, Bloomberg.com, Finance.yahoo.com, Republic of Turkey Ministry of Treasury & Finance, European Statistical Office (Eurostat), Turkey Statistics Institution (TUIK), Borsa Istanbul (BIST), The Federal Reserve Bank of St. Louis. It is obtained from St. Louis economic data and belongs to the years 2019-2023.

**Table 2.** Classification of Mathematical Models

<b>0.1.</b> Linear Deterministic models	<b>0.2.</b> Nonlinear Deterministic models
<b>2.1.</b> Linear Stochastic models	<b>2.2.</b> Nonlinear Stochastic models
The analysis made with Eviews, Stata, R statistical programs	The analysis made with R statistical program

**Table 3.** List of variables used in time series analysis

Variables	Explication
BIST100	Stock market index where 100 Turkish companies are traded
DAX	German Stock exchange index
S&P500	Stock market index where 500 American companies are traded
VIX	Volatility index
US10YR	USA 10 year treasury bond interest rate
GER10YR	German 10 year treasury bond interest rate
TR10YR	Turkish 10 year treasury bond interest rate

Variables	Explication
EUCPI	Percentage change in European-27 consumer price index
USCPI	Percentage change in US consumer price index
TRCPI	Percentage change in Turkish consumer price index
CBR	CBRT policy interest rates
FEDR	FED policy interest rates
USDXY	Global index for the value of the US dollar
USDTR	Turkish lira to US dollar exchange rate
TLR	Interest on Turkish lira bank deposits – average weight
USBR	Interest on US bank deposits – average weight

Source: Author

## 2.1. Model Equation

In order to understand whether the obtained variables are suitable for Granger Causality models: first, Jarque-Bera values were examined by looking at the skewness and kurtosis values in order to determine whether the variables showed a normal distribution. Second, correlogram analysis was performed to examine whether the variables were affected by their past values. Appropriate lag lengths were selected according to Akaike, Schwarz and Hannan Quinn information criteria and Dickey-Fuller tests were applied to perform the stationarity tests, and the non-stationary variables were made stationary by taking the first differences.

VAR (p) Equation:

There are seven different variables in the econometric model established in this study. To serve as a reference for the analysis to be carried out

within the framework of the VAR model (Lütkepohl, 2005:112), the equations of 7 different dependent variables must be established. In this case, the equations are established as follows.

$$\mathbf{X}_t = \alpha + \beta t + \sum_{i=1}^p \Gamma_i \mathbf{X}_{t-i} + \varepsilon_t \quad \text{where } \varepsilon_t \sim iid(0, \Sigma) \quad (1)$$

Where  $\mathbf{X}_t$  is vector of interested variables.  $\Gamma_i$ ,  $i=1, \dots, p$  denote the coefficient matrix which should be estimated. It is stable if the polynomial defined by

$\det(I_K - \Gamma_1 z - \Gamma_2 z^2 \dots - \Gamma_p z^p)$  has no roots in and on the complex unit circle.

In the regression model established above, the main purpose is to learn the causalities for the volatility shock created by the pandemic crisis in the USD/TRY exchange rate, BIST100, DAX, GER10YR, S&P500, US10YR, USDTR, USDXY, VIX, TR10YR, EUCPI, USCPI, TRCPI, FEDR, USBR, TLR, CBR.

This set of variables is grouped as stock markets, bond markets, money markets and consumer price indices. In both the VAR model and Granger causality analysis (Granger et al. 1987:251-276), the return of stock market variables is employed as bond return, VIX return and percentage change in CPI. In this sense, triggering parameters of both global and local crises are given among the factors that will cause volatility.

The VIX index, known as the implied volatility for S&P500 index, is included in the model. In the pandemic crisis, USDXY, US dollar against other strong currencies, is another index parameter likely to

affect the volatility of USD/TRY. Inflation, which has been major problem for all global central banks has been compared with the inflation expectation of Turkish economy and it has been examined whether this effect contributes to the exchange rate volatility. Finally, the overnight reference interest rates, which are one of the most effective policy-instrument of central banks and play an important role in almost all crises, have been added to the model as a parameter.

The Table 4 reports summary statistics for the variables. ADF is the *t*-statistics for the Augmented Dickey-Fuller test. PP is the *t*-statistics for the Phillips-Perron test, KPSS test denote significance at the 5% level respectively.

### 3. Empirical Results

2019-2023 Descriptive Statistics with Monthly Variables as shown in Table 4; such as average, standard deviation, skewness, kurtosis, Jarque Bera of monthly data for the years 2019-2023 were examined, and according to the data in the table, the variable with the highest average was seen as USCPI. When Jarque Bera values are examined, it is seen that BIST100, US10YR, USDXY, TR10YR and EUCPI variables show normal distribution, while all other data do not show normal distribution. When looking at the Skewness values; DAX, S&P500, USDXY, and FEDR variables were found to be negatively skewed to the left, and when the kurtosis values were examined, it was seen that the values of all variables were greater than 3 and showed a leptokurtic distribution.

We have to test whether all the variables are stationary. The explanatory variables imposed in the ADF, KPSS and PP models should be stationary. If these variables are determined to be non-stationary, then by implementing suitable methods such variables are transformed into stationary behavior.

Table.4 presents the stationary test results. The test is employed under the Dickey-Fuller test method. Table.4 has 10 columns, first depicts the variables name. The first seven columns stands for the value of test statistics The eighth, ninth and tenth columns show threshold values for desired significance levels. In the empirical literature, the %5 significance level is shown to be sufficient to accept or reject the  $H_0$  hypothesis.

After that, stationary data is going to be estimated. As can be seen in detail in the appendix section, the following procedures were examined in order to observe the stationarity of each data used in the model:

The stationarity conditions of the variables are statistically tested by Dickey-Fuller and Phillips Perron unit-root tests. The test methodology is defined in detail in Appendix. The DAX, USDXY and TLR is determined to have one unit root and is accepted to be non-stationary variables. We take the first difference of the variables and eliminate the unit root to obtain it in the stationary domain. The stationary states of these variables should be included in the VAR model [Eq.1] to be installed.

The presence of a significant constant term in the model indicates that volatility cannot be zero even if the variables determined in this model are assumed to be zero. This is evidence that some parameters not considered in this model are also effective in the formation of volatility.

**Table 4.** Descriptive Statistics

Variables	Mean	Median	St.dev.	Skewness	Kurtosis	Jarque bera	ADF	PP	KPSS
BIST100	0,03	0,03	0,08	0,1	3,06	0,009	-5,27	-5,13	0,055
DAX	0,08	0,11	0,05	-2,28	14,19	329,07	-6,67	-6,65	0,05
GER10YR	0,041	0,00	0,18	1,22	5,89	32,36	-6,11	-6,35	0,07*
S&P500	0,011	0,017	0,04	-2,21	10,75	179,62	-6,65	-6,65	0,07*
US10YR	0,02	0,02	0,22	0,16	4,22	3,67	-5,02	-4,98	0,08*
USDTR	0,03	0,01	0,05	2,12	9,35	131,64	-3,56	-3,56	0,04
USDXY	0,001	0,003	0,01	-0,36	3,2	1,28	-4,69	-4,61	0,12*
VIX	-0,01	-0,47	6,56	3,39	22,97	1001,3	-8,24	-9,4	0,078*
TR10YR	0,04	-0,04	1,52	0,13	3,56	0,88	-5,82	5,96**	0,069**
EUCPI	0,003	0,002	0,005	1,006	5,95	27,67	-4,4	-4,4	0,129*
USCPI	4,94	-0,18	38,85	6,93	49,41	5083,8	-7,1	-7,1	0,06*
TRCPI	0,02	0,018	0,03	2,29	9,65	141,48	-1,97	-8,98	0,39*
FEDR	0,05	0,00	0,25	-0,57	7,08	41,14	-3,10	-3,08	0,089*
USBR	0,00	-0,03	0,39	0,39	8,69	97,46	-7,15	-7,15	0,03
TLLR	-0,01	-0,19	1,97	2,04	13,33	282,80	-6,76	-6,76	0,22*
CBR	0,09	0,00	1,75	2,22	10,09	160,58	-13,70	-3,04	0,09*

\*Denotes in the presence of within %95 significance level.

\*\* The series contains a unit root within %95 significance level

The interest rate path and monetary policies followed in developed and developing countries are implemented by central banks. Interest rate and monetary policy implementations should be evaluated by policy makers in order to control the functioning of the monetary transmission mechanism in economies and to ensure price stability. The channels through which monetary policies affect the transmission mechanism are also revealed by Granger causality analysis. One of the factors affecting the monetary transmission mechanism is the monetary policy instruments chosen by central banks.(Mishkin, 2013:689). In their monetary and interest rate policies, the major central banks aim to achieve objectives such as stable prices (long-term inflation has an upper bound %2), financial stability, high employment, stable exchange rates and high growth within the scope of the trilemma theory and monetary transmission mechanisms (Koç, 2020: 383-412). The realization of these objectives can be possible by analyzing the reaction of the economy to these practices and impact analyses. (Lütkepohl, 2004:89)

In order to examine the 2019 pandemic effect, data for the 2019-2023 periods were separated at monthly frequencies and analyzed in this way. In the study, Granger causality analysis was applied in accordance with the VAR model [Eq.1]. Before applying causality analysis, monthly variables were subjected to unit root analysis; ADF and PP unit root tests were preferred and the stationarity hypothesis was tested with the KPSS test.

As a result of the tests, the difference of the non-stationary series were taken and the analyzes continued in this way.

When the 2019-2023 data are analyzed within the scope of the global Covid-19 pandemic, the result obtained is interpreted within the scope of the narrowing of the causality cluster.



According to the results of the series analysis for the 2019-2023 period; CBR has no causality relationship with BIST100 and USDTR, USDXY has an effect on the USDTR exchange rate process, and there is also causality between VIX and S&P500 and DAX. On the other hand, the outsider gap in BIST100 gradually decreased after 2020 and fell below 1%. Nevertheless, the persistence of the causality between VIX and BIST100 in 2019-2023 can be interpreted with the weight of the emerging markets index and the Banking index. However, we can observe that the causality coefficient of this relationship has weakened compared to previous studies.

Our analysis of the period from 2019 to 2023 has revealed several important insights into the relationships between various financial indicators and market indices.

Firstly, our study found that the CBR index does not have a causal relationship with either the BIST100 index or the USDTR exchange rate. This indicates that changes in CBR do not directly influence these specific market variables. However, we did observe that the USDXY index significantly affects the USDTR exchange rate process, highlighting a clear linkage between the value of the U.S. dollar relative to other currencies and the USDTR exchange rate.

Additionally, we identified a causal relationship between the VIX index, which measures market volatility, and both the S&P 500 and DAX indices. This finding underscores the influence of market uncertainty on major stock indices, with the VIX providing valuable insights into how volatility can impact broader market performance.

Interestingly, our analysis of the BIST100 index revealed that the outsider gap, or the difference between the BIST100 and other global indices, gradually decreased after 2020 and eventually fell below 1%. This trend suggests that the BIST100 index became more aligned

with global market movements over time, possibly due to improved stability and integration of emerging markets into the global financial system.

Despite this decrease in the outsider gap, the persistence of the causal relationship between the VIX and BIST100 from 2019 to 2023 indicates that market volatility continued to play a significant role in shaping the BIST100 index. This ongoing influence can be attributed to the weight of the emerging markets index and the Banking index within the BIST100, which remain sensitive to global economic fluctuations and investor sentiment.

In summary, our analysis highlights the complex interactions between financial indicators and market indices during a transition period. The evolving relationships and decreasing outsider gap reflect broader trends in financial integration and market behavior, while the persistent impact of the VIX on the BIST100 underscores the enduring significance of volatility in emerging markets.

The increase in the FEDR starting from 2021 and the inflationary processes in both the US and the EU explain the effect of the FEDR on the DAX. This effect is due to the fact that the ECB follows the FED in its policy rate process (lagged effect). This tracking is still ongoing and is also reflected in the EUR/USD parity process.

The data for the period 2019-2023 shows that the macroeconomic variables of the US and the EU continue to interact, and only Turkey's own macrofinancial variables continue to be causal among themselves. This is due to a decline in the volume of transactions of the Turkish lira with the US dollar in the London interbank market (SWAP) from 3% to 0.5%. In rival emerging markets, this level remains above 3%. The political economy reason for this was the government's reaction to the repeated currency attacks starting in August 2018. These attacks and

exchange rate fluctuations were thought to have an impact on elections and voting behavior, which led to a reduction in Turkey's financial openness. Since protectionism is not as prominent in global financial markets as it is in the real economy, this explains the lack of causality in US and EU macrofinancial variables. (Akbakay, 2018:1-13).

When we look at the results obtained, it is also determined that the variables, which are correlated with Granger causality, react to each other. Thus, it shows that by choosing one variable, information about the other can be obtained. As a result, it shows how the interest and monetary policies to be implemented can be directed with the existing variables and which targets can be chosen. Granger causality test results are included in the appendix section.

#### **4. Conclusion**

Our examination of the effects of interest rate changes by central banks on the broader economy provides valuable insights into the dynamics of credit markets, consumer behavior, and investment patterns.

In general terms, when central banks change interest rates, banks' credit costs and conditions are affected; a decrease in interest rates may lead to an increase in the credit supply of banks, allowing consumers to obtain cheaper loans and borrow; and may increase consumer spending, which in turn leads to an increase in production. This interest rate path is driven by strong expectations that real interest rates will remain low in the long run. Medium-sized firms, which can increase their investments by relying more on bank loans, are also able to attract high demand through public offerings during these periods. Compared to large firms, the credit mechanism works differently for these firms and may increase the demand for the stock market. At the same time, low real interest rates will lead to low expected returns on bonds. Thus, the demand for the stock market will strengthen, and

stock prices will rise. Firms are expected to turn to investment. We can say that the period between September 2021 and June 2023 in Turkey is an example of this. This expansionary policy is also fueled by price stickiness and the inflationary process.

Additionally, the interplay of variables, as evidenced by Granger causality tests, indicates that changes in one economic variable can provide insights into the behavior of others. This interrelationship suggests that central banks and policymakers can use these correlations to better guide their monetary policies and set effective targets.

In summary, our analysis underscores the complex mechanisms through which interest rate adjustments impact the economy. Lower interest rates can stimulate credit supply, boost consumer spending, and encourage investment, particularly among medium-sized firms. These dynamics, along with the observed correlations among key economic variables, offer important guidance for formulating and implementing effective monetary policies.

The findings reveal that the variables identified through Granger Causality not only share a significant relationship but also react to one another. This interdependence provides valuable insights into predicting one variable based on the other. Therefore, the study demonstrates how interest rates and monetary policies can be strategically adjusted using the existing variables, and which objectives can be selected in line with the trilemma hypothesis. This integration of variable responses and policy guidance highlights a more refined approach to economic forecasting and decision-making.

## 5. Appendix

### Granger Causality Tests Results

#### **EUCPI DAX GER10YR LAG (1)**

Variable	Null hypothesis	Variable	Prob.	Results
EUCPI	Does not Granger Cause	DAX	0,95	Does not Granger Cause
DAX	Does not Granger Cause	EUCPI	0,30	Does not Granger Cause
EUCPI	Does not Granger Cause	GER10YR	0,07	Does not Granger Cause
<b>GER10YR</b>	<b>Does not Granger Cause</b>	<b>EUCPI</b>	<b>0,05</b>	<b>Cause Granger</b>
GER10YR	Does not Granger Cause	DAX	0,99	Does not Granger Cause
DAX	Does not Granger Cause	GER10YR	0,45	Does not Granger Cause

#### **USCPI USDXY US10YR LAG(1)**

Variable	Null hypothesis	Variable	Prob.	Results
USCPI	Does not Granger Cause	USDXY	0,18	Does not Granger Cause
USDXY	Does not Granger Cause	USCPI	0,09	Does not Granger Cause
USCPI	Does not Granger Cause	US10YR	0,34	Does not Granger Cause
US10 YR	Does not Granger Cause	USCPI	0,44	Does not Granger Cause
US10YR	Does not Granger Cause	USDXY	0,81	Does not Granger Cause
USDXY	Does not Granger Cause	US10YR	0,66	Does not Granger Cause

#### **VIX BIST100 LAG(3)**

Variable	Null hypothesis	Variable	Prob.	Results
BIST100	Does not Granger Cause	VIX	0,5	Does not Granger Cause
VIX	Does not Granger Cause	BIST100	0,12	Does not Granger Cause

#### **VIX DAX LAG(2)**

Variable	Null hypothesis	Variable	Prob.	Results
VIX	Does not Granger Cause	DAX	0,23	Does not Granger Cause
DAX	Does not Granger Cause	VIX	0,46	Does not Granger Cause

**TRCPI USDTR TR10YR LAG(3)**

Variable	Null hypothesis	Variable	Prob.	Results
USDTR	Does not Granger Cause	TRCPI	0,07	Does not Granger Cause
TRCPI	Does not Granger Cause	USDTR	0,48	Does not Granger Cause
TR10YR	Does not Granger Cause	TRCPI	0,65	Does not Granger Cause
TRCPI	Does not Granger Cause	TR10YR	0,75	Does not Granger Cause
TR10YR	Does not Granger Cause	USDTR	0,21	Does not Granger Cause
<b>USDTR</b>	<b>Does not Granger Cause</b>	<b>TR10YR</b>	<b>0,03</b>	<b>Cause Granger</b>

**VIX S&P500 LAG(2)**

Variable	Null hypothesis	Variable	Prob.	Results
VIX	Does not Granger Cause	S&P500	0,18	Does not Granger Cause
S&P500	Does not Granger Cause	VIX	0,09	Does not Granger Cause

**CBR TRCPI TLR LAG(2)**

Variable	Null hypothesis	Variable	Prob.	Results
TRCPI	Does not Granger Cause	CBR	0,51	Does not Granger Cause
CBR	Does not Granger Cause	TRCPI	0,4	Does not Granger Cause
TLR	Does not Granger Cause	CBR	0,33	Does not Granger Cause
CBR	Does not Granger Cause	TLR	0,27	Does not Granger Cause
<b>TLR</b>	<b>Does not Granger Cause</b>	<b>TRCPI</b>	<b>0,02</b>	<b>Cause Granger</b>
TRCPI	Does not Granger Cause	TLR	0,14	Does not Granger Cause

**CBR USBR USDTR LAG(2)**

Variable	Null hypothesis	Variable	Prob.	Results
USBR	Does not Granger Cause	CBR	0,63	Does not Granger Cause
<b>CBR</b>	<b>Does not Granger Cause</b>	<b>USBR</b>	<b>0,0003</b>	<b>Cause Granger</b>
USDTR	Does not Granger Cause	CBR	0,37	Does not Granger Cause
CBR	Does not Granger Cause	USDTR	0,15	Does not Granger Cause

USDTR	Does not Granger Cause	USBR	0,06	Does not Granger Cause
USBR	Does not Granger Cause	USDTR	0,14	Does not Granger Cause

#### TLR CBR BIST100 LAG(2)

Variable	Null hypothesis	Variable	Prob.	Results
CBR	Does not Granger Cause	TLR	0,27	Does not Granger Cause
TLR	Does not Granger Cause	CBR	0,33	Does not Granger Cause
BIST100	Does not Granger Cause	TLR	0,64	Does not Granger Cause
TLR	Does not Granger Cause	BIST100	0,82	Does not Granger Cause
BIST100	Does not Granger Cause	CBR	0,23	Does not Granger Cause
CBR	Does not Granger Cause	BIST100	0,63	Does not Granger Cause

#### FEDR US10YR USCPI LAG(1)

Variable	Null hypothesis	Variable	Prob.	Results
<b>US10YR</b>	<b>Does not Granger Cause</b>	<b>FEDR</b>	<b>0,02</b>	<b>Cause Granger</b>
FEDR	Does not Granger Cause	US10YR	0,91	Does not Granger Cause
USCPI	Does not Granger Cause	FEDR	0,76	Does not Granger Cause
FEDR	Does not Granger Cause	USCPI	0,78	Does not Granger Cause
USCPI	Does not Granger Cause	US10YR	0,34	Does not Granger Cause
US10YR	Does not Granger Cause	USCPI	0,44	Does not Granger Cause

#### FEDR GER10YR DAX LAG(4)

Variable	Null hypothesis	Variable	Prob.	Results
<b>GER10YR</b>	<b>Does not Granger Cause</b>	<b>FEDR</b>	<b>0,003</b>	<b>Cause Granger</b>
FEDR	Does not Granger Cause	GER10YR	0,77	Does not Granger Cause
DAX	Does not Granger Cause	FEDR	0,09	Does not Granger Cause
<b>FEDR</b>	<b>Does not Granger Cause</b>	<b>DAX</b>	<b>0,01</b>	<b>Cause Granger</b>
DAX	Does not Granger Cause	GER10YR	0,43	Does not Granger Cause
GER10YR	Does not Granger Cause	DAX	0,44	Does not Granger Cause

<b>FEDR VIX S&amp;P500 LAG(2)</b>				
Variable	Null hypothesis	Variable	Prob.	Results
VIX	Does not Granger Cause	FEDR	0,08	Does not Granger Cause
FEDR	Does not Granger Cause	VIX	0,67	Does not Granger Cause
S&P500	Does not Granger Cause	FEDR	0,28	Does not Granger Cause
FEDR	Does not Granger Cause	S&P500	0,46	Does not Granger Cause
S&P500	Does not Granger Cause	VIX	0,09	Does not Granger Cause
VIX	Does not Granger Cause	S&P500	0,18	Does not Granger Cause
<b>TR10YR CBR TRCPI LAG(2)</b>				
Variable	Null hypothesis	Variable	Prob.	Results
CBR	Does not Granger Cause	TR10YR	0,46	Does not Granger Cause
<b>TR10YR</b>	<b>Does not Granger Cause</b>	<b>CBR</b>	<b>0,02</b>	<b>Cause Granger</b>
TRCPI	Does not Granger Cause	TR10YR	0,72	Does not Granger Cause
TR10YR	Does not Granger Cause	TRCPI	0,71	Does not Granger Cause
TRCPI	Does not Granger Cause	CBR	0,51	Does not Granger Cause
CBR	Does not Granger Cause	TRCPI	0,46	Does not Granger Cause
<b>CBR FEDR LAG(2)</b>				
Variable	Null hypothesis	Variable	Prob.	Results
FEDR	Does not Granger Cause	CBR	0,94	Does not Granger Cause
CBR	Does not Granger Cause	FEDR	0,9	Does not Granger Cause
<b>TR10YR FEDR LAG(1)</b>				
Variable	Null hypothesis	Variable	Prob.	Results
FEDR	Does not Granger Cause	TR10YR	0,12	Does not Granger Cause
TR10YR	Does not Granger Cause	FEDR	0,23	Does not Granger Cause

Source: Author



## References

- Akbakay, Z. (2018). Avrupa Merkez Bankasının Para Politikası: Fiyat İstikrarının Niceliksel Tanımı ve İki Sütunlu Analiz Yaklaşımı, *Balkan Journal of Social Sciences*, 14, 1-13.
- Aytekın İ. and Uçan O. (2022). Döviz Kuru Enflasyon ve Dış Ticaret Arasındaki İlişkinin Ekonometrik bir Analizi:Türkiye Örneği, *Academic Review of Economics and Administrative Sciences*, 460–475.
- Aytüre S. and Keskin M. (2024). The Relationship between the Istanbul Stock Market and Türkiye's Foreign Trade, *BMIJ Journal*, 12 (2), 345-355. Doi:10.15295.
- Baek S., Mohanty S.K. and Glambosky M. (2020). Covid-19 and Stock Market Volatility: An Industry Level Analysis. *Finance Research Letters*, 1-10.
- Baker, S.R. et.al. (2020). The Unprecedented Stock Market Impact of Covid-19, *NBER Working Paper Series*. Working Paper 26945, 1-22.
- Bernanke, B. S. and Kuttner, K. N. (2005). What Explains the Stock Market's Reaction to Federal Reserve Policy?. *The Journal of Finance*, 60 (3), 1057-1592.
- Coşkuner M. and Özer A. (2024). Döviz Kuru ve Enflasyonun Hisse Senedi Getirisi Üzerindeki Etkisi- *Balıkesir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 5(1), 15-24
- Dickey, D. A. and Fuller, W. A. (1979). Distribution of Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 427-431.
- Dickey, D. A. and Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica*, 1057-1072.
- Engle, R. and Granger C.W.J. (1987). Co-integration and Error Correction: Representation, Estimation, Testing. *Econometrica*, 55, 251-276.
- Engle, R.F., Ghysels, E. and Sohn, B. (2013). Stock Volatility and Macroeconomic Fundamentals. *The Review of Economics and Statistics* 95 (3): 776-797.
- Fama, Eugene F. and French, Kenneth R. (1989). Business Conditions and Expected Returns on Stock and Bonds, *Journal of Financial Economics*, 23-49.
- Fama, Eugene F. (1976). Inflation Uncertainty and the Expected Returns on Treasury Bills; *Journal of Political Economy*, 84 (3), 427-448.
- Fama, Eugene F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work; *The Journal of Finance*, 25 (2) , *Papers and Proceedings of the Twenty-Eighth Annual Meeting of the American Finance Association New York*, 383-417.
- Fama, Eugene F. and Schwert G.W. (1977). Asset Returns and Inflation; *Journal of Financial Economics*, 5(2), 115- 146

- Farokhnia K. and Osterrieder J. (2020). High Frequency Causality between Stochastic Volatility Time Series: *Empirical Evidence*, 1-15.
- Geske, R. and Roll, R. (1983). The Fiscal and Monetary Linkage between Stock Returns and Inflation; *The Journal of Finance*, 1-33. Doi: 10.1111/j.1540-6261.1983.
- Granger, C. W. J. and Newbold, P. (1977). *Forecasting Economic Time Series*. New York: Academic Press. ISBN 0122951506
- Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing; *Econometrica*, 55 (2), 251-276.
- Koç, H. (2020). Trilemma Hipotezi: Türkiye Ekonomisi Üzerine arklı bir Perspektif. *İstanbul İktisat Dergisi*, 383-412.
- Lutkepohl, H. and Kratzig, M. (2005). *Applied Time Series Econometrics*. Cambridge University Press.
- Lutkepohl, H. and Netsunajev, A. (2018). The Relation between Monetary Policy and the Stock Market in Europa. *Econometrics*, 6-36.
- Meher K.B., Hawaldar I.T., Mohapatra L. and Sares A.M. (2020). The Impact of Covid-19 on Price of Crude Oil and Natural Gas Listed on Multi Commodity Exchange of India. *International Journal of Energy Economics and Policy*, 422-431.
- Mishkin, F.S. (2013). *The Economics of Money, Banking and Financial Markets* (10th edition.). *The Pearson Series in Economics*.
- Molnár A. and Csiszárík-Kocsir, Á. (2022). Forecasting Economic Growth with the Hungarian Composite Stock Market Index – a Granger Causality Test. *Acta Polytechnica Hungarica* 19 (8), 205-227.
- Ohmura, H. (2020). The Connection between Stock Market Prices and Political Support: Evidence From Japan. *Applied Economic Letters*, 1-7
- Özkaya, A. (2022). Non-linear Dynamics and Recurrent Patterns in Stock Markets: A Comparison between BIST-100 and S&P500 Indices. *OÜSOBİAD* 12 (2), 1365-1380, Doi: 10.48146/odusobiad.1123224, 1365-1380.
- Özkaya, A. and Altun Ö. (2024). Domestic and Global Causes for Exchange Rate Volatility: Evidence from Turkey. *SAGE Open* 14 (2), 1-14.
- Özmen, M., Karlılar, S. and Karlılar, G. (2017). Türkiye için Döviz Kuru, Faiz ve Enflasyonun Hisse Senedi Getirileri Üzerine Etkileri. *Çukurova Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 107-120.
- Sekula P. (2019). Causality Analysis between Stock Market Indices. *Financial Sciences Nauki O Finansach* 24 (1), 74-83.
- Schwert G.W. (1989). Why Does Stock Market Volatility Change Over Time? *The Journal Of Finance*, 1115-1153.

- Trivedi, J., Spulbar,C., Birau, R. and Minea E.L. (2021). Assessing the Changes in Statistical Property of Selected Stock Markets Behaviour before and after Covid-19 Pandemic: A Case Study. *Research and Science Today Journal* 2(22), 63-80.
- Tsay, Ruey S. (2002). Analysis of Financial Time Series. *New York: Wiley Series in Probability and Statistics*, 81- 110.
- Tsay, Ruey S. (1987). Conditional Heteroscedastic Time Series Models, *Journal of the American Statistical Association*, 590-604.
- Ünal, S. (2020). Hisse Senedi Getirileri Üzerinde Para ve Maliye Politikası Araçlarının Etkisi: Borsa İstanbul üzerine bir Araştırma; *Journal of Yasar University*, 15(60), 772-789.
- Vega P., Zack G, Calvo J. and Libman E. (2023). Inflation Determinants in Argentina (2004-2022); arXiv.org. [econ.GN],1-33. Doi: 10.48550.
- Yeboah E. and Lamin C. (2024). The Dynamic Effect of Trade Openness, Debt, and Foreign Investment in Ghana's Economy: An ARDL Bound Testing Approach; *International Journal of Engineering and Management Sciences (IJEMS)* 9 (2), 94-112. Doi: 10.21791/IJEMS.2024.01.
- You K., Chinthalapati V.L. R., Mishra T. and Patra R. (2024). International Trade Network and Stock Market Connectedness: Evidence from Eleven Major Economies, *Journal of International Financial Markets, Institutions & Money*, 1-24.



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

İbrahim Halil UÇAR<sup>1\*</sup>

<sup>1</sup> Dr., Bağımsız Araştırmacı, Adana, Türkiye  
Orcid Numarası: 0000-0002-6046-1285

Geliş Tarihi: 25.07.2024

\*Sorumlu Yazar e mail: bodrum351@hotmail.com Kabul Tarihi: 18.11.2024

Atf/Citation: Uçar, İ.H. (2024). "The Impact of Exchange Rate Volatility on The Inflation Rate: Evidence from Turkey", *Haliç Üniversitesi Sosyal Bilimler Dergisi* 2024, 7(2): 143-191.

### 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 (Büyükkakın, 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 Dağdır,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).

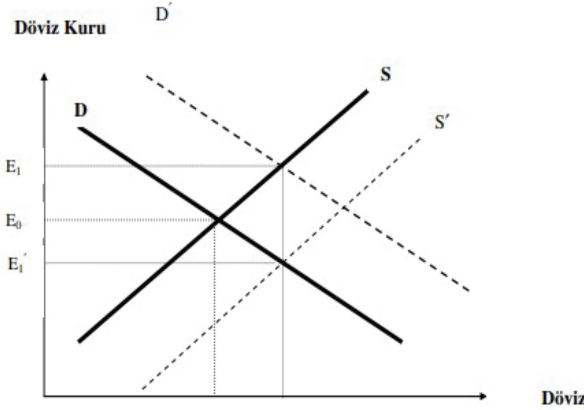
The fixed exchange rate system provides less uncertainty and prevents destabilizing fluctuations for international trade and investment. In this system, destabilizing speculation is lower than in the flexible exchange rate system. Due to the reduction in fluctuations in exchange rate movements, lower 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 Dağdır, 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 Dağdır, 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  $E_0$ . 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  $E_1$ . 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  $E_1'$ . 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  $E_0$ , 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

<b>Author or Authors</b>	<b>Period, Data Type and Variables</b>	<b>Method</b>	<b>Findings</b>
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 Dağdır (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 (Quarterly 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 al (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:M1 to 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  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.
Emikönel and Orhan (2023)	1990:M1–2020:M12 (Monthly Data) The Exchange Rate and Inflation	ARDL 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
Gridigbi 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) Consumer 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 (Quarterly 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 al (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 nonlinear 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 (Quarterly 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 al (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-Regression 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:

$$Inf_t = \alpha_0 + \alpha_1 Exc_t + \alpha_2 M1_t + \varepsilon_t \quad (2)$$

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,  $\varepsilon_t$ ; 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.

$$\text{Inf}_t = \theta + \sum_{i=1}^k \beta_i \text{Inf}_{t-i} + \sum_{j=1}^k \vartheta_j \text{Exc}_{t-j} + \sum_{m=1}^k \varphi_m \text{M1}_{t-m} + \mu_{1t} \quad (3)$$

$$\text{Exc}_t = \theta + \sum_{i=1}^k \beta_i \text{Inf}_{t-i} + \sum_{j=1}^k \vartheta_j \text{Exc}_{t-j} + \sum_{m=1}^k \varphi_m \text{M1}_{t-m} + \mu_{2t} \quad (4)$$

$$\text{M1}_t = \theta + \sum_{i=1}^k \beta_i \text{Inf}_{t-i} + \sum_{j=1}^k \vartheta_j \text{Exc}_{t-j} + \sum_{m=1}^k \varphi_m \text{M1}_{t-m} + \mu_{3t} \quad (5)$$

In the equations,  $\theta$  is the constant term,  $\beta$ ,  $\varphi$  and  $\vartheta$  are the coefficients to be estimated;  $\mu_{1t}$ ,  $\mu_{2t}$  and  $\mu_{3t}$  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

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

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:

H<sub>0</sub>: The time series contains a unit root.

H<sub>1</sub>: The time series does not contain a unit root.

**Table 5.** Unit Root Test Results

<b>Augmented Dickey Fuller (ADF)</b>						
	<b>With Constant</b>		<b>With Constant &amp; Trend</b>		<b>Without Constant &amp; Trend</b>	
	<b>Level</b>	<b>First Difference</b>	<b>Level</b>	<b>First Difference</b>	<b>Level</b>	<b>First Difference</b>
	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>
<b>Inf</b>	4.9824	-3.2267	4.1704	-4.3070	2.9051	-1.5763
	1.0000	0.0196	1.0000	0.0036	0.9992	0.1081
<b>Exc</b>	3.6098	-11.0445	-0.1914	-12.1435	5.1206	-7.2323
	1.0000	0.0000	0.9930	0.0000	1.0000	0.0000
<b>M1</b>	0.8529	-18.9434	-0.4032	-18.9625	7.6359	-3.4613
	0.9948	0.0000	0.9870	0.0000	1.0000	0.0006

<b>Phillips Perron (PP)</b>						
	<b>With Constant</b>		<b>With Constant &amp; Trend</b>		<b>Without Constant &amp; Trend</b>	
	<b>Level</b>	<b>First Difference</b>	<b>Level</b>	<b>First Difference</b>	<b>Level</b>	<b>First Difference</b>
	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>	t-Statistic <i>Prob</i>
<b>Inf</b>	6.5930	-7.2370	5.3876	-8.2893	6.2082	-5.1126
	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
<b>Exc</b>	4.0762	-10.1602	-0.0421	-10.5824	6.0123	-9.9280
	1.0000	0.0000	0.9956	0.0000	1.0000	0.0000
<b>M1</b>	0.7383	-18.7832	-0.6546	-18.8410	8.0143	-17.1543
	1.0000	0.0000	0.9745	0.0000	1.0000	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:

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

$$X_t = \delta + \sum_{i=1}^p \vartheta_i X_{t-i} + \sum_{j=1}^q \theta_j Y_{t-j} + \varepsilon_{2t} \tag{7}$$

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
$r\leq 1^*$	29.60323	14.26460	36.15428	15.49471	0.0000
$r\leq 2^*$	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.

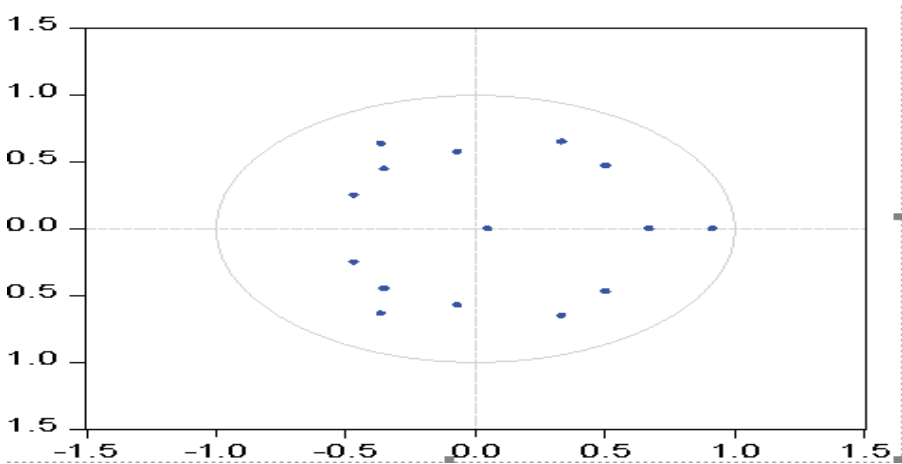
However, in case of autocorrelation problem in the VAR model estimated with this lag length, one of the later lag lengths should be selected (Kaygısız,2018:128).

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 Length	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

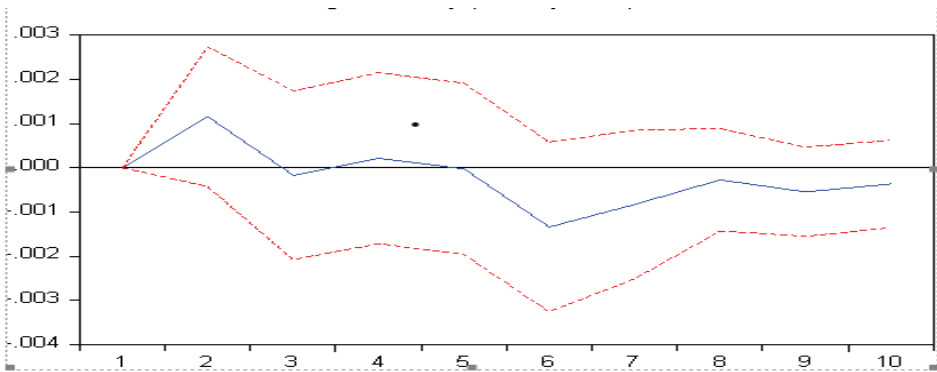
**Note:** The variance decomposition results were obtained using Cholesky decomposition.

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

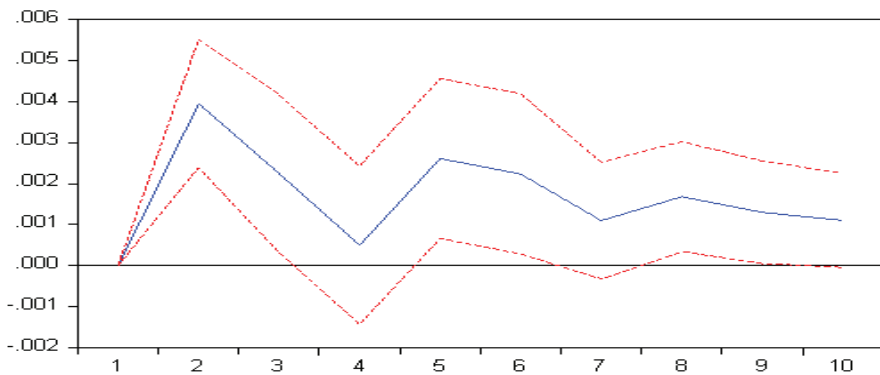


**Note:** The vertical axis represents the change in the response to a 1% exchange rate shock. The horizontal axis represents the time period (1 to 10 periods). The red dotted line represents the two standard error confidence bands around the prediction.

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.

## References

- Akdemir.S and Özçelik.M (2018) Döviz Kurlarının Yurtiçi Fiyatlara Geçiş Etkisi: Türkiye Ekonomisi 2003-2017 Dönemi Uygulaması, *Ekonomik ve Sosyal Araştırmalar Dergisi*, 14(1), 35-50.
- Aytekin.İ., Aksoy.E and Bayrakdar.S (2023). Türkiye’de Döviz Kuru ile Enflasyon Arasındaki Uzun ve Kısa Dönemli İlişkinin İncelenmesi, *İktisat Politikası Araştırmaları Dergisi*, 10(1), 87-112
- Alkan.U and Dağdırı.C (2020) Türkiye’de Döviz Kuru ve Enflasyon Arasındaki İlişkinin Çoklu Yapısal Kırımlı Eşbütünleşme Analizi, *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*,5(2), 270-287

- Asad.I., Ahmad.N and Hussain.Z (2012) Impact of Real Effective Exchange Rate on Inflation in Pakistan, *Asian Economic and Financial Review* 2(8), 983-990
- Asafo.S.S (2019) Exchange Rate Pass-Through to Prices : Bayesian VAR Evidence for Ghana, *MPRA Munich Personal RePEc Archiv*, 1-14
- Baidoo.S.T., Yusif.H., Duodu.E and Valogo.M.K (2023) Effect of Exchange Rate on Inflation in The Inflation Targeting Framework: is The Threshold Level Relevant?, Elsevier, *Research in Globalization* 6, 100119, 1-10
- Bozdağlıoğlu.E.Y and Yılmaz.M (2015) Türkiye’de Enflasyon ve Döviz Kuru İlişkisi: 1994-2014 Yılları Arası Bir İnceleme, *BEU Akademik İzdüşüm*, 2(3), 1-20.
- Büyükkakin.T (1995) Enflasyon Teorileri ve Türkiye’de 1980 Sonrası Enflasyon, *T.C. İstanbul Üniversitesi Sosyal Bilimler. Enstitüsü Siyasal Bilgiler Fakültesi Maliye Teorisi Ana Bilim Dalı*, 1-110
- Cabral.R., Carneiro.G and Mollick.A.V (2020) Inflation Targeting and Exchange Rate Volatility in Emerging Market, *Springer Empir Econ*, 58, 605–626, <https://doi.org/10.1007/s00181-018-1478-8>
- Celkan, Ö.S (2023) Döviz Kuru ve Enflasyon İlişkisi: Türkiye Örneği, *Ekonomi ve Finansal Araştırmalar Dergisi*, 5(1), 19-37
- Demir E.E (2007) Esnek Kur Sisteminin Rekabete Etkisi *T.C. İstanbul Üniversitesi Sosyal Bilimler Enstitüsü İktisat Teorisi Bilim Dalı Yüksek Lisans Tezi*, 1-138
- Dereli.D.D (2018) Türkiye’de Döviz Kuru ile Enflasyon Arasındaki İlişkinin Analizi (2005-2017), *Turkish Studies* 13(30), 138-150
- Duman.Y.K and Sağdıç.A (2019) Türkiye’de Döviz Kuru ve Enflasyon İlişkisi: Ekonometrik Bir Analiz (2003:1–2017:3), *Sakarya İktisat Dergisi*, 8(1), 1-16
- Emikönel, M and Orhan, A. (2023) An Empiric Analysis on The Relationship Between Exchange Rates and Inflation in Fragile Five Countries, *Journal of Yasar University*, 18(70), 237-251
- Gidigbi M. O., Babarinde G. F., Lawan M. W (2018) Inflation and Exchange Rate Volatility Pass-Through in Nigeria, *ResearchGate Journal of Management, Economics, and Industrial Organization*, 2(3), 18-40
- Güneş.S (2013) Türkiye’de Kur Rejimi Uygulaması ve Enflasyon İlişkisi Üzerine Bir Analizi, *Ekonomik ve Sosyal Araştırmalar Dergisi*, 9(2), 65-77
- Imimole.B and Enoma.A (2011) Exchange Rate Depreciation and Inflation in Nigeria (1986–2008), *Business and Economics Journal*, 2011(28),1-13
- Frankel.A.J (2003) Experience of and Lessons From Exchange Rate Regimes in Emerging Economies, *NBER Working Paper Series*, 1-39
- Kaygısız.A.D (2018) Döviz Kuru Dalgalanmalarının Enflasyon Üzerindeki Geçiş Etkisi: Türkiye Örneği, *International Review of Economics and Management*, 6(2), 117-137.

- Keefe.H.G (2020) The Impact of Exchange Rate Volatility on Inflation Targeting Monetary Policy in Emerging and Advanced Economies, *John Wiley and Sons Ltd International Finance*, 417–433
- Kennedy.K and Nourizad.F (2016) Exchange Rate Volatility and Its Effect on Stock Market Volatility, *Int. J. Hum. Cap. Urban Manage*, 1(1), 37-46
- Korkmaz.S and Bayır.M (2015) Döviz Kuru Dalgalanmalarının Yurtiçi Fiyatlara Etkisi, *Niğde Üniversitesi İİBF Dergisi* 8(4), 69-85
- Labonte.M (2004) Fixed Exchange Rates, Floating Exchange Rates and Currency Boards: What Have We Learned? *CRS Report for Congress*, 1-27
- Lado. E.P.Z (2015) Test of Relationship Between Exchange Rate and Inflation in South Sudan: Granger-Causality Approach, *Science Publishing Group, Economics* 2015; 4(2), 34-40
- Madesha.W., Chidoko.C and Zivanomoyo.J (2013) Empirical Test of the Relationship Between Exchange Rate and Inflation in Zimbabwe, *Journal of Economics and Sustainable Development*, 4(1), 52-59.
- Mignon.V and Villavicencio.A.L (2017) Exchange Rate Pass-Through in Emerging Countries: Do The Inflation Environment, Monetary Policy Regime and Central Bank Behavior Matter? *Journal of International Money and Finance* 79, 20–38
- Monfared.S.F.S and Akin.F (2017) The Relationship Between Exchange Rates and Inflation: The Case of Iran, *European Journal of Sustainable Development* 6(4), 329-340
- Mugambi.P.J., Nyabuto.K.O and Sumba.J.O (2024) Exchange Rate and Inflation Dynamics in Kenya: Does The Threshold Level Matter? *Heliyon* 10, e35726, 1-13
- Nuhu.M (2021) Impact of Exchange Rate Volatility on Inflation in Nigeria, *Journal of Contemporary Research in Business, Economics and Finance*, 3(1), 26-38
- Olamide.E., Ogujiuba.K and Mare.A (2022) Exchange Rate Volatility, Inflation and Economic Growth in Developing Countries: *Panel Data Approach for SADC, Economics*, 10(67), 1-19
- Özen, E., Özdemir, L and Grima, S. (2020) The Relationship between The Exchange Rate, Interest Rate and Inflation: The Case of Turkey, *Scientific Annals of Economics and Business*, 67(2), 259-275
- Selim.S and Güven.E.T.A (2014) Türkiye’de Enflasyon, Döviz Kuru ve İşsizlik Arasındaki İlişkinin Ekonometrik Analizi *Ekonomik ve Sosyal Araştırmalar Dergisi*, 10(1), 127-145
- Sesan.A (2013) Exchange Rate Volatility and Inflation Upturn in Nigeria: Testing for Vector Error Correction Model, *MPRA Munich Personal RePEc Archive*, 1-20

- Shaari.M.S.,Hussain.N.E and Abdullah.H (2012) The Effects of Oil Price Shocks and Exchange Rate Volatility on Inflation: Evidence from Malaysia, *International Business Research*, 5(9), 106-112
- Şeker.H (2022) Türkiye’de Kur-Enflasyon Geçişkenliği Üzerine Ekonometrik Bir Analiz, *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*, 7(1), 131-142
- Şen.H., Kaya.A., Kaptan.S and Cömert.M (2020) Interest Rates, Inflation and Exchange Rates in Fragile Emes: A Fresh Look At The Long-Run Interrelationships, *The Journal of International Trade and Economic Development*, 29(3), 289–318.
- Özçiçek.Ö (2010) Döviz Kuru Hareketlerinin Enflasyon Üzerindeki Etkisi: Sektörel Analiz, *Ç.Ü. Sosyal Bilimler Enstitüsü Dergisi*, 19 (2), 313-327
- Stone.M., Anderson.H and Veyrone.R (2008) Exchange Rate Regimes, *Finance and Development*,, <https://www.imf.org/external/pubs/ft/fandd/2008/03/pdf/basics.pdf>
- Timothy.O.T., Ada.M.S and Chigozie.A.O (2016) Exchange Rate Volatility and Inflation: The Nigerian Experience, *Journal of Economics and Sustainable Development* ,7(10), 6-15
- Tümtürk O. (2017). Türkiye’de Döviz Kurlarının Yurtiçi Fiyatlara Geçiş Etkisi ve Enflasyon Hedeflemesi. *Yönetim ve Ekonomi Dergisi*, 24(3), 837- 855
- Türk.E (2016) Döviz Kuru Enflasyon İlişkisi Türkiye Örneği, *Ufuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 5(9), 81-102.
- URL1(2016)<https://www.cbn.gov.ng/out/2017/rsd/education%20in%20economics%20series%20no.%204.pdf>,
- Yüksel.Ö and Baycan.I.O (2022) The Role of Inflation Targeting on Exchange Rate Volatility: An Evidence From Propensity Score Matching Approach, *Yönetim ve Ekonomi Araştırmaları Dergisi*, 20(4), 56-81



## Makine Öğrenme Yöntemleri Kullanılarak EEG Tabanlı Duygu Sınıflandırma Araştırmaları Üzerine Bibliyometrik Analiz

Selma İlknur UĞUR<sup>1\*</sup>, Nesibe MANAV MUTLU<sup>2</sup>,  
Kübra EROĞLU<sup>3</sup>

<sup>1</sup> Yüksek Lisans Öğrencisi, Nişantaşı Üniversitesi, Lisansüstü Eğitim Enstitüsü, Yapay Zeka Mühendisliği Anabilim Dalı, İstanbul, Türkiye

**Orcid Numarası:** 0009-0008-9803-1249

<sup>2</sup> Dr. Öğr. Üyesi, Nişantaşı Üniversitesi, İktisadi, İdari ve Sosyal Bilimler Fakültesi, Yönetim Bilişim Sistemleri Bölümü, İstanbul, Türkiye

**Orcid Numarası:** 0000-0002-7853-6337

<sup>3</sup> Dr. Öğr. Üyesi, Topkapı Üniversitesi, Mühendislik Fakültesi Elektrik-Elektronik Mühendisliği Bölümü, İstanbul Türkiye Türkiye

**Orcid Numarası:** 0000-0001-5098-8924

**Geliş Tarihi:** 14.05.2024

**\*Sorumlu Yazar e mail:** 20221500298@std.nisantasi.edu.tr **Kabul Tarihi:** 20.05.2024

**Atf/Citation:** Uğur, S.İ. & Manav Mutlu, N. & Eroğlu, K. (2024). "Makine Öğrenme Yöntemleri Kullanılarak EEG Tabanlı Duygu Sınıflandırma Araştırmaları Üzerine Bibliyometrik Analiz", *Haliç Üniversitesi Sosyal Bilimler Dergisi* 2024, 7(2): 193-212.

### Öz

Elektroensefalografi (EEG) tabanlı duygu tanıma, bilişsel bilimler ve insan-bilgisayar etkileşimi alanlarında giderek artan bir ilgi görmektedir. Bu ilgi, özellikle beyin dalgalarını analiz ederek insan duygularını anlama ve yorumlama potansiyelinden kaynaklanmaktadır. Farklı duygusal uyaranlar karşısında beyin aktivitesinde birtakım değişiklikler olmakta ve bu değişiklikler EEG kayıtlarında gözlemlenebilmektedir. Makine öğrenme teknikleri ise farklı duygusal durumlar karşısında beyin aktivitesine yansıyan bu değişimlerin yüksek doğrulukta sınıflandırılmasına olanak tanımaktadır. Son yıllarda, bu alanda yapılan akademik çalışmaların sayısında büyük bir artış olmuş ve bu da EEG tabanlı duygu tanıma

tekniklerinin geliştirilmesi için geniş bir literatür birikimi oluşturmuştur. Bu çalışma, makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu tanıma çalışmalarının bibliyometrik analizini sunmayı amaçlamaktadır. Analiz, bu alandaki yayın trendlerini, araştırma ağlarını, anahtar kelimeleri ve en etkili çalışmaları ortaya koyarak, alanın mevcut durumunu ve gelecekteki potansiyel yönlerini değerlendirecektir. Ayrıca EEG ve makine öğrenmesi teknolojilerinin duygu tanıma uygulamalarındaki rolünü derinlemesine incelemeyi ve bu alandaki akademik katkıları haritalamayı hedeflemektedir.

**Anahtar Kelimeler:** EEG, Makine Öğrenmesi, Bibliyometri, Duygu Analizi

## **Bibliometric Analysis on EEG-Based Emotion Classification Research Using Machine Learning**

### **Abstract**

An increasing interest has been observed in the fields of Electroencephalography (EEG)-based emotion recognition, cognitive sciences, and human-computer interaction. This interest primarily arises from the potential to understand and interpret human emotions by analyzing brain waves. EEG can accurately record emotional responses, and when combined with machine learning techniques, it enables the precise classification of emotional states. In recent years, there has been a significant increase in academic research within this domain, leading to a substantial accumulation of literature aimed at understanding and developing EEG-based emotion recognition techniques. This study aims to present a bibliometric analysis of machine learning methods in EEG-based emotion recognition. The analysis aims to clarify publication trends, research networks, key terms, and influential studies, thereby assessing the present status and potential future trajectories of the field. This endeavor aims to comprehensively explore the role of EEG and machine learning technologies in emotion recognition applications and chart the academic contributions in this domain.

**Keywords:** EEG, Machine Learning, Bibliometri, Emotion Recognition

### **1. Giriş**

Duygular, çeşitli dış uyaranlar sonucu ortaya çıkan öznel psikofizyolojik tepkilerdir ve günlük hayatımızı önemli ölçüde etkilemektedir. İnsanlar duygularını çeşitli yollarla ifade eder; jestler, beden dili, ses



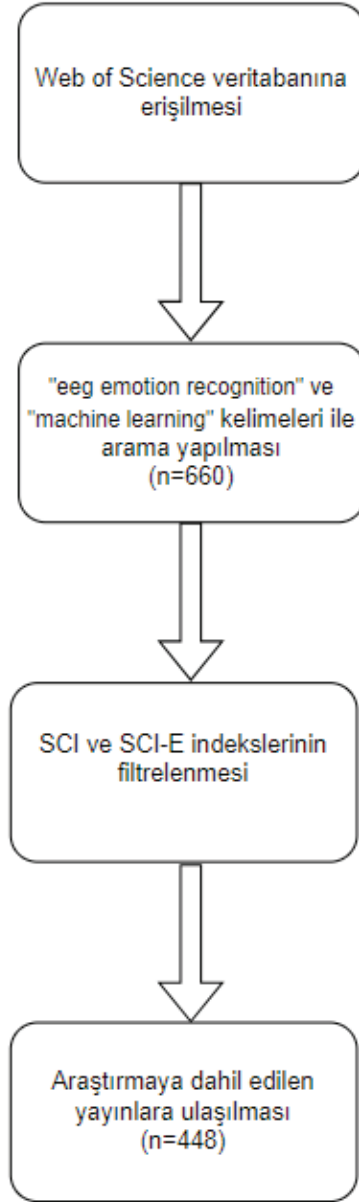
tonu ve fizyolojik işaretler bu ifade şekilleri arasındadır. Duygular karar verme ve algı gibi yetenekleri şekillendirme konusunda önemli rol oynamaktadır. Bu nedenle, duyguları anlamak ve tanımlamak, insan davranışı üzerine yapılan çalışmaların temel bir parçası haline gelmiştir.

Son yıllarda, makine öğrenmesi (ML) ve bilgi füzyonundaki hızlı gelişmeler, makinelere/ bilgisayarlara duygu anlama, tanıma ve analiz etme yeteneği kazandırmayı mümkün kılmıştır (Zhang ve Yin, 2020: 103-126). Fizyolojik sinyaller, duyguları tanımda daha objektif ve güvenilir bilgiler sunar çünkü bu sinyaller, insanların kontrolü dışında gerçekleşir. Özellikle EEG beyin dalgalarını ölçen bir teknik olarak, duygusal tepkileri algılamada son derece hassas bir yöntemdir (Xie, Luo, Wang ve Liu, 2024: 1-3). EEG sinyalleri, duygusal durum dalgalanmalarına daha hassas ve gerçek zamanlı tepki verdiği için, duygusal durumların önemli özelliklerini sunabilir. Bu nedenle, son zamanlarda çeşitli EEG tabanlı duygu tanıma teknikleri geliştirilmiştir.

Bibliyometri, bilimsel yayınlar ve bunların ilişkilerini inceleyen istatistiksel ve sayısal analiz yöntemidir (Al, Sezen ve Soydal, 2012: 54-57). Bu alanda araştırmacılar, kitaplar, makaleler ve diğer yayınların sayısını, türlerini ve alıntı yapma sıklıklarını analiz ederek belirli bir alanın ya da yazarın bilimsel üretkenliğini, etkisini ve iş birliği ağlarını değerlendirebilirler. Bibliyometri, bilimsel çalışmaların performansını ölçmek, araştırma trendlerini belirlemek ve iş birliği modellerini anlamak için yaygın olarak kullanılır. Bibliyometrik yöntemler, yazarların, dergilerin, ülkelerin ve enstitülerin performansını ve araştırma modellerini değerlendirmenin yanı sıra aralarındaki iş birliği modellerini tanımlamak ve ölçmek için de kullanılabilir (Li and Zhao, 2015: 158-166).

## 2. Materyal ve Metot

Bu çalışmada yöntem olarak bibliyografik analiz kullanılmıştır. Web of Science (WoS), dünya çapında önde gelen bilimsel atıf ve analiz platformlarından biridir ve bilimsel yayınların analizinde en yaygın kullanılan platformdur (Yang vd, 2013: 133-146). Hem geniş çaplı bilimsel işlevleri destekleyen bir araştırma aracı olarak, hem de büyük ölçekli yoğun çalışmalar için kapsamlı bir veri seti olarak hizmet vermektedir. Çeşitli bilgi alanlarında detaylı araştırmalar yapılmasına olanak tanıyan WoS, akademik çalışmaların doğruluk ve derinliğini artırarak bilim insanlarına ve araştırmacılara değerli iç görüler sunar. (Li, Rollins ve Yan, 2018: 1-20). Clarivate Analytics tarafından üretilen Web of Science veritabanı üzerinden verilere erişim sağlanmıştır. “10.05.2024” tarihinde “machine learning” ve “eeg emotion recognition” kelimeleri ile yapılan aramaya göre toplam 660 adet yayına erişilmiştir. SCI ve SSC-I indeksli yayınlar filtrelendiğinde 448 adet yayına erişilmiştir. Verilerin analizi için VOSviewer v1.6.20 uygulaması kullanılarak çeşitli alanlarda analiz elde edilmiştir.

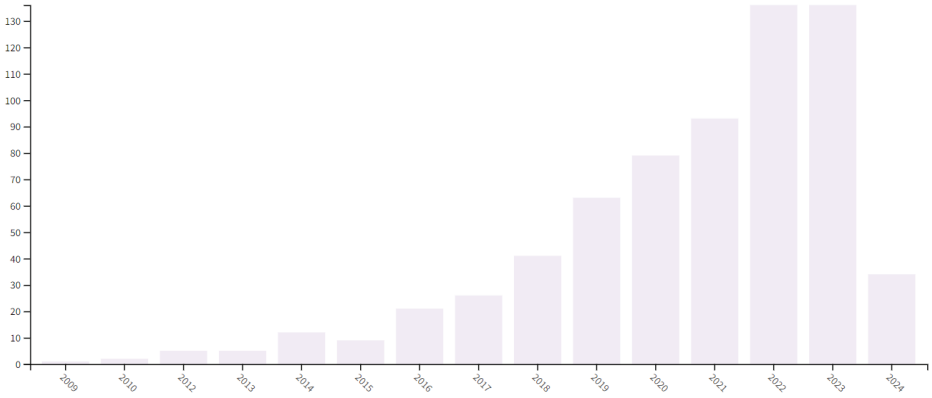


Şekil 1. Yayınların Seçilmesinde İzlenen Prosedür.

### 3. Bulgular

#### 3.1. Yayın Yılı Analizi

Şekil 2’ de yıl bazında yayınların artışı analiz edilmiştir. “Makine Yöntemi ile Duygu EEG Sinyallerinin Belirlenmesi” konulu araştırmalara ilişkin 2009 yılında 1 adet yayın görülmüştür. 2018 yılından itibaren konuya ilginin artmış olduğu ve son yıllarda kriterlere uyan 100 ün üzerinde yayının olduğu gözlemlenmiştir.



Şekil 2. Yıl Bazında Yayınların Artış Grafiği.

#### 3.2. Kategori Analizi

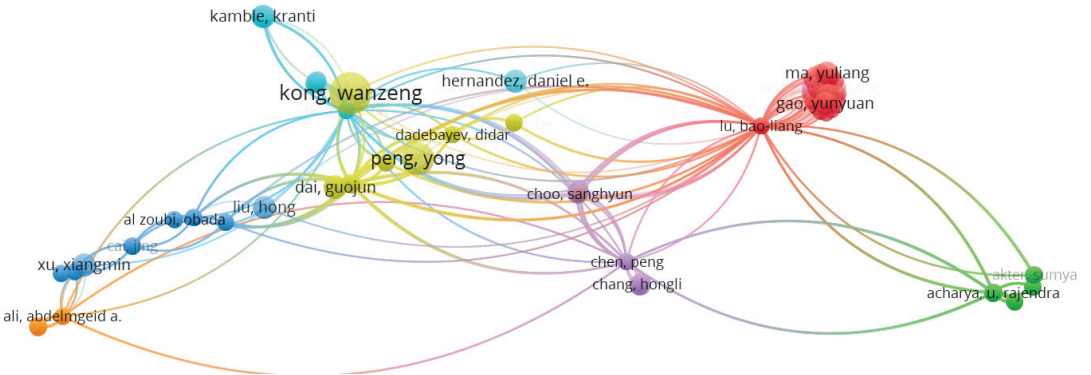
Yapılan aramaya göre 448 adet yayına ulaşılmıştır. Tablo 1’ de yayınların ilk beş kategorisine yer verilmiştir. Ulaşılan yayınların yüzdesel çoğunluğunun mühendislik alanı kategorilerinde olduğu görülmüştür.

**Tablo 1.** Araştırmaya Dahil Olan Yayınların Kategorileri.

Kategori	Kayıt Sayısı	Yüzde (%)
Elektrik Elektronik Mühendisliği	134	29.9
Yapay Zeka Mühendisliği	100	22.3
Nörobilim	90	20.1
Bilgisayar ve Bilgi Sistemleri Bilimi	84	18.7
Biyomedikal Mühendisliği	60	13.4

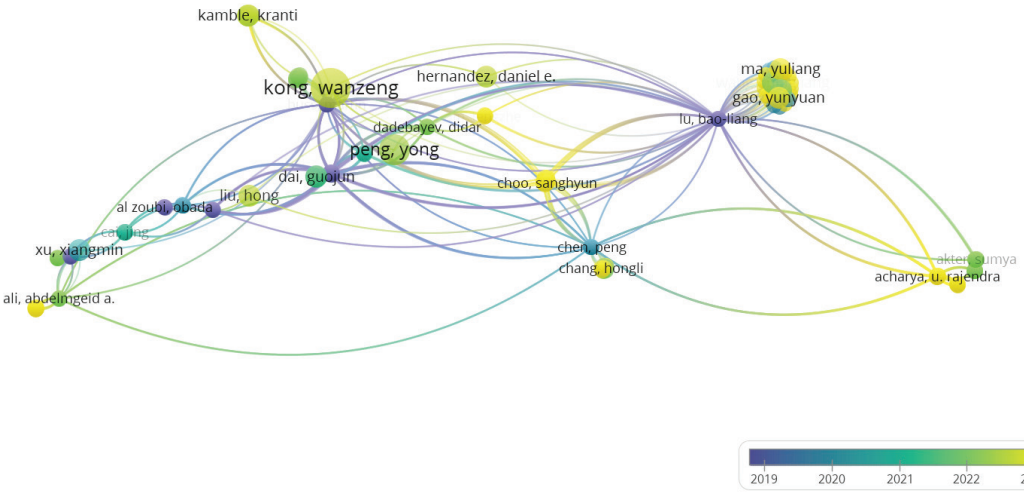
### 3.3. Yazar Atıf Analizi

Yazarların atıflarına göre analiz yapıldığında minimum doküman sayısı 1 ve atıf sayısı 1 seçilerek haritalandırma yapılmıştır. Buna göre 188 yazara ulaşılmıştır. Şekil 3’te görüldüğü üzere en fazla atıf yapılan yazarlar Kong Wanzeng, Bao-Liang Lu, Zheng Wei-Long, Zhu Jia-yi, Ma Yuliang, Gao Yunyuan olarak görülmektedir.



Şekil 3. Yazar Atıf Haritası.

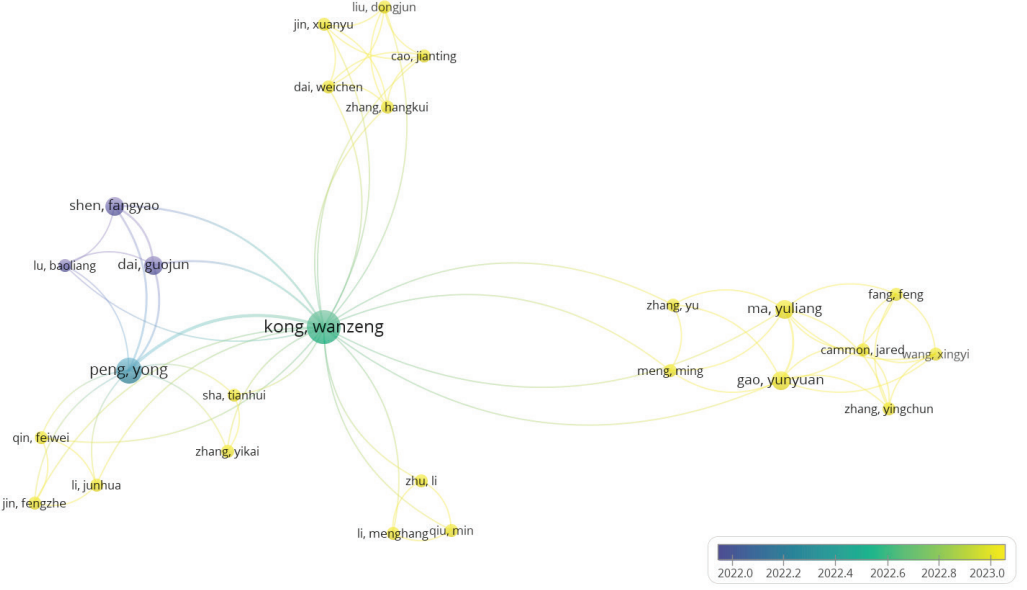
Yazarların yıllara göre haritasına bakıldığında ise Şekil 4’te görüleceği üzere sarı renkli yazarların 2022 yılından itibaren atıf sayıları artmıştır. Ma Yuliang, Gao Yunyuan, Kamble Kranti, Ali Abdelmgeid gibi yazarların son yıllarda atıf sayılarının arttığı görülmüştür.



Şekil 4. Yazar Atıf Zaman Haritası.

### 3.4. Ortak Yazarlık Analizi

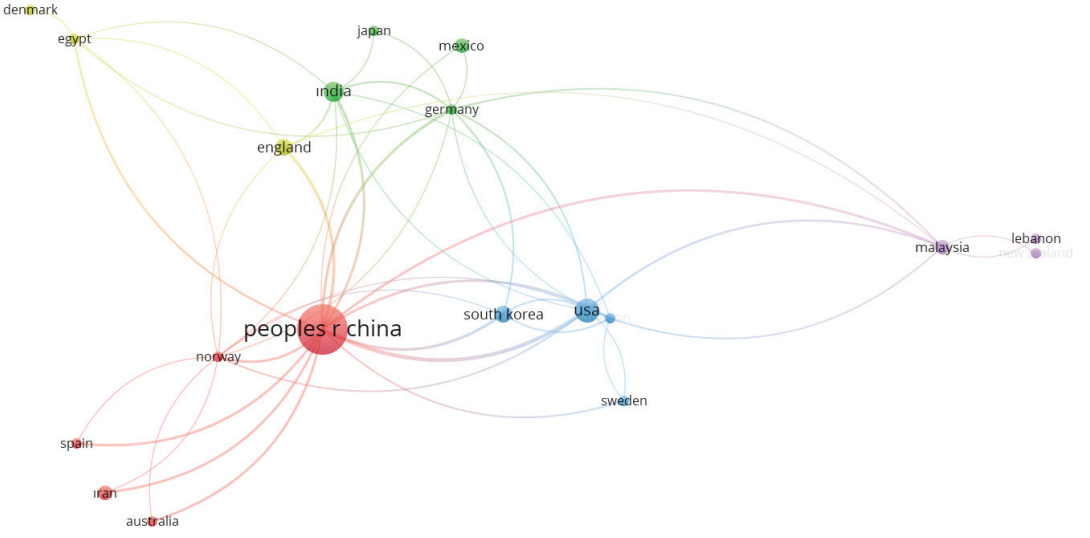
Yazarların ortaklıklarına göre en fazla iş birliği yapan yazarlar tespit edilmiştir. Minimum atıf yapılan yazar 1 ve minimum atıf yapılan doküman 1 seçilerek ilerlendiğinde 6 farklı kümede toplam 26 yazara ulaşılmış ve Şekil 5’te gösterilmiştir.



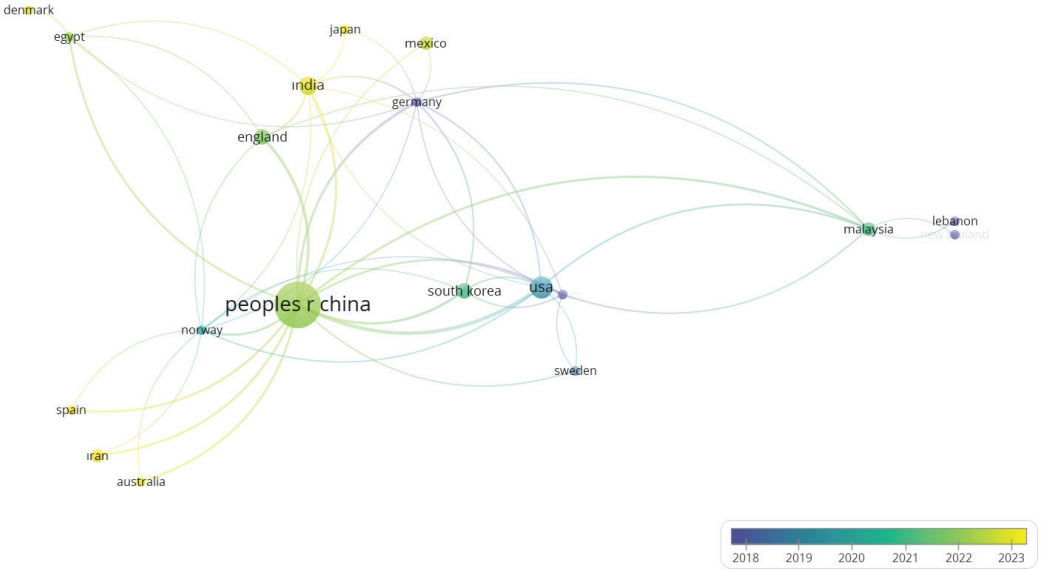
Şekil 5. Yazarların Ortak Yazarlık Zaman Haritası.

### 3.5. Ülke Analizi

Ülkelerdeki çalışmalarını incelemek üzere minimum doküman sayısı 1 ve atıf sayısı 1 olacak şekilde haritalandırma yapılmıştır. 25 adet ülkeden 22'si bu kriterleri sağlamıştır. Duygu EEG sinyallerinin makine öğrenme yöntemi ile sınıflandırılmasına ilişkin olarak Çin'in büyük bir alan kapladığı ve bu konu üzerinde diğer ülkelere baskın şekilde yayınlar yaptığı görülmektedir. Bu durum Şekil 6'da haritalandırılmıştır. Şekil 7'deki zaman haritasında görüldüğü üzere, son yıllarda Hindistan, Japonya, Meksika, Danimarka, İspanya, İran ve Avusturya gibi ülkelerin konuya ilgilerinin arttığı, güncel yayınlar ortaya koydukları gözlemlenmiştir.



Şekil 6. Ülkelerin Yayın Atıf Haritası.



Şekil 7. Ülkelerin Yıllara Göre Yayın Atıf Zaman Haritası.



“Makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu sınıflandırma” konusu üzerine gerçekleştirilmiş çalışmalara katkı veren ve en çok yayın üreten ilk on ülke Tablo 2’ de verilmiştir.

**Tablo 2.** Ülkelerin Yayın Sayıları.

Ülke	Yayın Sayısı	Yüzde
Çin	184	41.1%
Hindistan	54	12.1%
Amerika	48	10.7%
Suudi Arabistan	26	5.8%
İngiltere	25	5.6%
Güney Kore	23	5.1%
İtalya	19	4.2%
Malezya	17	3.8%
Japonya	15	3.3%
Türkiye	15	3.3%

Tablo 2 incelendiğinde, en çok araştırma gerçekleştiren ülkenin Çin olduğu görülmektedir. En çok yayın üreten on ülkenin toplam yayın sayısı 448 olup Çin’ in %41 lik bir orana sahip olduğu görülmektedir. Türkiye 15 yayın ile Japonya ile beraber en çok araştırma gerçekleştiren 9. ülke konumundadır.

### 3.6. Kurum Analizi

Kurumların yayınları üzerinden analiz yapılmak istenildiğinde minimum atıf sayısı 1 ve minimum doküman sayısı 1 seçilerek ilerlenmiştir. Bu kriterleri 79 adet kurum sağlamıştır. Yapılan analize göre toplam bağlantı gücü en yüksek olan kurumlar şu şekildedir; Shanghai Jiao Tong University, Technology University Munich, East

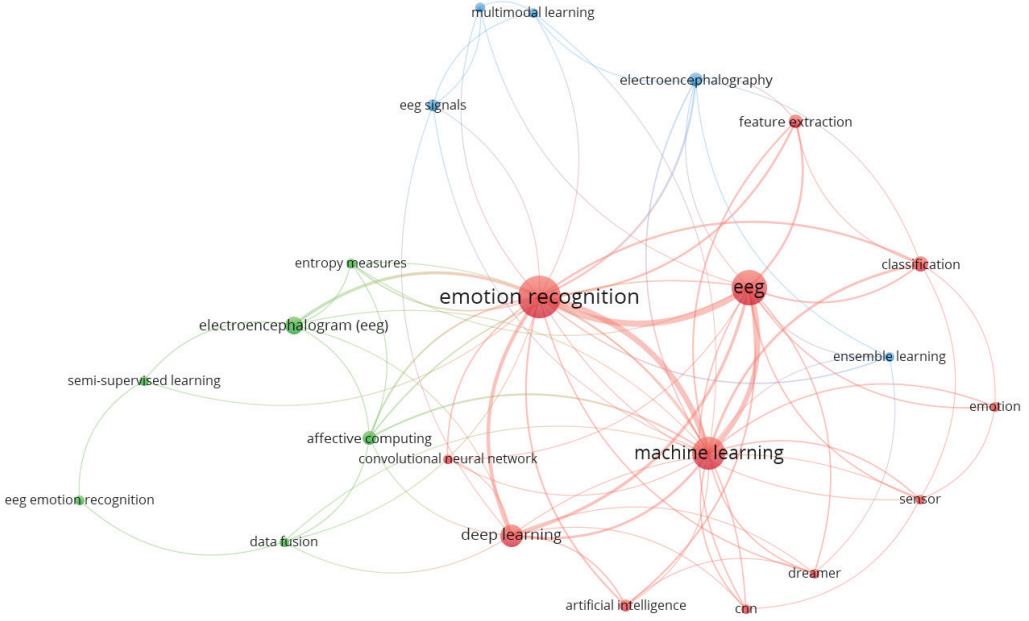


**Tablo 3.** Kurumların Yayın Sayıları.

Kurum	Yayın Sayısı	Yüzde (%)
HANGZHOU DIANZI UNIVERSITY	35	7.813
SHANGHAI JIAO TONG UNIVERSITY	17	3.795
CHINESE ACADEMY OF SCIENCES	15	3.348
NATIONAL INSTITUTE OF TECHNOLOGY NIT SYSTEM	12	2.679
NORTHWESTERN POLYTECHNICAL UNIVERSITY	12	2.679
FIRAT UNIVERSITY	10	2.232
EGYPTIAN KNOWLEDGE BANK EKB	9	2.009
NANYANG TECHNOLOGICAL UNIVERSITY	9	2.009
IMAM MOHAMMAD IBN SAUD ISLAMIC UNIVERSITY	8	1.786
UNIVERSITY OF CALIFORNIA SYSTEM	8	1.786

### 3.7. Kelime Analizi

Yayınlaraın özet bilgilerinde minimum iki kez tekrar edilen kelimeler için seçim yapıp ilerlendiğinde 134 adet kelimedenden 23 adeti kriterlere uymuştur. Buna göre yapılan haritalandırma Şekil 8’de gösterilmiştir. En çok kullanılan kelimeler “duygu analizi”, “makine öğrenmesi”, “eeg”, “sınıflandırma”, “derin öğrenme” olmuştur.

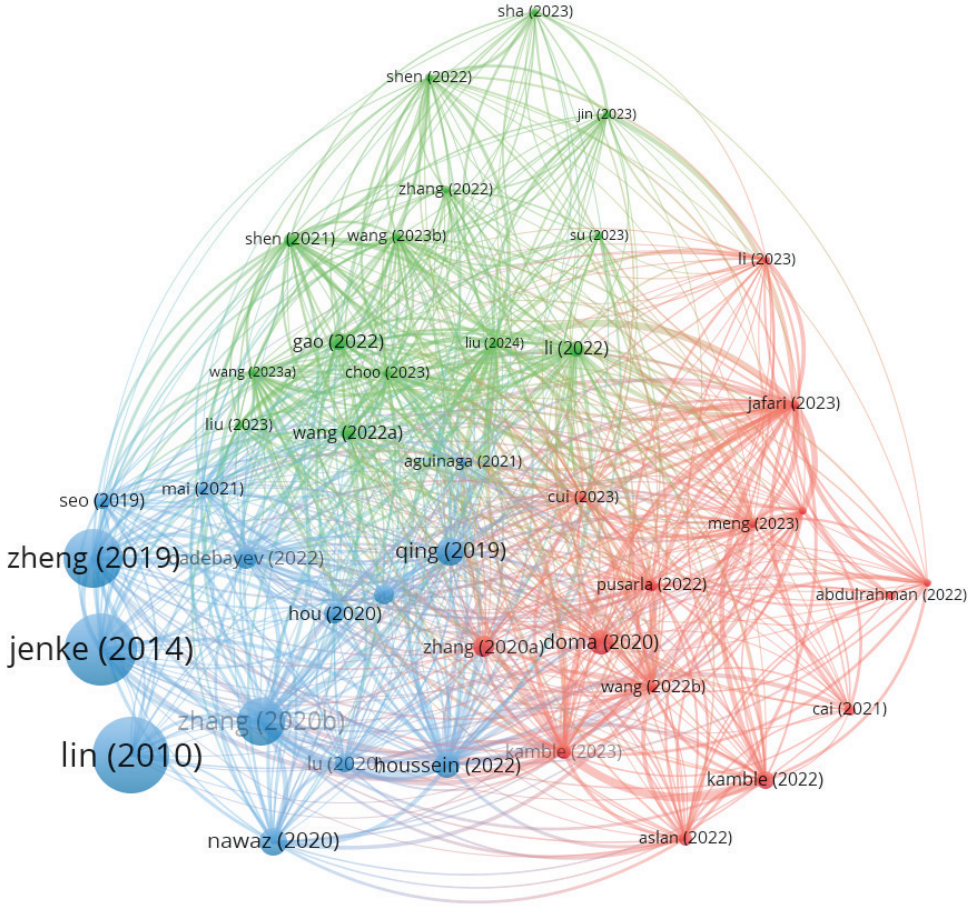


Şekil 8. Kelimelerin Kullanılma Sıklığı Haritası

### 3.8. Yayınların Bibliyografik Eşleşme Analizi

“Bibliyografik eşleşme” (bibliographic coupling), bilimsel literatürde iki veya daha fazla dokümanın ortak referansları paylaşması durumudur. Bu, belirli kaynakları paylaşan makalelerin, belirli konular veya fikirler etrafında birbirleriyle ilişkili olabileceğini gösterir. Bibliyografik eşleşme, belirli bir araştırma alanında çalışmalar arasındaki ilişkileri ve etkileşimleri anlamak için kullanılır (Dirik vd. 2023: 164-188).

Yayınlar arası bibliyografik eşleşme incelendiğinde en az 1 atıfta bulunulmak kaydıyla 448 yayının 43 adeti bu kriteri sağlamıştır. Bu yayınlar aralarındaki bağ üç farklı grupta kümelenmiştir.



Şekil 9. Yayınların Bibliyografik Eşleşme Haritası.

### 3.9. Yazarların Bibliyografik Eşleşmesi

En az 1 eser yayınlamış ve 1 atıf almış olmak kriteri ile seçilen ve aralarında bağlantı bulunan 215 yazarın 188 tanesi bu kriterleri sağlamıştır. Toplam bağlantı gücüne göre en fazla bibliyografik eşleşmesi olan 20 yazar ve bilgileri aşağıdaki Tablo 4' te listelenmiştir.

**Tablo 4.** Yazarların Doküman Sayısı, Atıf Sayısı ve Toplam Bağlantı Gücü.

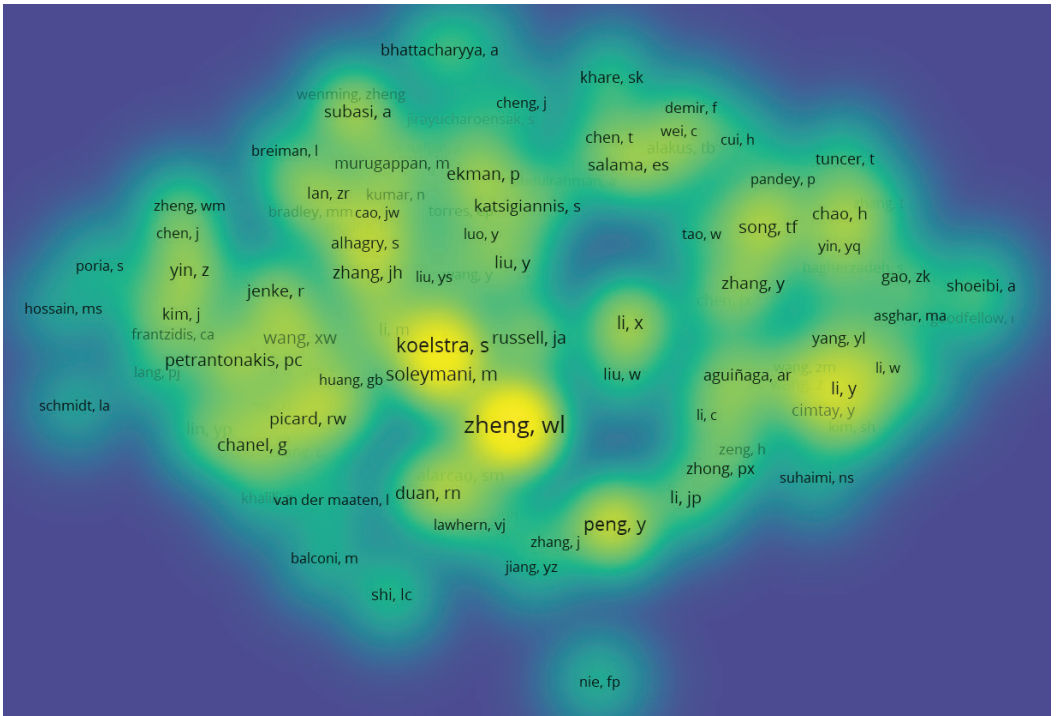
Yazar	Doküman Sayısı	Atıf Sayısı	Toplam Bağlantı Gücü
Kong, Wanzeng			
Acharya, Rajendra	23	300	66382
Bagherzadeh, Sara	16	1243	50632
Garcia, David Lopez	19	241	48636
Gorriz, Juan	11	441	38276
Jafari, Mahboobeh	7	39	4067
Khodatars, Marjane	1	8	3814
Shalhaf, Ahmad	1	8	3814
Shoeibi, Afshin	1	8	3814
Jensen, Christian	1	8	3814
Liu, Huan	1	1	2458
Lou, Tianyu	1	1	2458
Wu, Yixiao	1	1	2458
Xiao, Yang	1	1	2458
Zhang, Dalin	1	1	2458
Zhang, Yuzhe	1	1	2458
Peng, Yong	4	29	2151
Kamble, Kranti	2	47	1888
Sengupta, Joydeep	2	47	1888
Chen, Peng	1	237	1766

### 3.10. Yazarların Eş Atıf Analizi

Eş atıf, bilimsel literatürde iki ya da daha fazla yayının aynı çalışmalara atıf yapması durumunu ifade eder. Eş-atıf analizi, belirli bir alanda hangi yayımların birlikte sıklıkla atıf aldığını belirlemeye yardımcı olur. Bu, belirli bir konu, teori veya metodoloji etrafında bilim dünyasında nasıl bir topluluk oluştuğunu ve bu topluluğun yapılanmasını anlamak

için önemlidir. Eş-atıflar, genellikle aynı veya benzer konular üzerine çalışan araştırmalar arasında güçlü ilişkilerin olduğunu gösterir.

Eş atıf yapılan yazarlar belirlenmek istendiğinde minimum atıf sayısı 5 seçilerek ilenlenmiş ve 2101 yazarın 115 bu kriterleri sağlamıştır. Eş atıf analizine ilişkin ısı haritası Şekil 10’ da verilmiştir.



Şekil 10. Yazarların Eş Atıf Isı Haritası.

#### 4. Sonuç

Makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu sınıflandırma, beyin sinyallerini anlamak ve duygusal durumlarla ilişkilendirmek açısından büyük önem taşımaktadır. Bu yöntemler, depresyon ve anksiyete gibi duygusal rahatsızlıkların erken teşhisine

olanak sağlayarak duygusal sağlık takibinde devrim yaratılabileceği düşünülmektedir. Aynı zamanda, beyin-bilgisayar ara yüzleriyle engelli bireylerin cihazları düşünceleriyle kontrol etmeleri veya iletişim kurmaları mümkün hale gelebilecektir. Ayrıca, bilgisayar oyunları, eğitim yazılımları ve sanal gerçeklik uygulamalarında kullanıcı deneyimini kişiselleştirerek insan-bilgisayar etkileşimini geliştirebileceği düşünülmektedir. Duygusal durumların beyin aktiviteleriyle ilişkisi psikoloji ve nörobilim araştırmalarına yeni iç görüler katabilirken, klinik uygulamalarda tedavi süreçlerini iyileştirmek ve terapilerin etkinliğini artırmak açısından da umut vaat etmektedir. Bu nedenle, makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu sınıflandırma bilimsel ve teknolojik gelişmelerin yanı sıra insan sağlığı alanında da önemli bir katkı sağlayacaktır.

Bu araştırma, “Makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu sınıflandırma” üzerine yapılan yayınların kapsamlı bir incelemesini sunmaktadır. İlk inceleme ve filtreleme aşamalarından sonra, WoS veri tabanında indekslenen 448 yayın seçilmiş ve bibliyometrik analizler için verileri hazırlanmıştır.

VOSViewer uygulaması ile ülke, yazar, yayın, kurum haritaları çıkarılmıştır. Ortak yazarlık, Yazarların Eş Atıf Analizi (Co-citation of Authors), Yazarların Bibliyografik Eşleşmesi, Yayınların Bibliyografik Eşleşme Analizi, Kelime Analizi (Co-occurrence Author Keywords) gibi bibliyometrik analiz teknikleri kullanılmıştır.

Bu bağlamda, “Makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu sınıflandırma” yayınlarının eğilimleri, genel özellikleri ve iş birliği ağları ayrıntılı bir şekilde incelenmiştir. Özellikle son yıllarda artan yayın sayısı ile birçok değerli araştırma bulgusu ortaya konmuştur.



Yayımlar incelendiğinde en çok geçen kelimelerden en önemlileri “duygu analizi”, “makine öğrenmesi”, “eeg”, “sınıflandırma” ve “derin öğrenme” olarak görülmektedir. Buradan anlaşılacağı üzere makine öğrenme yöntemleri kullanılarak EEG tabanlı duygu sınıflandırma üzerine yapılan araştırmalarda derin öğrenmeye de yer verildiği görülmüştür. Bu da araştırılması gereken başka bir konu olarak karşımıza çıkmaktadır.

Ülkelerin yayın sayısı incelendiğinde en çok yayın yapan ülkenin %41 lük oranla Çin olduğu görülmektedir. Hindistan ve Amerika da sırasıyla %12 ve %10 lük yüzdeler ile Çin’ i takip ettiği görülmektedir. Bu üç ülkenin toplam yayın sayısı %63 oran ile konu alanını baskıladıkları görülmüştür.

En çok atıf yapılan ülkeler incelendiğinde Çin’ in yine önde geldiği görülmüştür. Aynı zamanda son yıllarda Hindistan, Avustralya, İspanya, Japonya ve Danimarka gibi ülkelerin de atıf sayılarının arttığı görülmektedir.

Ülkelerin iş birliği haritası incelendiğinde Çin, Hindistan, Amerika ve Suudi Arabistan’ ın önde geldiği görülmüştür. Bu ülkeler, kapsamlı araştırma altyapıları, kaliteli üniversiteleri ve Ar-Ge’ye yaptıkları büyük yatırımlarla dikkat çekmektedir. Bu durum, diğer ülkelerle iş birliği yaparak bilimsel çalışmalarını daha ileri taşımalarını sağlayacağı öngörülmektedir. Öte yandan, Hindistan ve Suudi Arabistan gibi gelişmekte olan ülkeler, uluslararası iş birlikleriyle bilgi ve teknolojiyi paylaşarak bilimsel gelişimlerini hızlandırmayı hedeflemektedirler. Bu ülkelerin bilimsel çeşitlilik ve farklı perspektiflere açık olmaları, iş birliklerinin kalitesini artırır ve bilimsel inovasyonu destekleyeceği düşünülmektedir.

## Kaynakça

- Al, U., Sezen, U., ve Soydal, İ. (2012). Hacettepe Üniversitesi bilimsel yayınlarının sosyal ağ analizi yöntemiyle değerlendirilmesi. Hacettepe Üniversitesi Edebiyat Fakültesi Dergisi, 29(1).
- Dirik, D., Eryılmaz, İ. ve Erhan, T. (2023). Post-truth kavramı üzerine yapılan çalışmaların VOSviewer ile bibliyometrik Analizi. Sosyal Mucit Academic Review, 4(2), 164-188. doi: 10.54733/smar.1271369
- Li, K., Rollins, J. ve Yan, E. (2018) Web of science use in published research and review papers 1997–2017: A selective, dynamic, cross-domain, content-based analysis. *Scientometrics*, 115, 1–20. <https://doi.org/10.1007/s11192-017-2622-5>
- Li, W., Zhao, Y., 2015. Bibliometric analysis of global environmental assessment research in a 20-year period. *Environ. Impact Assess. Rev.* 50, 158–166. <https://doi.org/10.1016/j.eiar.2014.09.012>
- URL-1: <https://www.webofscience.com/wos>, Erişim Tarihi: 10.05.2024)
- Xie, J., Luo, Y., Wang, S., & Liu, G. (2024). Electroencephalography-based recognition of six basic emotions in virtual reality environments. *Biomedical Signal Processing and Control*, 93, 106189. <https://doi.org/10.1016/j.bspc.2024.106189>
- Yang, L., Chen, Z., Liu, T., Gong, Z., Yu, Y., Wang, J. (2013). Global trends of solid waste research from 1997 to 2011 by using bibliometric analysis. *Scientometrics* 96, 133–146. <https://doi.org/10.1007/s11192-012-0911-6>
- Zhang, J., Yin, Z., Chen, P., & Nichele, S. (2020). Emotion recognition using multi-modal data and machine learning techniques: A tutorial and review, *Information Fusion*, Volume 59, 2020, Pages 103-126, <https://doi.org/10.1016/j.inffus.2020.01.011>

## YAZIM KILAVUZU

### **Çalışmanın Türkçe İsmi Her Kelimenin İlk Harfi Büyük (Bağlaçlar Hariç) ve “Times New Roman” Fontunda 14 Punto ve Tek Satır Boşluk Olacak Şekilde**

(Sisteme yüklenen word dosyasında kişisel bilgiler yazılmamalı. Bu bilgiler eksiksiz ve doğru olarak makale gönderimi kısmında yer alan kutucuklara doldurulmalıdır.)

Birinci YAZAR<sup>1\*</sup>, İkinci YAZAR<sup>2</sup> (12 Punto)  
(Boşluk olacak)

<sup>1</sup>Üniversite, Fakülte ve/veya Bölüm, Şehir, Ülke, Orcid numarası (10 Punto)

<sup>2</sup>Görev Yaptığı Kurum, Şehir, Ülke, Orcid numarası (10 Punto)

(Boşluk olacak)

\*Sorumlu Yazar e mail: xxxxx@xxxxx.com

Atıf/Citation:

---

(Boşluk olacak)

### **Öz (12 punto)**

Bu Microsoft Word belgesi Haliç Üniversitesi Sosyal Bilimler Enstitüsü Müdürlüğü tarafından yayınlanan Sosyal Bilimler Dergisi'ne gönderilecek olan makaleler için örnek olması amacıyla hazırlanmıştır. Dergimizde yayınlanmak üzere gönderilen makalelerin bu şablona göre düzenlenmeleri gerekmektedir. Özet kısmında çalışmanın yenilikleri ve temel bulguları vurgulanmalıdır. Türkçe ve İngilizce özet kısımları Times New Roman yazı tipi ile yazılmalı ve 10 punto büyüklüğü seçilmelidir. Yazım metni iki tarafa yaslanmalıdır. Özet bölümünün yazımında tek satır aralığı seçilmelidir. Makale özetinin 100 ila 200 kelime arasında olmasına dikkat edilmelidir. Türkçe ve İngilizce özetlerin 1 (bir) sayfayı geçmemesi gerekmektedir. Makalenin İngilizce olarak sunulmak istenmesi durumunda başlık ve anahtar kelimelerin önce İngilizcelerin sonra Türkçelerinin verilmesi gerekmektedir. Anahtar kelime sayısı en az 3 en fazla 6 olmalıdır. (10 Punto)

**Anahtar Kelimeler:** Anahtar Kelime 1, Anahtar Kelime 2, Anahtar Kelime 3. (10 Punto)

## Çalışmanın İngilizce İsmi Her Kelimenin İlk Harfi Büyük (Bağlaçlar Hariç) ve “Times New Roman” Fontunda 14 Punto ve Tek Satır Boşluk Olacak Şekilde

### Abstract (12 punto)

Bu Microsoft Word belgesi Haliç Üniversitesi Sosyal Bilimler Enstitüsü Müdürlüğü tarafından yayınlanan Sosyal Bilimler Dergisi'ne gönderilecek olan makaleler için örnek olması amacıyla hazırlanmıştır. Dergimizde yayınlanmak üzere gönderilen makalelerin bu şablona göre düzenlenmeleri gerekmektedir. Özet kısmında çalışmanın yenilikleri ve temel bulguları vurgulanmalıdır. Türkçe ve İngilizce özet kısımları Times New Roman yazı tipi ile yazılmalı ve 10 punto büyüklüğü seçilmelidir. Yazım metni iki tarafa yaslanmalıdır. Abstract bölümünün yazımında tek satır aralığı seçilmelidir. Makale özetinin 100 ila 200 kelime arasında olmasına dikkat edilmelidir. Türkçe ve İngilizce özetlerin 1 (bir) sayfayı geçmemesi gerekmektedir. Makalenin İngilizce olarak sunulmak istenmesi durumunda başlık ve anahtar kelimelerin önce İngilizcelerin sonra Türkçelerin verilmesi gerekmektedir. Anahtar kelime sayısı en az 3 en fazla 6 olmalıdır. (10 Punto)

**Keywords:** Keywords 1 , Keywords 2 , Keywords 3 , (10 Punto)

### 1. Giriş

Ana metin, A4 kağıt boyutuna 2 cm kenar boşlukları ile 12 punto yazı büyüklüğünde Times New Roman yazı tipi ile 1 satır aralığı ve her iki yana yaslı şekilde yazılmalıdır. Ana bölüm başlıkları numaralandırılmalı, kelimelerin ilk harfleri büyük olmalı ve **koyu (bold)** karakterde yazılmalıdır. Başlıkla üst metin arasında da bir satır boşluk bırakılmalıdır. Ana bölüm başlığından sonra paragraf aralığı (önce 12nk) olacak şekilde ayarlanmalı, metin arası da 1 satır olmalıdır. Paragraflar arasında boşluk bırakılmalıdır. Çalışmanın İngilizce olarak sunulmak istenmesi durumunda bölüm başlığı “**Introduction**” olarak verilmelidir. Araştırma makalelerinde bölümler şu şekilde olmalıdır: “Giriş”, “Amaç Ve Yöntem”, “Bulgular”, “Tartışma ve Sonuç”, “Kaynakça”. Derleme ve yorum yazıları için ise, çalışmanın önemini belirttiği, sorunsal ve amacın

somutlaştırıldığı “Giriş” bölümünün ardından diğer bölümler gelmeli ve çalışma “Tartışma ve Sonuç”, “Kaynakça” şeklinde bitirilmelidir.

Bu bölümde çalışmayla ilgili yeterli literatür bilgisi verilmeli ve çalışmanın gerekçesi belirtildikten sonra amacı vurgulanmalıdır. Ancak konu ile ilgisi olmayan ve gereğinden fazla literatür bilgisi vermekten kaçınılmalıdır.

Metin içi kaynak gösterimi APA formatındadır. (Yazar Soyadı, Yıl: Sayfa aralığı). (Dayanç Kıyat, 2004: 106-110). Birden fazla kaynak ile atıf yapılacak ise yazar alfabetik sıra ile yazılır (Allport, 1961: 15-17; Levy ve Guttman, 1974: 25).

## 2. Materyal ve Metot

Bu bölümde, uygulanan yöntemler ve teknikler anlaşılır bir şekilde verilmeli ve metin “Times New Roman” yazı tipinde 12 punto büyüklüğünde ve tek satır aralıkla yazılmalıdır. Metinle ilgili olarak Giriş bölümünde yapılan açıklamalar bu bölüm için de geçerlidir. Başlıkta bağlaç haricindeki tüm kelimelerde ilk harf büyük yazılmalıdır.

Çalışmanın İngilizce olarak sunulmak istenmesi durumunda bölüm başlığı “**Material and Method**” olarak verilmelidir. Bölüm içerisinde alt bölüm başlıkları açılması mümkündür.

### 2.1. Materyal ve Metot Alt Başlığı

Materyal ve metot bölümünde alt başlık altında bilgi verilmek istenmesi durumunda alt başlık “Times New Roman” yazı tipi, 12 punto ve kalın olarak yazılmalıdır. Alt başlığın ilk harfleri büyük yazılmalıdır.

## 2.2. Şekiller, Tablolar ve Denklemler

Şekiller grafik, diyagram, fotoğraf, resim ve harita şeklinde olabilir. Şekil yazısı şeklin alt kısmına yazılmalıdır. Hem şekil hem de şekil yazısı sayfaya ortalanmalıdır. Şekil yazıları okunaklı olmalıdır. Şekil ile üst metin arasında 1 satır boşluk bırakılmalıdır. Şekil yazısı ile alt metin arasında da 1 satır boşluk bırakılmalıdır. Şekil yazısı 11 punto olarak yazılmalı ve aşağıdaki örnekte (Şekil 1) olduğu gibi verilmelidir. Metin içerisinde şekillere atıfta bulunulmalıdır.



**Şekil 1.** Örnek Resim

**Kaynak:** Soyadı, A. A., (yıl). *Kitap Adı(İtalik)*. Kitabın Basıldığı Yer, Yayınevi.

Tablolar açık çerçeveli tercih edilebilir. Tablo yazısı tablonun üst kısmına yazılmalıdır. Hem tablo hem de tablo yazısı sayfanın ortasına hizalanmalıdır. Tablo yazısı ile üst metin arasında 1 satır boşluk bırakılmalıdır. Tablo ile alt metin arasında 1 satır boşluk bırakılmalıdır. Tablo yazıları tercihen 9 ile 11 punto ile yazılmalı ve tek satır aralığı seçilmelidir. Metin içerisinde tablolara atıfta bulunulmalıdır.

**Tablo 1.** Tablo Başlığı.

Sütun Başlığı	Sütun Başlığı	Sütun Başlığı
Bilgi satırı	Bilgi satırı	Bilgi satırı
Bilgi satırı	Bilgi satırı	Bilgi satırı
Bilgi satırı	Bilgi satırı	Bilgi satırı
Bilgi satırı	Bilgi satırı	Bilgi satırı

**Kaynak:** Soyadı, A. A., (yıl). *Kitap Adı(İtalik)*. Kitabın Basıldığı Yer, Yayınevi.

Denklemler sırasıyla 1'den başlanarak numaralandırılmalıdır. Denklem sola yaslanarak yazılmalı ve denklem numarası sağ kenara yerleştirilmelidir. Denklem ile metin arasında üstten ve alttan birer satır boşluk bırakılmalıdır. Denklemler resim formatında olmamalıdır. Word denklem düzenleyicisi tercih edilebilir.

### 3. Bulgular

Bu bölümde çalışma sonucunda elde edilen bulgular çalışma sırasına göre sunulmalıdır. Çalışmanın İngilizce olarak sunulmak istenmesi durumunda bölüm başlığı "**Results**" olarak verilmelidir.

### 4. Tartışma

Bu bölümde, yapılan çalışmadan elde edilen bulgular bilimsel ilkelerin ışığı altında önceki verilerle karşılaştırılarak irdelenmelidir. İstenilmesi halinde, elde edilen bulgular ve bunların irdelenmesi **Bulgular ve Tartışma** başlığı altında da verilebilir.

### 5. Sonuç

Bu bölümde çalışmadan elde edilen özgün sonuçlar bir sıra dâhilinde sunulmalıdır. Çalışmanın İngilizce olarak sunulmak istenmesi durumunda bölüm başlığı "**Conclusions**" olarak verilmelidir.

### Teşekkür

Varsa bu bölümde, çalışmada yardım ya da destekleri bulunan kişi veya kişilere ya da kurum yetkililerine teşekkür edilebilir. Çalışmanın İngilizce olarak sunulmak istenmesi durumunda bu bölümün başlığı "**Acknowledgment**" olarak verilmelidir.

## **Kaynakça**

Kaynakça başlığı diğer başlıklar gibi “Times New Roman” fontunda 12 punto, bold olarak yazılmalıdır. Çalışmada yararlanılan kaynaklar alfabetik sıra ile “Kaynakça” başlığı altında 11punto ile yazılmalıdır. Kaynakların tamamı çalışmanın son sayfasındaki “Kaynakça” başlığı altında verilmelidir. Ancak Öz bölümünde kaynak gösterilmez. Her referans arasında 6 punto boşluk olmalıdır. Çalışmanın İngilizce olarak sunulmak istenmesi durumunda bölüm başlığı “**References**“ olarak verilmelidir.

## **Sürelî Yayınlar:**

Soyadı, A., Soyadı, B. B., ve Soyadı, C., (yıl). Yayınlanan Makalenin Adı. *Makalenin Yayınlandığı Dergi Adı (İtalik)*, Cilt ve sayı numarası 7(1), Makalenin sayfa numarası aralığı 1-12. Doi:

## **Kitaplar:**

Soyadı, A. A., (yıl). *Kitap Adı (İtalik)*. (B. Soyadı, Çev.)Kitabın Basıldığı Yer, Yayınevi.

## **Sempozyum, Kongre, Bildiri:**

Soyadı, A., Soyadı, B. B., ve Soyadı, C., (yıl).Yayınlanan Bildirinin Adı. *Bildirinin Yayınlandığı Sempozyum Kongre, Toplantı ya da Konferans Adı (İtalik)*, sayfa aralığı 1-12, Şehir, Varsa Üniversite veya Kuruluş.

## **Kitap İçi Bölüm:**

Soyadı, A. A., (yıl). Bölümün Adı. A. Soyadı (Ed.), *Kitabın Adı (italik)* içinde, Basım Yeri, Basım Evi.

## **Tez:**

Soyadı, A. A., (yıl). *Yüksek Lisans veya Doktora Tezinin Adı (İtalik)*. Tezin türü, Üniversite, Enstitü.



## **Web Sitesi:**

Soyadı, A. A., / Kurum, / Rapor, (yıl). Makale Başlığı. / Konu Başlığı. Erişim adresi, (Erişim Tarihi:).

Sadece link adresi ise:

URL1 erişim adresi, (Erişim Tarihi:).

**Makaleler format dışında yazıldığı takdirde direkt reddedilecektir.**

Makale yazım kılavuzunu buradan indirebilirsiniz:

<http://dergipark.gov.tr/download/journal-file/10641>

Doç. Dr. G. Banu DAYANÇ KIYAT

Editör

banukiyat@halic.edu.tr

Arş. Gör. İlkay YURDAL

Dergi Asistanı

ilkayyurdal@halic.edu.tr

e-posta: sosbd@halic.edu.tr

<https://dergipark.org.tr/tr/pub/husbd>

Haliç Üniversitesi, 5. Levent Mahallesi, 15 Temmuz Şehitler

Caddesi, No: 14/12 34060 Eyüpsultan/İSTANBUL

Tel: (0 212) 924 24 44