A REVIEW ON CURRENCY SHOCKS AND INFLATION VOLATILITY: EVIDENCE FROM A DCC-GARCH MODEL

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PLAGIARISM

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

In the present research, the relationship among the exchange rate and inflation in Turkey was investigated by considering the monthly dataset among 1990:1-2022:4 years. The consumer price index, producer price index, industrial production index, nominal exchange rate, and money supply are used as variables to represent inflation. Impulse-Response analyzes were used to find the short-term effects of the variables, decomposition of variance analysis for the causes of the changes in the variances of the variables, and the medium and long-term relationships of the variables in pairs were determined by DCC-GARCH models. While the models were being created, they were seasonally adjusted, and the inputs of the DCC-GARCH models were determined, consequently, the VAR analysis. In the results of the impulse-response analysis, it is seen that the reaction of inflation to the exchange rate shock is positive and lasts for five periods, after which the response fades. In the results of the impact-response analysis of the exchange rate, it has been determined that the reaction of the exchange rate to inflation has been stable for twelve periods. In the results of the variance decomposition analysis for inflation, at the end of twelve periods, 4.83% of the change in inflation was caused by the exchange rate; In the exchange rate variance decomposition analysis, it was concluded that 8% of the difference in the exchange rate was caused by inflation. While GARCH models show a negative interaction between inflation and exchange rate, DCC-GARCH results show that the permanence degree of short-term shocks between inflation and exchange rate is 0.43%. In addition, while a semi-strong GARCH process was found between inflation and money supply, a strong GARCH process was found between inflation and producer price index.

Keywords: DCC-GARCH, Exchange Rate, Inflation, Impulse-Response, Variance Decomposition

ÖZET

Türkiye'de enflasyon ve döviz kuru ilişkisi aylık veriler ile 1990:1-2022:4 yılları arası baz alınarak incelenmiştir. Enflasyonu temsil etmesi için tüketici fiyat endeksi; ayrıca para arzı, üretici fiyat endeksi, nominal döviz kuru ve sanayi üretim endeksi değişken olarak kullanılmıştır. Değişkenlerin kısa vadede etkilerini bulmak için Etki-Tepki analizleri, değişkenlerin varyanslarındaki değişimlerin nedenlerini bulmak için Varyans Ayrıştırma analizi, değişkenlerin ikili olarak orta ve uzun vadeli ilişkilerini bulmak için ise DCC-GARCH modelleri ile belirlenmiştir. Analizde modeller mevsimsellikten arındırılmış olup VAR analizlerinin sonuçlarına göre DCC-GARCH modellerinin girdileri belirlenmiştir. Etki-tepki analizi sonuçlarında enflasyonun döviz kuru şokuna tepkisinin pozitif olduğu ve beş dönem sürdüğü, sonrasında tepkinin söndüğü görülmektedir. Döviz kurunun etki-tepki analizi sonuçlarında ise döviz kurunun enflasyona olan tepkisinin on iki dönem boyunca istikrarlı olarak sürdüğü tespit edilmiştir. Enflasyon için yapılan varyans ayrıştırma analizi sonuçlarında ise on iki dönem sonunda enflasyondaki değişimin 4,83%'ü döviz kurundan kaynaklanırken; döviz kuru varyans ayrıştırma analizinde ise kurdaki değişimin 8%'i enflasyondan kaynaklandığı sonucuna ulaşılmıştır. GARCH modelleri ise enflasyon ve döviz kuru arasında negatif yönlü bir etkileşim olduğunu gösterirken DCC-GARCH sonuçlarında ise enflasyon ve döviz kuru arasındaki kısa vadeli şokların kalıcılık derecesi 0,43% olduğu sonucuna ulaşılmıştır. Ayrıca enflasyon ve para arzı arasında yarı güçlü GARCH sürecine rastlanırken, enflasyon ve üretici fiyat endeksi arasında güçlü bir GARCH sürecine rastlanılmıştır.

Anahtar kelimeler: Enflasyon, Döviz Kuru, DCC-GARCH, Etki-Tepki Analizi, Varyans Ayrıştırma Analizi

To my family…

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1. INTRODUCTION

The movements in the exchange rates significantly impact the macroeconomic performance indicators of the economies. The reflection of the volatility of the exchange rate on the economy is most evident in the stability of prices.

From the perspective of developing countries, exchange rate shocks can affect inflation. Alterations in exchange rates in these economies have a significant influence on prices. When the value of foreign money versus domestic currency increases, the general level of prices also increases; when the price of foreign currency decreases in domestic currency, the general level of prices tends to decrease. Since developing countries such as Turkey are foreign-dependent, that is, production is dependent on imports, the change in foreign exchange enhances the imported inputs prices and production costs. It is essential to test the influence of the rate of exchange volatility on inflation, especially in countries where the exchange rate is constantly fluctuating. For this reason, the exchange rate is frequently used as one of the variables explaining inflation in the models established while conducting economic analysis.

Whether the volatility in exchange rates affects inflation, and if so, to what extent this effect is and how long this effect will last are very important in terms of the policies that countries will implement. How inflation responds to changes in exchange rates is essential for the post-inflationary period. Various exchange rate policies, such as exchange rate fluctuations and fixed exchange rate policies, have been implemented in Turkey in the past. After the 2001 crisis, a free-floating exchange rate policy was adopted in our country. Afterward, in 2022, the implicit inflation targeting system was introduced by the fact Central Bank to provide price maintenance, so since 2006, the explicit inflation targeting system has been adopted. If there is an inflation-targeting

system in economies, the volatility in exchange rates should not be too high and be stable. Because the currency rate volatility can prevent reaching the inflation target (Arı, 2010).

The present study aimed to examine whether inflation impresses the currency rate in Turkey by using monthly data between the 1990:1 and 2022:4 periods. Due to the importance of price stability for our country, it is necessary to examine inflation and, since we are a country that is open to foreign countries and has a high demand for imported products, the volatility in exchange rates should be examined so as currency rate variances will affect costs. Present study differs from other studies in that it consists of up-to-date data. It includes variables other than the exchange rate, which are effective on inflation, in the analysis. In addition, the study is essential in terms of the policies to be implemented due to the high monetary depreciation with the increasing current rate trend, especially in recent periods.

1.1. Inflation and Exchange Rate

In economic literature, most of the research and discussion exists about the currency rate and inflation. It is important to determine the direction of the connection between inflation and exchange rate to ensure macroeconomic balance and economic stability.

Volatility in the currency rate affect the prices and monetary depreciation in the market in many ways. The prices of imported goods are the most important thing that demonstrate that the rate of exchange affects these price variations and inflation. The volatility in exchange rates causes increases and decreases in imported product prices. While upward shifts in the rate of exchange increase the costs of imported products, domestic goods become more attractive in exports. The decrease in imports and the increase in exports positively affect the balance sheet (Kendirli & Çankaya, 2016).

Local prices are directly or indirectly affected by any change in the rate of exchange. In a direct effect, while the local currency depreciates against foreign money, the prices of imported products increase.

Moreover, price increases in goods sold in foreign currency also show the direct effect of exchange rates on domestic prices. As inflation expectations and wage demand increase due to rising inflation and costs, inflation will again be pressured upwards. Thus, since imported product prices will ascend, the inland produce prices will also change according to costs and expectations. The indirect effect is reflected through exports. With the shrinkage of the local currency versus the foreign money, there will be decreases in the prices of household products, the demand for exports will increase, and the import will become expensive, and the need for imported goods will decrease. When import demand declines, domestic demand will shift to exported goods and imported substitutes, so the price of domestic goods will also increase. Herewith,

fluctuations in rate of exchange affect costs in the local market according to the change in total demand (Hyder & Sardar, 2004).

If a fluctuating exchange rate system is applied in the market, the value of the local currency is determined by the balance of supply and demand. In this system, as the sudden depreciation of the local currency against the exchange hurts inflation, the Central Bank intervenes in the exchange rate and sells foreign currency to the market (İşcan & Durgun Kaygısız, 2019).

In the fixed exchange rate system, when the stability in the currency rate is ensured, this sense of confidence, which is formed because the inflation expectations of households, firms, and the government are positive, provides price stability (Süslü, 2005).

Inflation is imported into the country to ensure price stability by using the exchange rate as the nominal anchor and connecting the local currency to the foreign currency. In other words, inflation will decrease as the prices of trade goods will be stabilized, so the current account will be impressed positively (İşcan & Durgun Kaygısız, 2019).

There are different approaches to the tie between inflation and the rate of exchange: the Classical Approach, Keynesian Approach, Monetary Approach, and Rational Expectations Hypothesis.

According to the Classical Approach, stable exchange rates mean the local currency maintains its value. If there is a change in which the exchange rates increase, then the demand for foreign currency will decrease, and the foreign exchange supply will increase so that exports will increase. With the increase in exports, the money supply will rise as there will be gold inflows into the country. In the case of full employment,

increases in gold and money supply will cause an enhance in the general price level, which will reduce exports and enhance the foreign money demand. As a result, the rate of exchange level will return to the initial level (Alacahan, 2011).

Contrary to the Classical Approach, in the Keynesian Approach, the economy comes to equilibrium at underemployment, not at full employment. If the economy is in equilibrium at the whole employment level, an increase in aggregate demand causes an increase in production and employment. That is, production and jobs depend on aggregate demand. At the level of underemployment, despite the infinity of supply of output, production increases with the increase in demand in the short term (Yılmaz, 2016). According to the Keynesian Approach, eventually, the rise in the rate of exchange, the domestic currency depreciates, and exports increase (Alacahan, 2011).

According to the Monetary Approach, expectations affect the relationship between the increase in the supply of money and the inflation rate. To reduce inflation, the amount of money available in the market is reduced by policymakers (Bozdaloğlu & Yılmaz, 2017).

The Rational Expectations Hypothesis makes decisions based on past experiences and current data. In a market environment where expectations are rational, the equilibrium point of the rate of exchange is known of households. The relationship between inflation and the rate of exchange is based on expectations (Alacahan, 2011).

2. LITERATURE REVIEW

Since inflation and exchange rates are of great importance to economies, lots of studies have been done in this area. In the studies, the connection between inflation and the rate of exchange was also inspected with various macroeconomic variables.

Ozdurak and Karatas (2020) divided the monthly data set for Turkey between the years 2006-2020 into two as the period before and after the 2018 August exchange rate shock. The model was analyzed by DCC-GARCH and Wavelet analysis. The authors aimed to examine the transformation of the increase in production costs on inflation inertia after the exchange rate shock in August 2018 and with the effect of the Covid-19 epidemic. In the study, impulse-response analyses and variance decomposition analyzes were performed first, and the inputs of the GARCH models were determined according to the results of these analyzes. According to the analysis results, it is concluded that inflation act in concert with both the money supply and producer price index, and that the money supply and producer price index affect the inflation change.

Durgun Kaygısız (2018) tested the link between inflation and the rate of exchange with VAR models using monthly data for the period 2002-2016 for Turkey. Various macroeconomic variables were added to the model. According to the results of the analysis, it was seen that the reaction of the consumer price index to the rate of exchange drove for sixteen periods and then decreased. Moreover, as for the results of the variance decomposition analysis, it was stated that 20% of the alteration in the consumer price index was derived from the exchange rate. It has been concluded that the effect of the rate of exchange on inflation is similar in the short run, medium run, and long run.

Korkmaz and Bayır (2015) examined whether the long-run connection with the producer price index, nominal exchange rate and consumer price index in Turkey between 2008 and 2014 years by cointegration tests. In the present research, it was indicated that the variables have long-run connections together. Apart from that, a single-way causality was determined by the rate of exchange to the producer price index and the inflation to the rate of exchange.

Sheefeni and Ocran (2014) indicated that whether currency rates impressed inflation in Namibia between 1993- 2011 years a significant and long-term relationship with VAR analysis.

Loloh (2014) determined the effect of the nominal currency rate shock to local prices in Ghana during the period from 1994 to 2012 years by using vector autoregressive model analysis. As a result of, the impact of the rate of exchange shock to local prices is mostly felt within 12 months, while the effect disappears within 18 to 24 months.

Helali et al (2014) took the Tunisian economy's data set between 1993 and 2011. They examined whether there was a relationship between the prices and the rate of exchange with SVAR and VECM. The study concluded that the exchange rate directly and strongly affects prices.

Selim and Ayvaz Güven (2014) created a data set for the years 1990-2012. They used cointegration tests, VAR analysis, and causality analysis to determine whether the long-run connection between inflation and exchange rate. Moreover, the existence of a causal relationship among the rate of exchange and inflation has been determined.

Günes (2013) determined the connection between exchange rates and inflation with cointegration tests and VECM using the data set for the years between 2008 and 2012 of the Turkish economy. In the model results, the enhancement in the rate of exchange also increases inflation. In addition, in the long run, price level and exchange rates move together.

Kara and Öğünç (2012) investigated the impact of the rate of exchange to local prices in Turkey between 2002 and 2011 with VAR model analysis and impulse response analysis. The impact of volatility in exchange rates and import prices on core inflation weakened in the post-2001 period. It was stated that this was the contraction of economic activities during the crisis periods, the flexible exchange rate system, and the low inflation level.

Peker and Görmüş (2008) examined the inflationary effects on the rate of exchange during the 1987-2006 years in their research for Turkey using the VAR analysis method. Consequently, in the present research, the currency rate volatility is determined as primary variable of inflation, and the affection of inflation to the rate of exchange shock is higher than the other variables' shocks.

Berument (2002) examined inflation and the rate of exchange movements with VAR analysis; this study, the data set between 1983 and 2001 was used, and Turkey was taken as a sample. Real exchange rate, inflation, and GDP were used as variables, and WPI and CPI and their sub-items were used to represent inflation. It has been concluded that WPI is more affected by the exchange rate than the CPI. In addition, the most affected sector is the manufacturing industry, and the least affected sector is the agriculture sector.

Asari et al. (2011) added other selected variables to their models besides the rate of exchange and investigated the connection of these variables with inflation in Malaysia. They completed their analysis using the function of the impulse response, cointegration test, VECM, and test of causality. In their analysis, they stated that the shock in the rate of exchange affected inflation over a long time negatively.

Odusola and Akinlo (2001) analyzed the connection among inflation, output, and the rate of exchange to explore a nexus between naira depreciation. The analysis was made for Nigeria, and data of quarterly for the period from 1970 to 1995 were used as the data set. The consequences clarified a relationship in the long term among the variables. On the contrary, decomposition analyzes indicate that the reduction in output is an expansionist influence on the rate of exchange both in the medium term and in the long term, while analysis of impulse response shows the effects of shocks.

Madesha et al. (2013) clarified the relationship between exchange rate and inflation with causality test and cointegration analysis. The data from 1980 and 2007 were used as the data set in the analysis. As a result of the study, it was determined that there is a long-term relationship and dual causality between the variables.

Udoh and Egwaikhide (2010) aimed to analyze the effect of rate of exchange shocks on foreign direct investment and inflation. An annual data set from 1970 to 2005 was used in the analysis. Herewith the study results, it is stated that the volatility in exchange rates and the uncertainty in inflation have a significant mischievous effect on foreign direct investment.

Gül and Ekinci (2006) analyzed the currency rate and inflation connection using the data set between 1984 and 2003 using monthly series. The results explain that there is a unidirectional connection between currency rate to monetary depreciation.

Albuquerque and Portugal (2005) used GARCH models to interpret the relationship among inflation volatility and currency rate. Analysis findings indicate that the connection between currency rates and inflation shocks is semi-concave.

Asad et al. (2012) surveyed the relationships among money supply, exchange rate, real income, income circulation rate and inflation. Using the data sets during 1970 and 2007 years, analyzes were made for Pakistan. In the test inference, it was observed that the effect of exchange rate on Pakistan's inflation was insignificant. Besides, a positive relationship was discovered among inflation and exchange rates.

3. METHODOLOGY

In this study, impulse-response and variance decomposition analyses were performed first. According to the results of these analyzes, the inputs of the GARCH models were determined by looking at the responses of the variables. Then, the dynamic relationship between the binary variables defined by Dynamic Conditional Regression analyzes was examined.

3.1. Vector Autoregressive Model

In the VAR models developed by Sims (1980), each endogenous variable includes both self-lagged values and the other variables' lagged values (Sevüktekin & Çınar, 2014). To put it more clearly, two equations in a model are established with two variables, Y_t and X_t, and explained variables in these equations are X_t in one and Y_t in the other. In these equations, the explanatory variables of the dependent variables, that is, the independent variables, are the own lagged values of the variables. In the established equation systems, the lagged values of the dependent variables can be used to predict the future (Kumar, Leona, & Gaskins, 1995). The fact that there is no obligation to distinguish between internal and external variables in these equation systems indicates this equation system from simultaneous equation systems (Tarı & Bozkurt, 2006).

VAR models ensure that all variables in the model can be analyzed in a mutually consistent manner by establishing a single system of equations. For variables to be used in a model to predict each other, they must be related. Therefore, keeping the number of variables in the VAR model as low as possible increases the accuracy of the estimations (Stock, Watson, & Saraçoğlu, 2011).

VAR model can be constructed as a model in which there are as many equations as the variable coefficient and the lagged values of all variables are the explanatory variables of each equation. When the two-time series variables are Y_t and X_t, the unconstrained VAR model consists of two equations.

Y_t is expressed:

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + u_t \quad (1)$$

X_t is expressed:

$$X_t = \gamma_0 + \sum_{i=1}^{m} \gamma_i X_{t-i} + \sum_{i=1}^{m} \varphi_i Y_{t-i} + \vartheta_t \quad (2)$$

In these equations, α_i, β_i, γ_i, φ_i is the unknown coefficients; u_t and ϑ_t are the terms of error, so the optimum length of lag is showed m. The coefficients of VAR models are obtained by estimating each equation using the least squares method. Rather than determining parameter estimates in VAR models, it is targeted to examine the interrelationships of variables with each other (Enders, 2004).

In VAR models, instead of interpreting that the dependent variable will increase or decrease according to the coefficients of the independent variables after the model estimation, it is more accurate to make some deductions from these analyzes by performing variance decomposition analysis and impulse-response analysis. Error terms in time series are mainly used to express shocks.

The function of impulse response measures the reaction which self-variable and variables of else to this shock, given a one-unit random shock to the error terms of the exogenous variables of the model. In addition, the disappearance times of these shocks are also measured with analysis of impulse response. In this test, the variable that gives the shock represents the effect, while the variable that receives the shock represents the response (Tarı & Bozkurt, 2006). Thus, the variables that affect each other the most/least can be determined.

Moreover, variance decomposition and the function of impulse response are used as another method to analyze error terms obtained by VAR model estimation. In a test of decomposition, the rate of the movements occasioned by the shock of a variable and the changes caused by the shocks of other variables is shown (Sevüktekin & Çınar, 2014).

3.2. ARCH & GARCH Models

The ARCH model was introduced by (Engle R. , 1982) to accurately catch the variance of conditional financial series. If today's variance depends on past variance values, that is named variance of conditional.

The ARCH model states that the variance of u_t in period t, σ_t^2 is subject to own values of lagged, the last variances of conditional of the disturbance term in the $t-1$ period, u_{t-1}.

In the Autoregressive Conditional Heteroscedasticity model, in which the variance of conditional is the dependent variable, is a regression model in which the returns squared are a covariate with their past lags.

$$r_t = \mu + \varepsilon_t \ , \ t = 1, \dots, T \qquad (3)$$

where ε_t represents residual and μ stated the mean of the process.

The residual $\varepsilon_t = z_t \sigma_t$, where $z_t \sim N(0,1)$.

Concordantly, GARCH(q) and ARCH(q) models described as

$$\alpha_0 > 0, \alpha_q > 0 \qquad (4)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2 \qquad (5)$$

Generalized Autoregressive Conditional Heteroscedasticity model represent generalizations of the generalized form of Autoregressive Conditional Heteroscedasticity models and were improved by (Engle R. , 1982) and (Bollerslev, 1986) to reach confidential estimates and forecasts.

Generalized Autoregressive Conditional Heteroscedasticity models come into existence of variance conditional, besides to mean conditional in equation 6. Below, the general GARCH model is shown.

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \alpha_2\varepsilon_{t-2}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2 + \beta_1\sigma_{t-1}^2 + \beta_2\sigma_{t-2}^2 + \cdots + \beta_p\sigma_{t-p}^2 \quad (6)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{p}\beta_j\sigma_{t-j}^2 \quad (7)$$

The a_i parameter reflects the residuals of asset *i* in the ARCH process and shows asset fluctuations reflecting the effect of these exogenous shocks on the changes. The GARCH effects are identified by β_i and test long-term persistence, while ARCH effects test short-term persistence. β_i is the model's parameters, and p, q are orders of the GARCH model.

3.3. The Model of DCC GARCH

The model of DCC GARCH is fully named “Dynamic Conditional Correlation GARCH Model”. This model was promoted by (Engle & Sheppard, 2001) and stated as an expansion of the model of CCC-GARCH promoted by (Bollerslev, 1990). The DCC-GARCH model is subject to the class of “Conditional Variance and Correlation Models”. The opinion of models in this class is that a correlation matrix, R_t, the covariance matrix, H_t, so conditional standard deviations, D_t. R_t and D_t are designed to be time-variant in DCC-GARCH model.

By (Engle R. , 2002), The model of DCC-GARCH can be described as follows:

$$r_t = \mu_t + a_t \quad (8)$$

$$a_t = H_t^{1/2} z_t \quad (9)$$

$$H_t = D_t R_t D_t \quad (10)$$

r_t: $nx1$vector of log return of assets at time t,

a_t: $E[a_t] = 0$ and $Cov[a_t] = H_t$ $nx1$ vector of mean corrected return of assets at time t,

μ_t: $nx1$ vector of the expected values of the conditional r_t,

H_t: nxn matrix of the conditional variances of a_t at time t,

$H_t^{1/2}$: Conditional variance matrix obtained by Cholesky decomposition from H_t,

Z_t: $nx1$ error vector of iid as $E[a_t] = 0$ and $E[Z_t^T]$,

D_t: nxn diagonal matrix of conditional standard deviations of a_t at time t,

R_t: nxn conditional correlation of a_t at time t,

One of the disadvantages of the DCC-GARCH model is that the time-dependent correlation matrix must be positively definite. Although there is a requirement for the H_t covariance matrix to be positive definite, this condition can be met with ease of restrictions placed on the DCC model parameters.

To be sure that the condition of positive definiteness is met, the correlation matrix R_t must be positive definite. In addition, all elements of the R_t correlation matrix must be less than or equal to 1.

Additionally, ϱ_t has to be defined as positively to assurance H_t. The structure of correlation can be expanded to the model of DCC GARCH as follows:

$$R_t = \varrho_t^{*1} \varrho_t \varrho_t^{*1} \quad (11)$$

$$\varrho_t = (1 - \varrho_1 - \varrho_2)\bar{\varrho} + \varrho_1 \varepsilon_{t-1} \varepsilon_{t-1}^T + \varrho_2 \varrho_{t-1} \quad (12)$$

In this state ϱ_t can be estimated as mentioned follows:

$$\varrho_t = \frac{1}{T} \sum_{t-1}^{T} \varepsilon_t \varepsilon_t^T \quad (13)$$

There are some conditions to the parameters ϱ_1 and ϱ_2 to guarantee that H_t is positive definition. Besides to the conditions of the univariate GARCH model, the following conditions must also be met to ensure positive unconditional variances: $\varrho_1 \geq 0$, $\varrho_2 \geq 0$ and $\varrho_1 + \varrho_2 < 1$.

4. EMPIRICAL ANALYSIS

This chapter offers the evaluation of model and results of the data and model evaluation. Then, the volatility in the inflation rate will be discussed and the factors affecting it will be explained.

4.1. Dataset & Model Results

This study purposes to examine the effects of the money supply, industrial production index, producer price index and exchange rate and on inflation in a period of increased exchange rate shocks and inflation volatility. In this analysis, a total of five variables were used, and data consisted of monthly data for the period 1990:1-2022:4 periods. These data are obtained from OECD and TCMB-EVDS web pages. All variable descriptions are determined in Table 1.

Table 1

Dataset Description

Series	**Description of the series**
CPI	Consumer Price Index
MS	M1 Money Supply
EXCH	Nominal Exchange Rate (National currency per US dollar)
PPI	Producer Price Index
IPI	Industrial Production Index

In this model, the money supply defined with MS was included in the model since money supply is an important cause of inflation. Same time, the industrial production index was used to represent total demand. It aims to better reveal the exchange rate-inflation relationship by using the nominal exchange rate rather the real exchange rate.

In present study, the connection accepted to exist among the inflation and the rate of exchange rate will be estimated by variance decomposition based on the VAR model. The effects of these variables, which are thought to affect the general level of prices, are analyzed by vector decomposition to be obtained from the VAR model. The duration of the crisis (shock) is analyzed using the VAR model's impulse-response functions.

In short, while the effects of variables such as the rate of exchange and money supply on inflation are determined by impulse-response analyses in the short term, DCC-GARCH models were used to determine the medium or long-term relationships of variables on the exchange rate and inflation.

To make all the variables used in this study -normal- as much as possible, the logarithm of the data was taken. Converting the data to logarithms reduces or eliminates skewness in the original data. Since there is an increase in acceleration instead of an absolute increase in the data converted to logarithms, the proportional gain is interpreted while the model is being analyzed.

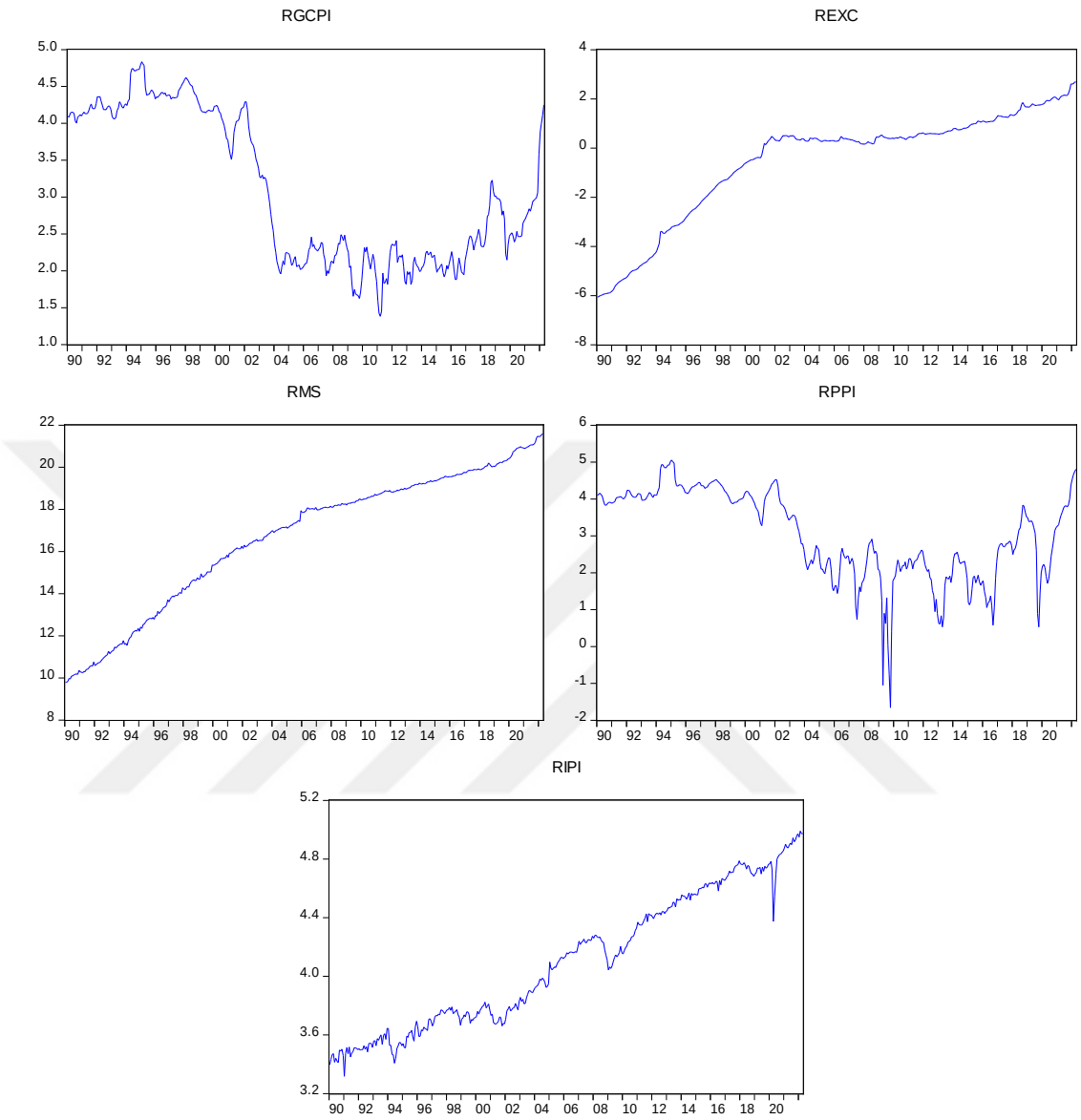
The monthly logarithmic changes used in our models are derived with the following calculation.

$$r_t = \frac{\ln (S_t)}{\ln (S_{t-1})} \quad (14)$$

Figure 1 shows a time series plot of the natural logarithm of the variables. Producer price index and consumer price index graphics show a fluctuating downward trend contrary to the nominal exchange rate; industrial production index, money supply, nominal exchange rate, and graphs show a continuous upward trend. The volatility of the graphs shows that the mean and variance of REXC, RMS, and RIPI change over time. This means that the mean is not constant, and the variance is unstable.

Figure 1

Logarithmic returns of variable



The logarithmic returns of the variables in the model show increase and decrease, not in a stationary series. For this reason, before the model was created, the data stationarity was analyzed via the test of unit root, and the series was made stationary. RGCPI and RPPI series have volatility, while REXC, RMS and RIPI series are in an uptrend.

4.2.Normality Tests

Financial time series are exposed to volatility and have a heavy- tailed dispersion. This section comprise of a normality test to validate the data.

4.2.1.Jarque-Bera Test of Normality

Jarque-Bera normality test is used to test whether the logarithmic data are normal or not normal distribution (Cryer & Chan, 2008).

Jarque-Bera test statistic is defined;

$$JB = \frac{n-1+1}{6}\left(S^2 + \frac{1}{4}(K-3)^2\right) \quad (15)$$

The skewness statistic is defined;

$$Skewness(S) = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2\right)^{3/2}} \quad (16)$$

The kurtosis statistics is defined;

$$Kurtosis(K) = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2\right)^2} \quad (17)$$

The H_0 hypothesis of the JB test is that the skewness and kurtosis are equal to each other and 0. Kurtosis measures how probable the extreme cases of a probability distribution are. In another saying, skewness is a dimension of the symmetry of the distribution of probability.

When skewness and kurtosis values are examined, the skewness statistic should be 0, and the kurtosis statistic should be 3 to accept that the series is distributed normally (Gujarati & Porter, 1999). A positive skewness expresses that it has a long tail to the right; contrary, a negative skewness coordinately has a long left tail. The hypothesis of null shows the series are distributed normally, while the hypothesis of alternative indicates the series is not normally distributed.

Table 2

Descriptive Statistics

	RCPI	**REXC**	**RMS**	**RPPI**	**RIPI**
Mean	3.091894	-0.531284	16.65442	3.029314	4.105066
Median	2.740685	0.357582	17.89888	3.131315	4.111610
Maximum	4.835420	2.688110	21.58719	5.054971	4.991029
Minimum	1.382798	-6.061705	9.781772	-1.660731	3.317732
Std. Dev.	1.015595	2.229052	3.256324	1.198402	0.459111
Skewness	0.218216	-1.113164	-0.6609705	-0.512075	0.196033
Kurtosis	1.379317	3.136563	2.171738	2.828794	1.697117
Jarque-Bera	45.54291	80.43211	35.12986	17.43082	29.92807
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	1199.655	-206.1383	6461.915	1175.374	1592.766
Sum Sq. Dev.	399.1647	1922.876	4103.612	555.7964	81.57314
Observations	388	388	388	388	388

Source: own calculations in Eviews

The study used skewness, kurtosis values, and Jarque-Bera test statistics to determine whether the series showed a normal distribution. Firstly, to see the normality of the series, kurtosis and skewness values are checked. (Brooks, 2008) states that the financial time series are generally not normally distributed. When Skewness and Kurtosis worth are among -1.5 and +1.5, it is considered a normally distributed (Tabachnik & Fidell, 2013). As seen clearly in Table 2, the skewness value of the exchange rate, money supply, and producer price index are negative; this means that the distribution of REXCH, RMS, and RPPI is skewed to the right. In addition, RCPI and RIPI have positive skewness values; this means that the distributions are skewed to the left. Considering the table, the kurtosis coefficients of all series are more significant than 0. This means that the distributions have leptokurtic distributions.

4.2.2.Unit Root Tests

Most financial data series show non-stationary characteristics. When a time series is stationary, it converges to a specific value over time. A stationary data has a fixed mean, fixed variance, and covariance depending on the lag level (Gujarati & Porter, 1999). If the time series is not stationary, a problem of spurious regression occurs forecast in model with these series (Granger & Newbold, 1974). If there is spurious regression, the results do not give the true relationship between the variables, and the t and F tests become invalid. Therefore, to reach a consistent and correct result, the variables should be made stationary and included in the model. In classical regression models, the analysis should be done when the variables are stationary.

Non-stationary series, on the other hand, should either not be used or used in the analysis after they have been differentiated and made stationary.

Before the analyses made here, the stability of the series was examined with the Augmented Dickey-Fuller Test (ADF) and Phillips Perron Tests (PP), widely used in the literature, to abstain the problem of spurious regression. The reason for making the series stationary; is that a shock at time t in a stationary series will have a minor effect at time $t+1$ and an even more negligible effect at time $t+2$. On the contrary, if the series is not stationary, the shocks in the system will continue and become permanent (Brooks, 2008). In the ADF test used in the model, the AR feature of the time series is taken into account. It is also assumed that the error terms of the ADF test are statistically independent and have constant variance.

Table 3

Augmented Dickey-Fuller Test Statistics

ADF TEST				
Variables	**Level**		**1st Difference**	
	Intercept	**Trend & Intercept**	**Intercept**	**Trend & Intercept**
RCPI	-1.046405	0.675354	-5.855920	-6.095736
	(0.7375)	(0.9996)	(0.0000)	(0.0000)
REXC	-3.507476	-2.344411	-	-
	(0.0083)	(0.4084)		
RIPI	-0.413276	-4.504351	-	-
	(0.9039)	(0.0017)		
RMS	-2.380091	-1.843330	-3.601062	-4.065442
	(0.1481)	(0.6816)	(0.0062)	(0.0077)
RPPI	-2.263845	-2.234301	-10.20701	-10.24128
	(0.1844)	(0.4686)	(0.0000)	(0.0000)

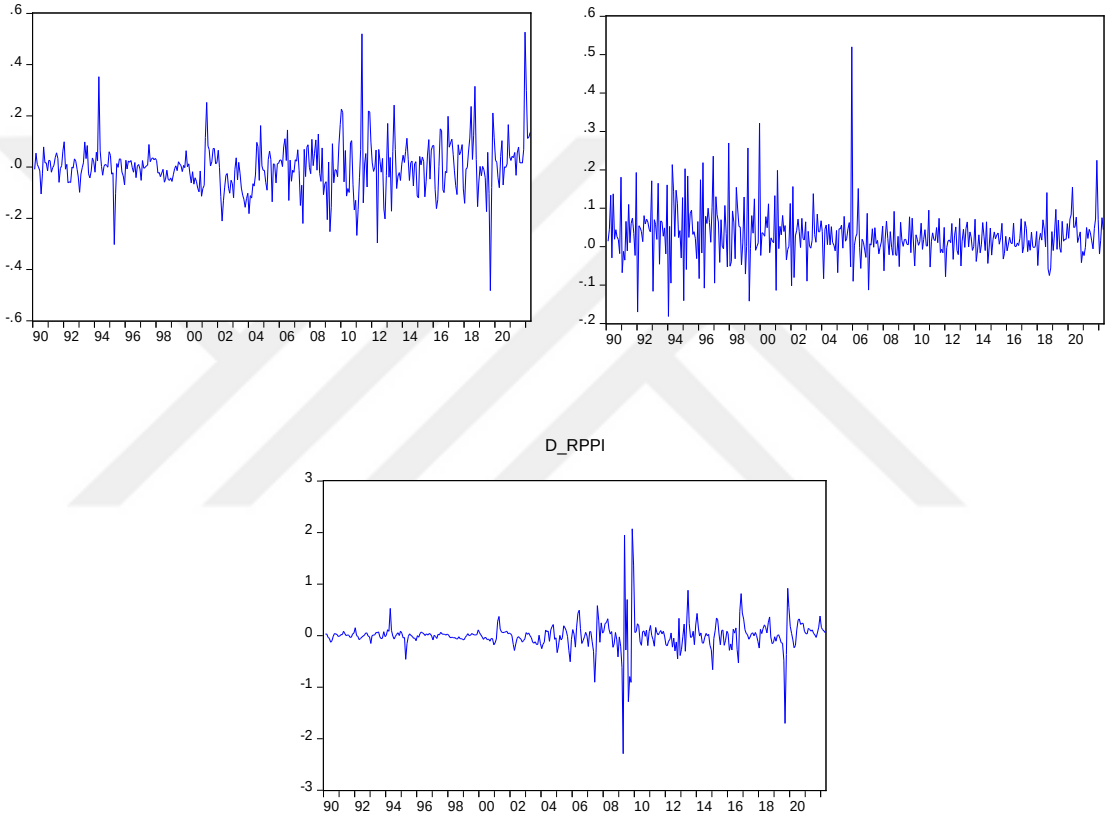
Note: All tests were performed using the Schwarz information criterion and using 16 lags.

Source: own calculations in Eviews

Accordingly Table 3, it is shown the series of REXC and RIPI are stationary at the level. In the same time, the RCPI, RMS, and RPPI are not stationary but are stationary at the first difference. Stationary series are shown in Figure 2.

Figure 2

Changes of the Consumer Price Index, Money Supply and Producer Price Index



Considering the graphs, CPI volatility was relatively low until 2008, when the financial crisis hit, and there were no significant fluctuations. The volatility increased after this crisis considerably, as seen by the large spikes. As seen in Figure 2, especially after the 2018 Exchange Rate Shock, severe fluctuations occurred in the consumer price index, producer price index, and money supply.

The analysis was started after the data used in the study were made stationary in the non-stationary series. First, VAR analysis, impulse-response analysis, and variance decomposition analyses will be performed, and GARCH models will be created according to the results.

4.3.VAR Analysis

Appropriate lag lengths must be determined to predict the analysis of VAR. To find the lag lengths, the series must be stationary. Using a small number of delays in determining the lag length reduces the accuracy of the estimation while adding a large number of delays increases the uncertainty of the analysis. The balance objectives must be satisfied between the marginal benefit of adding more delays to the model and the cost of making the other coefficient estimation. For this reason, various information criteria are used (Stock, Watson, & Saraçoğlu, 2011). The information criteria of LR, AIC, HQ, FPR, and SC are used to specify lag length. The results of the relevant criteria for determining the appropriate length of lag are specified in Table 4.

Table 4

Lag Length Criteria in VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-56.17938	NA	9.50e-07	0.322846	0.374793	0.343461
1	2196.62	4434.279	7.45e-12	-11.43337	-11.12170*	-11.30969
2	2245.251	94.42976	6.58e-12	-11.55805	-10.98664	-11.33129*
3	2285.202	76.52895	6.08e-12*	-11.63695*	-10.80581	-11.30711
4	2306.006	39.30350*	6.22e-12	-11.61481	-10.52393	-11.18190
5	2320.257	26.54555	6.58e-12	-11.55808	-10.20748	-11.02210
6	2340.173	36.57439	6.77e-12	-11.53126	-9.920917	-10.89220
7	2350.046	17.87138	7.34e-12	-11.45143	-9.581362	-10.70931
8	2361.992	21.30712	7.87e-12	-11.38254	-9.252743	-10.53735

Note: LR: Sequential modified LR test statistic, FPE: Final prediction error, AIC: Akaike information criteria, SC: Schwarz information criteria, HQ: Hannan-Quinn information criteria

Source: own calculations in Eviews

In the detection of optimum length of lag, the lag length level with the most * is considered the appropriate lag length. However, there may be an autocorrelation problem in the VAR model predicted with this length of lag. In the autocorrelation problem, one of the following lag lengths should be selected (Gujarati & Porter, 1999). The autocorrelation LM test was performed to detect the autocorrelation problem in the lag lengths. According to Table 5, since the 1st, 2nd, 3rd, and 4th lags were deemed appropriate by the information criteria, an autocorrelation test was performed, and an autocorrelation problem was observed in the 1st and 2nd lags. Therefore, the 3rd and 4th lags are appropriate for the VAR model. Between the 3rd and 4th lags, the lag length is 3, since the 3rd lag has the maximum *. As a result, the VAR model was estimated as three lags, namely VAR (3), and the autocorrelation table is shown in Table 5.

Table 5

Results of Autocorrelation LM Test

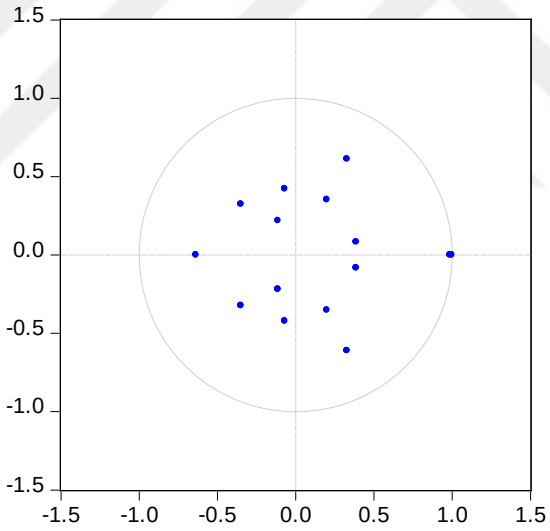
Lag	LM Test Stat.	Prob.
1	97.51004	0.0000
2	79.43458	0.0000
3	31.40637	0.1759
4	27.63162	0.3251

Source: own calculations in Eviews

As can be seen from Table 5, the lag length was chosen as 3 in the VAR model.

Figure 3

Inverse Roots of AR Characterictic Polynominal Graph



If the VAR model is VAR (3), it is seen that the modal in which the characteristic roots in Figure 3 will remain in the circle will be stationary and stable. However, the White test was used to detect and examine the problem of heteroscedasticity in this model.

4.3.1.Impulse-Response Functions

While evaluating the VAR models, impulse-response function, and variance decomposition analyses are performed instead of interpreting the coefficients of the variables. Since there are five variables in the model, the sum of the action-reaction graphics that each variable will show to itself and to other variables is twenty-five.

Based on these issues, the effects of changes in inflation, nominal exchange rate, producer price index, money supply and industrial production index on inflation were analyzed by making impulse-response and variance decomposition.

As mentioned earlier, impulse-response analyzes are functions found by VAR analysis. It shows the impact of a standard deviation shock in one of the error terms on both the present and future values of the endogenous variables.

To be suitable for the study, impulse-response graphs of each variable will be given and interpreted, but the charts of inflation and exchange rate variables will be emphasized. When a one-unit random shock is given to the producer price index, industry production index, money supply, exchange rate, and, the reactions of inflation to these shocks are shown in the chart below for 12 periods (months).

The continuous marks (blue lines) show the reaction of the endogenous variable in time to a 1 std deviation shock in the model's disturbance term.
The dashed lines (red lines) represent the confidence intervals obtained for $\pm$ 2 standard deviations.

Figure 4

Impulse-Response Analysis of CPI

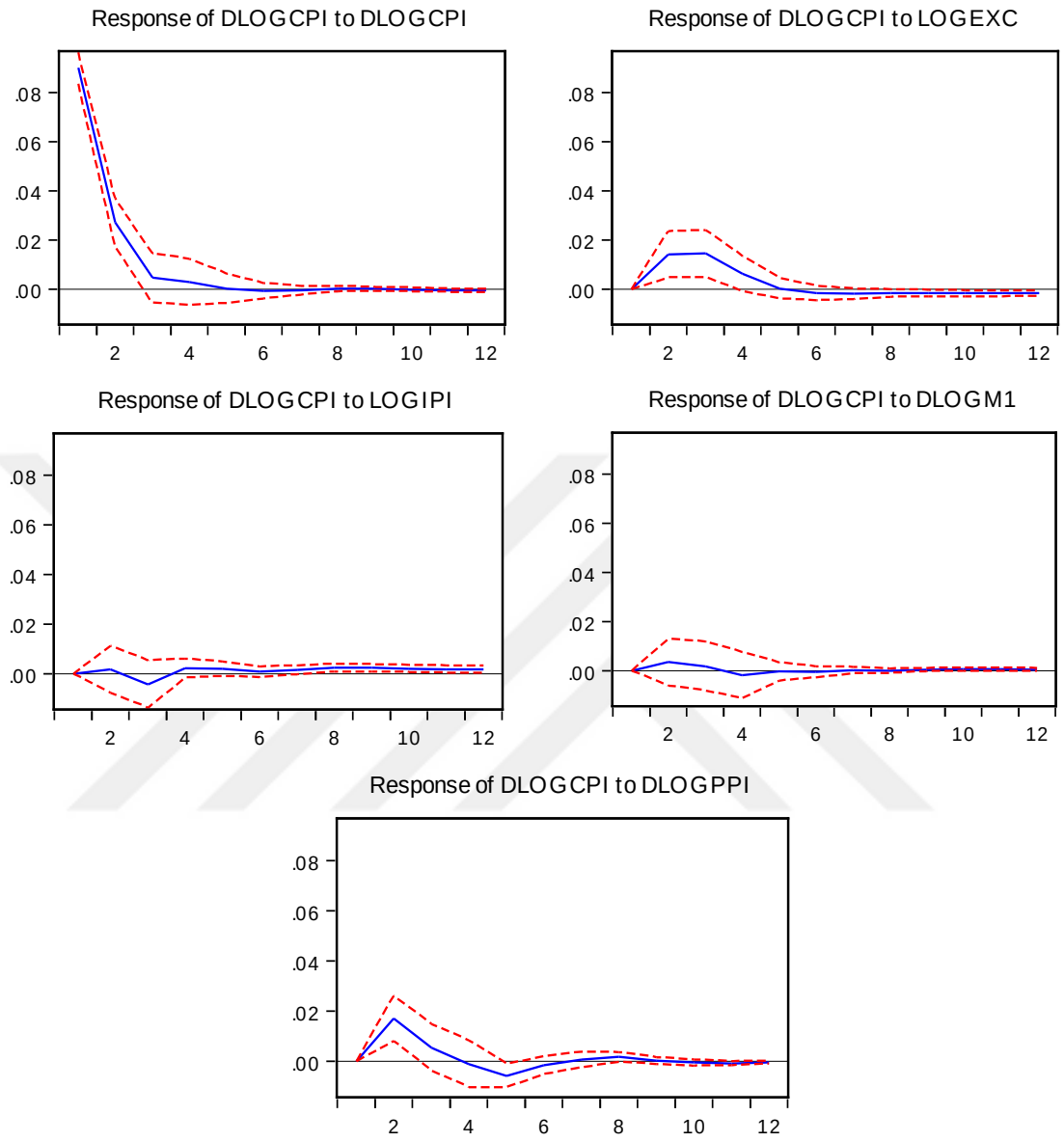
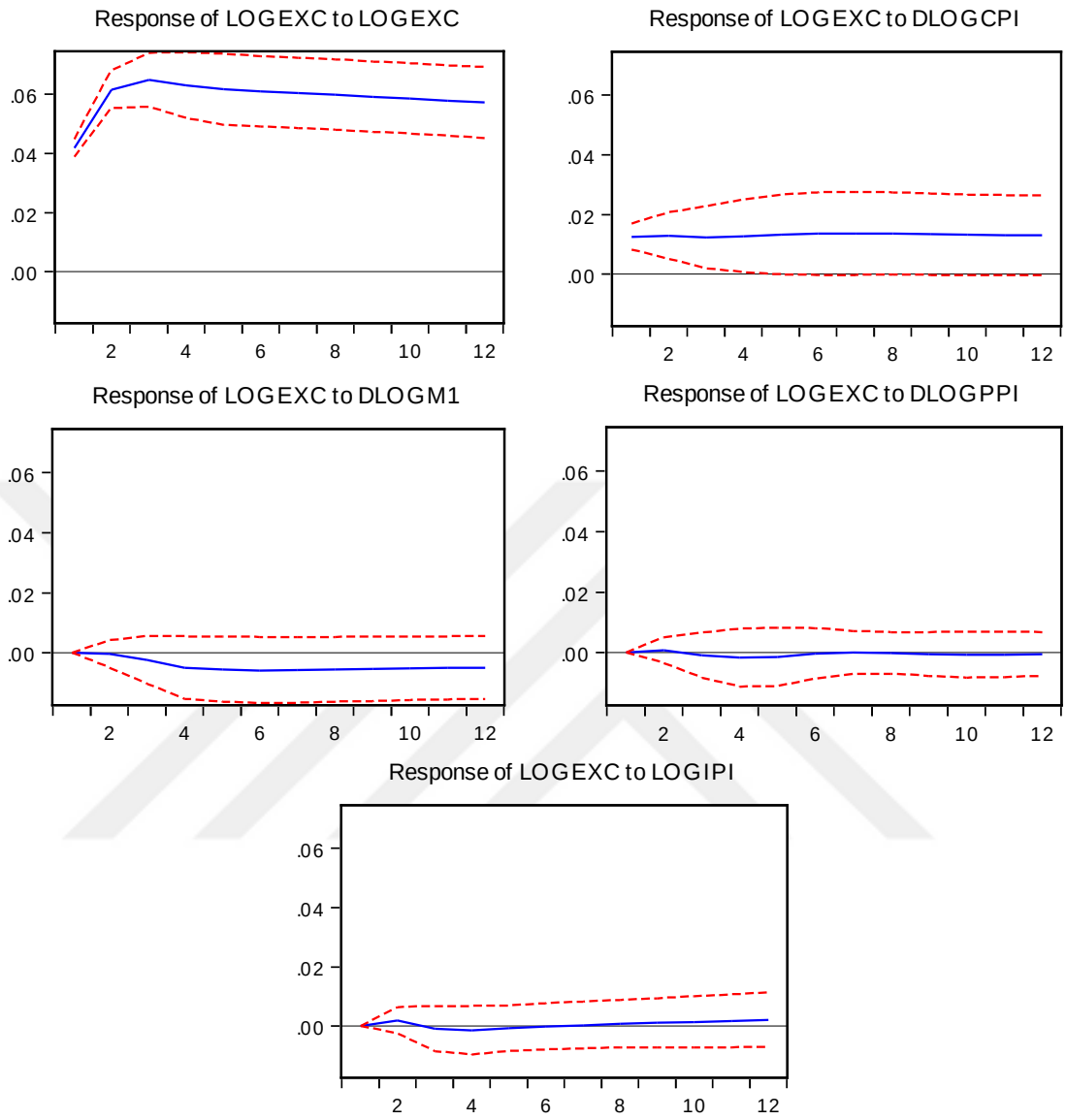


Figure 4 shows that the inflation rate variable internally responds positively to a given unit standard deviation shock over six periods. This effect stabilizes and disappears after six periods. The one-unit standard deviation shock given to the CPI had a positive impact on the exchange rate in about a quarter, and after six periods, the shock stagnated and disappeared. It is seen that the response of CPI to PPI, MS, and IPI lasts for about four periods, and then the response decreases.

Figure 5

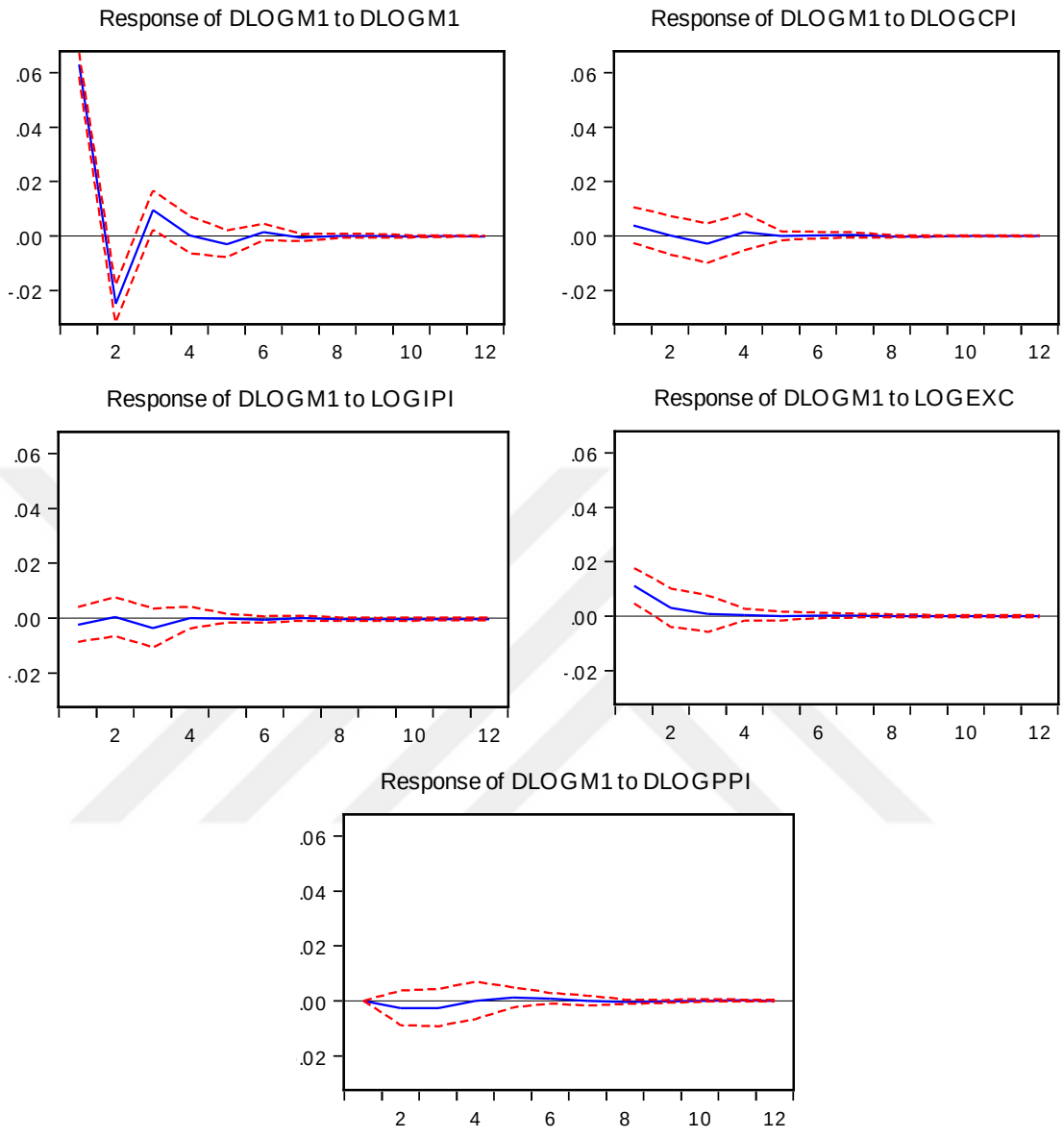
Impulse-Response Analysis of EXC



In consequence of the impulse-response analysis, the rate of exchange responds positively to a one-unit endogenous standard deviation shock. The reaction of the exchange rate to inflation has been positive and stable during 12 periods. While the EXC response to the MS is negative, the reaction to the producer price and industrial production index is stable at zero level.

Figure 6

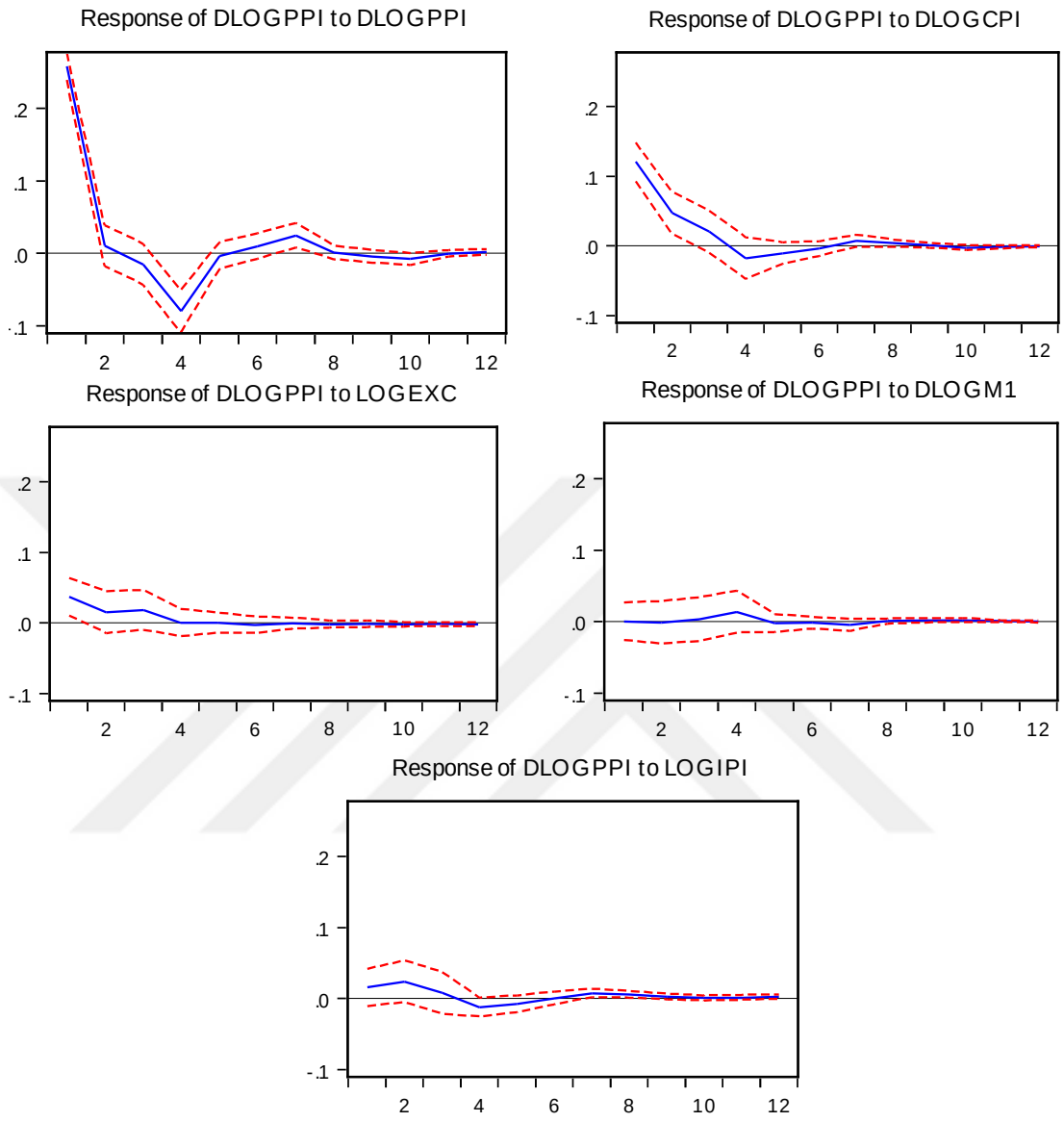
Impulse-Response Analysis of MS



In the period of first, a one-unit standard shock given to the money supply affects itself positively. In the second term it turns into a negatively effect, and back then the positive effect continues. At the end of 6 periods, it disappears by reducing the shock effect. The reaction of the shock in the money supply to other variables fades after approximately one quarter. According to Figure 6, CPI, IPI, EXC, and PPI do not respond to the shock given to the money supply.

Figure 7

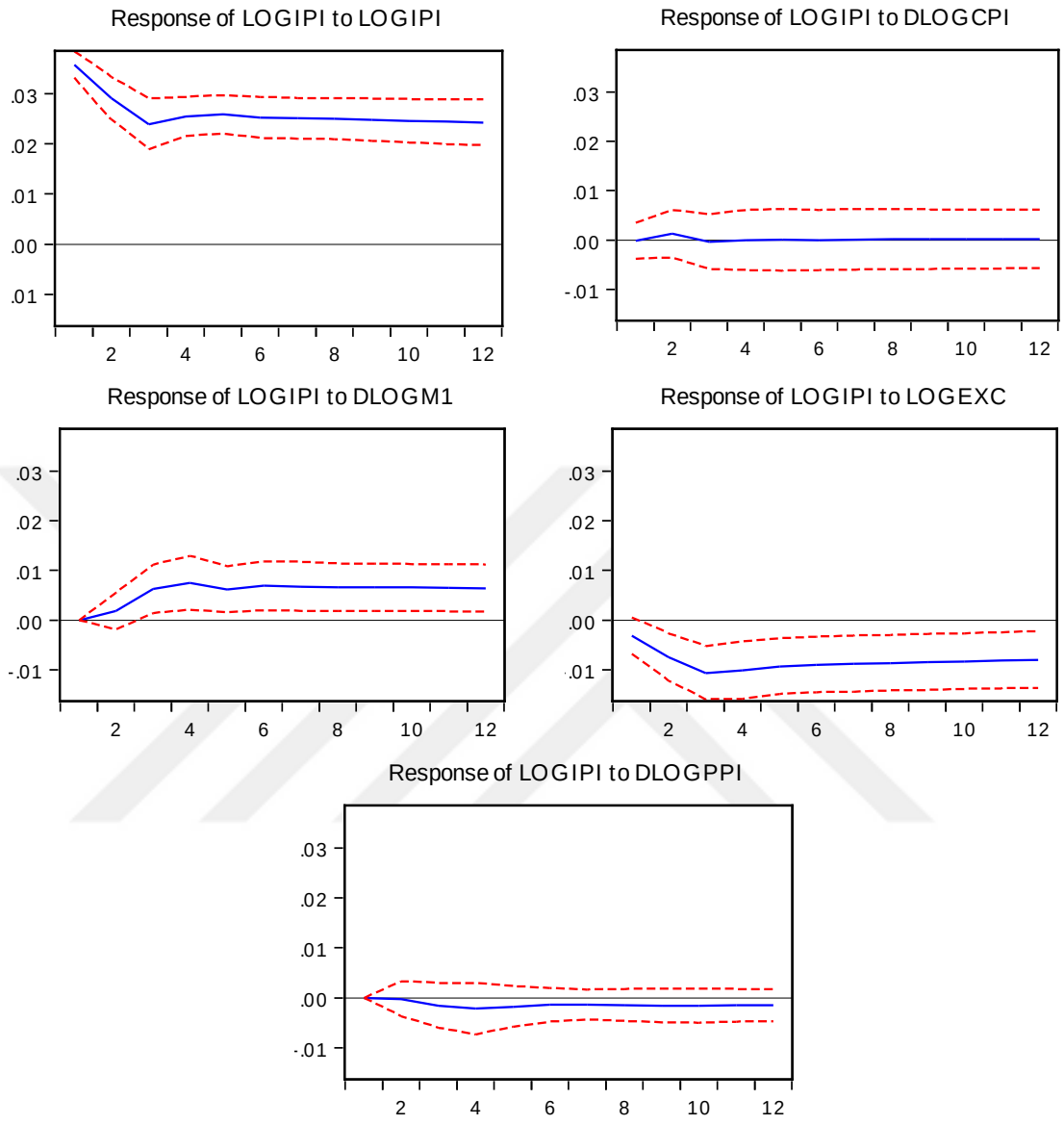
Impulse-Response Analysis of PPI



As seen in Figure 7, even though it gave a positive response in the first two periods against a one-unit standard shock endogenously given to the PPI, it gave a negative compensation even the fifth term. The shock response to the PPI lasted for about eight periods and then decreased. The shock to the PPI disappears by affecting the inflation positively in the first three periods, negatively until the sixth period, and zero after the sixth period. The effects of a shock to PPI on EXC, MS, and IPI were similar, but not very large responses were observed.

Figure 8

Impulse-Response Analysis of IPI



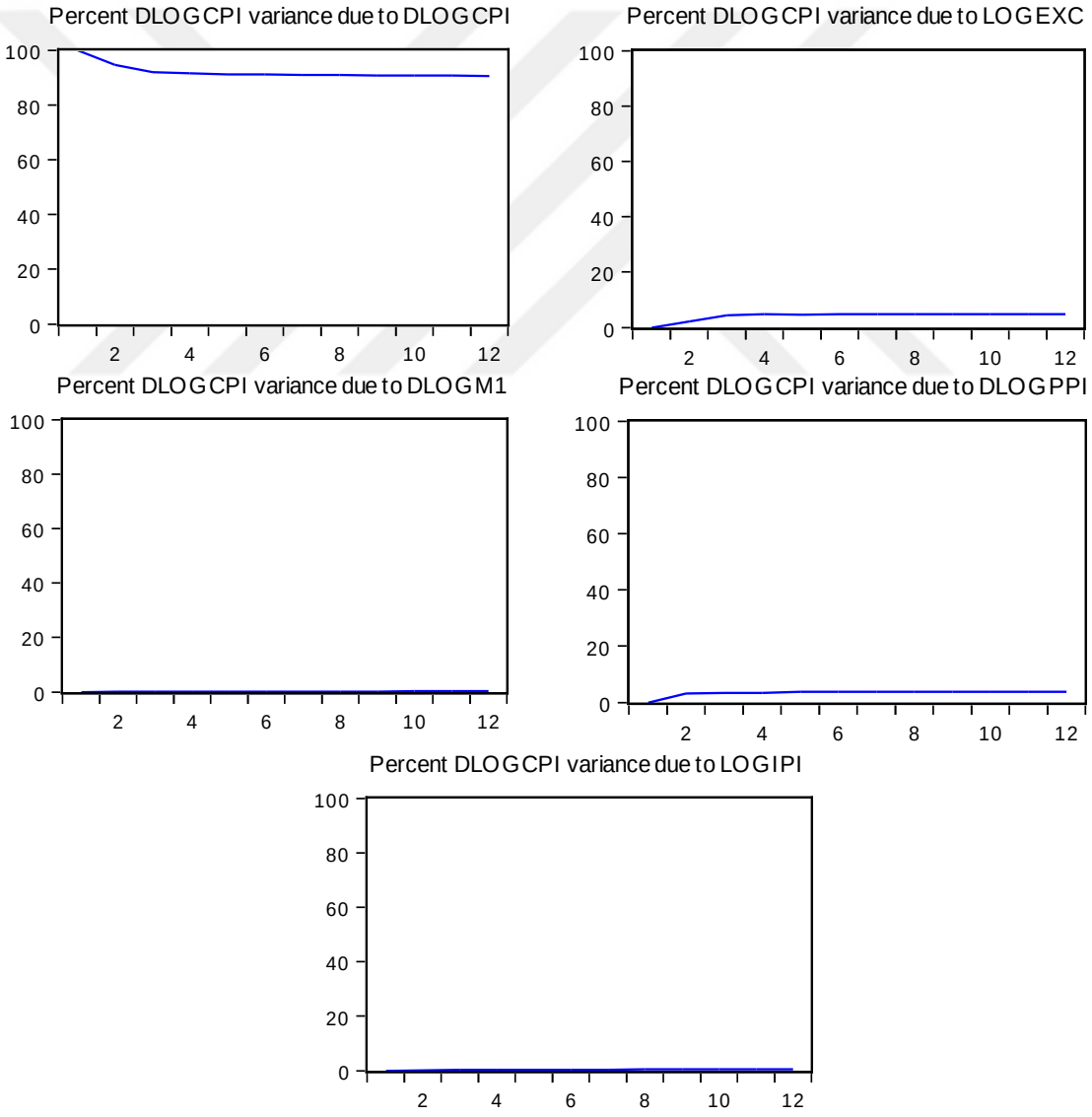
When Figure 8 is analyzed, it is seen that a one-unit standard shock to IPI positively affects itself for 12 periods. When the shock response to CPI is analyzed, it is seen that the shock in IPI has a zero-level response to CPI. Although the response of the shock in IPI to EXC and PPI is negative, the response of the shock to MS is positive. The reaction on the variables in the face of the PPI shock lasts approximately 12 periods.

4.3.2.Variance Decomposition

In variance decomposition analysis, the causes of changes in the variance of a variable are investigated. Thus, the ratio of the movements caused by the shocks of a variable and the changes caused by the shocks of other variables is shown. Variance decomposition results for CPI are given in Figure 9.

Figure 9

Variance Decomposition Analysis of CPI



Note: Variance decomposition results were created by Cholesky decomposition.

As indicated in the variance decomposition results of the consumer price index representing inflation, although it is the most effective shock itself on inflation, this effect decreases over time. While the effect of endogenous shocks on inflation is 100% in the initial term, it decreases to 90% by the end of the twelfth term.

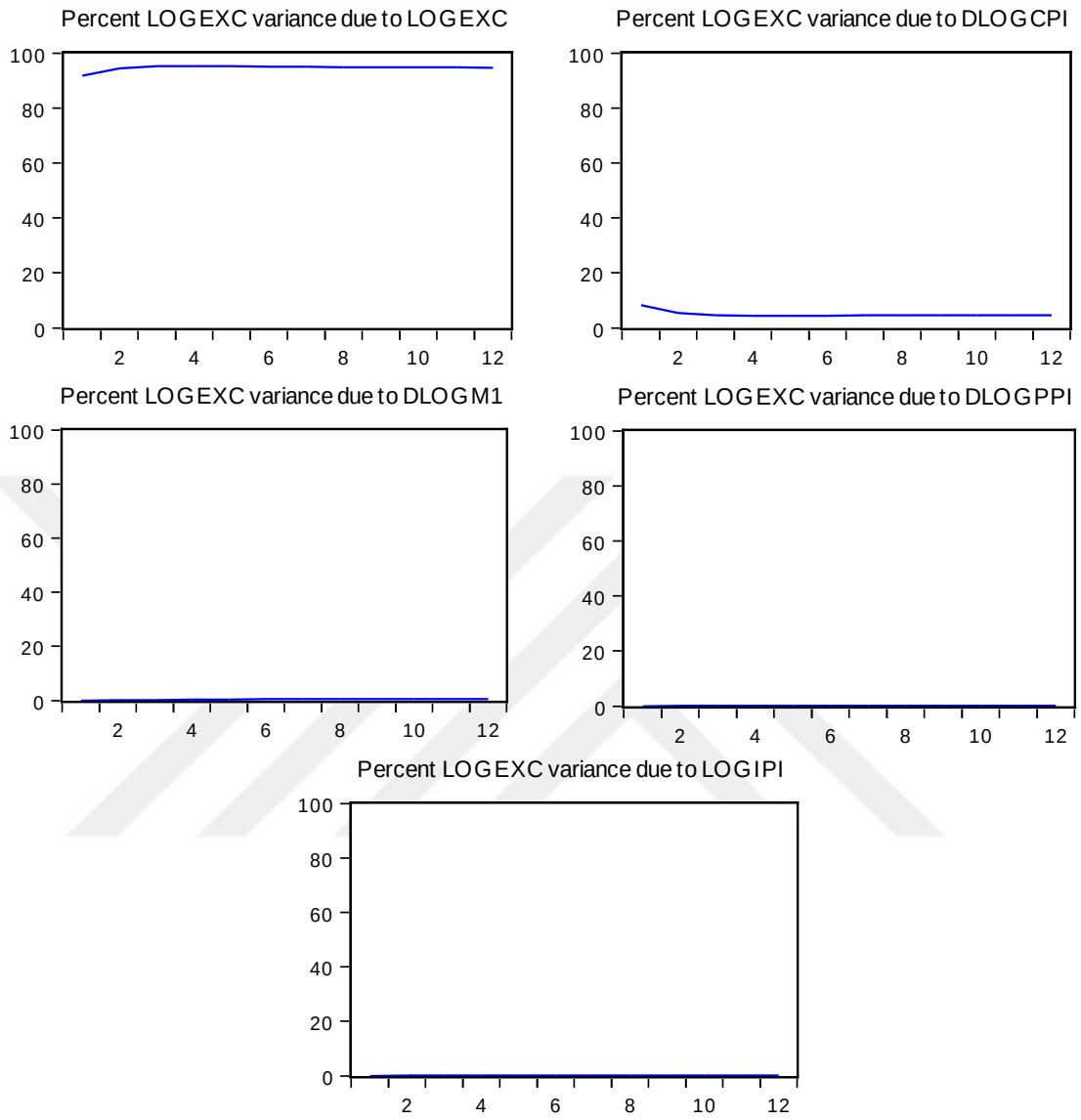
While it was the source of 100% of the change in inflation in the first period, it was followed by the exchange rate with 2% in the second period. In the first period, no variable affects inflation other than itself.

The impact of the currency rate and producer price index on inflation increases between the first period and the twelfth period. At the end of the 12th period, 4.83% of the alteration in inflation stems from the currency rate and 3.72% from the producer price index. This shows that inflation in Turkey is demand-driven rather than supply-driven. In other words, the main cause of inflation in the country is demand inflation.

It has been observed that the impact of money supply and index of industrial production did not change much between the first and twelfth periods, that is, the changes were at a minimum level. It is seen that the data with the lowest percentage of explaining changes in inflation among all data is the money supply. While the percentages of the money supply and the industrial production index explaining the consumer price index in the first period are 0.00%, finally of the twelfth term, the percentages of explaining changing in consumer price index are 0.21% and 0.60% respectively. In other words, this situation shows that the index of industrial production and money supply affect inflation at the similar ratio in the short, medium, and long term.

Figure 10

Variance Decomposition Analysis of EXC



Note: Variance decomposition results were created by Cholesky decomposition.

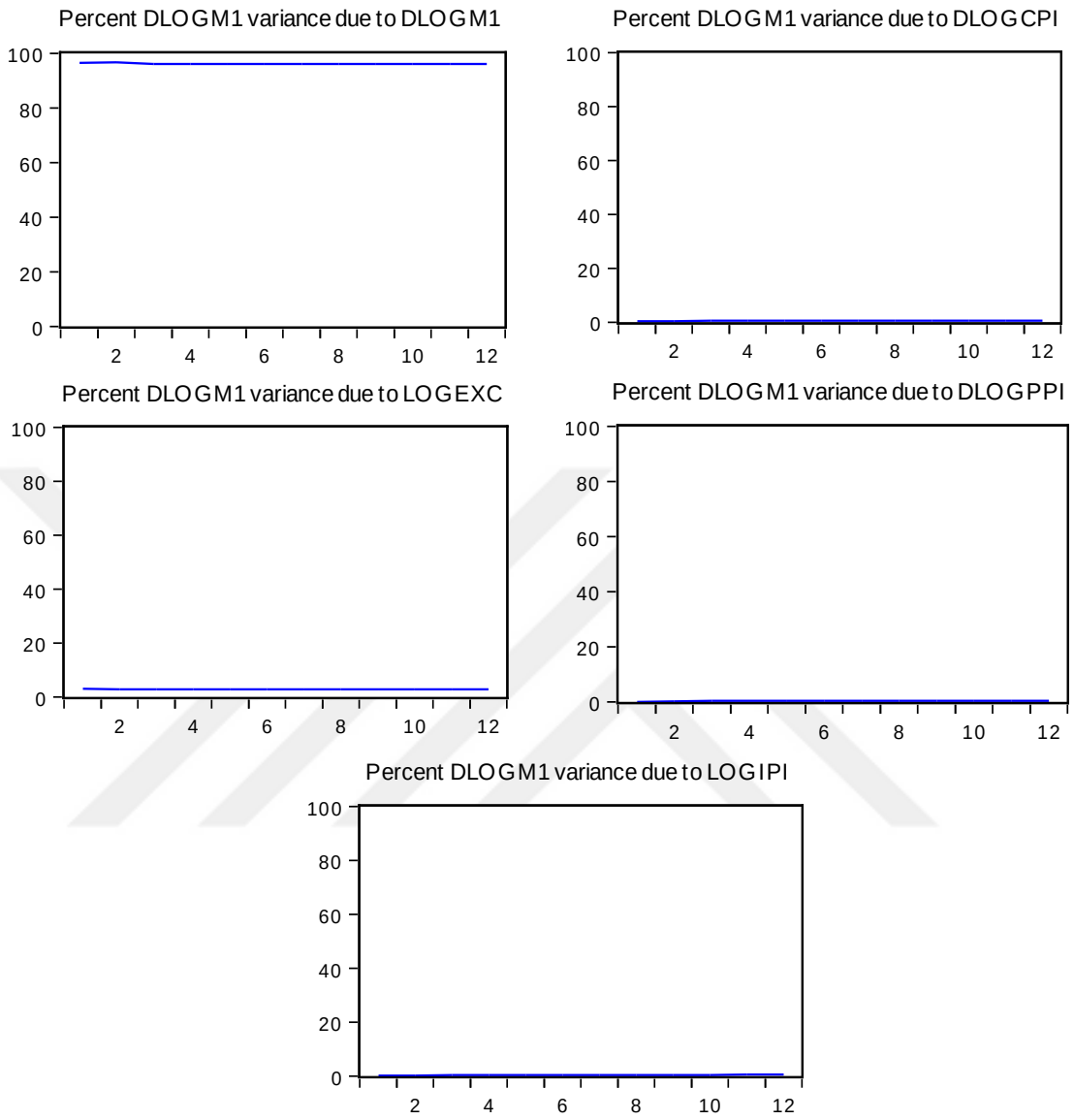
When the exchange rate variance decomposition results are analyzed, although the shock itself is the most effective on the exchange rate, this effect increases over time. While this rate was 91% in the first period, it reached 94% at the end of the twelfth period.

In the first period, 92% of the change in the exchange rate was his own, while 8% of the change in the exchange rate was due to inflation. In a consequence of analysis, it was concluded that the effect of the index of consumer price on the rate of exchange decreased from 8% to 4% from the first period to the twelfth period. This shows that inflation impress the rate of exchange more in the short period, and its effect reduces in the medium and long time. In short, it shows that the impact of inflation on the exchange rate is short-term.

From the second period, it was concluded that the industrial production index, money supply, and producer price index affected the rate of exchange changes at a minimum degree. The impacts of these variables on the rate of exchange at the end of the twelfth period are 0.04%, 0.58%, and 0.016%, respectively. Among all the data, the producer price index has the lowest rate of explanation of the alteration in the rate of exchange. As a result, the impacts of short-run and long-run of IPI, MS, and PPI variables on the exchange rate are quite low.

Figure 11

Variance Decomposition Analysis of MS

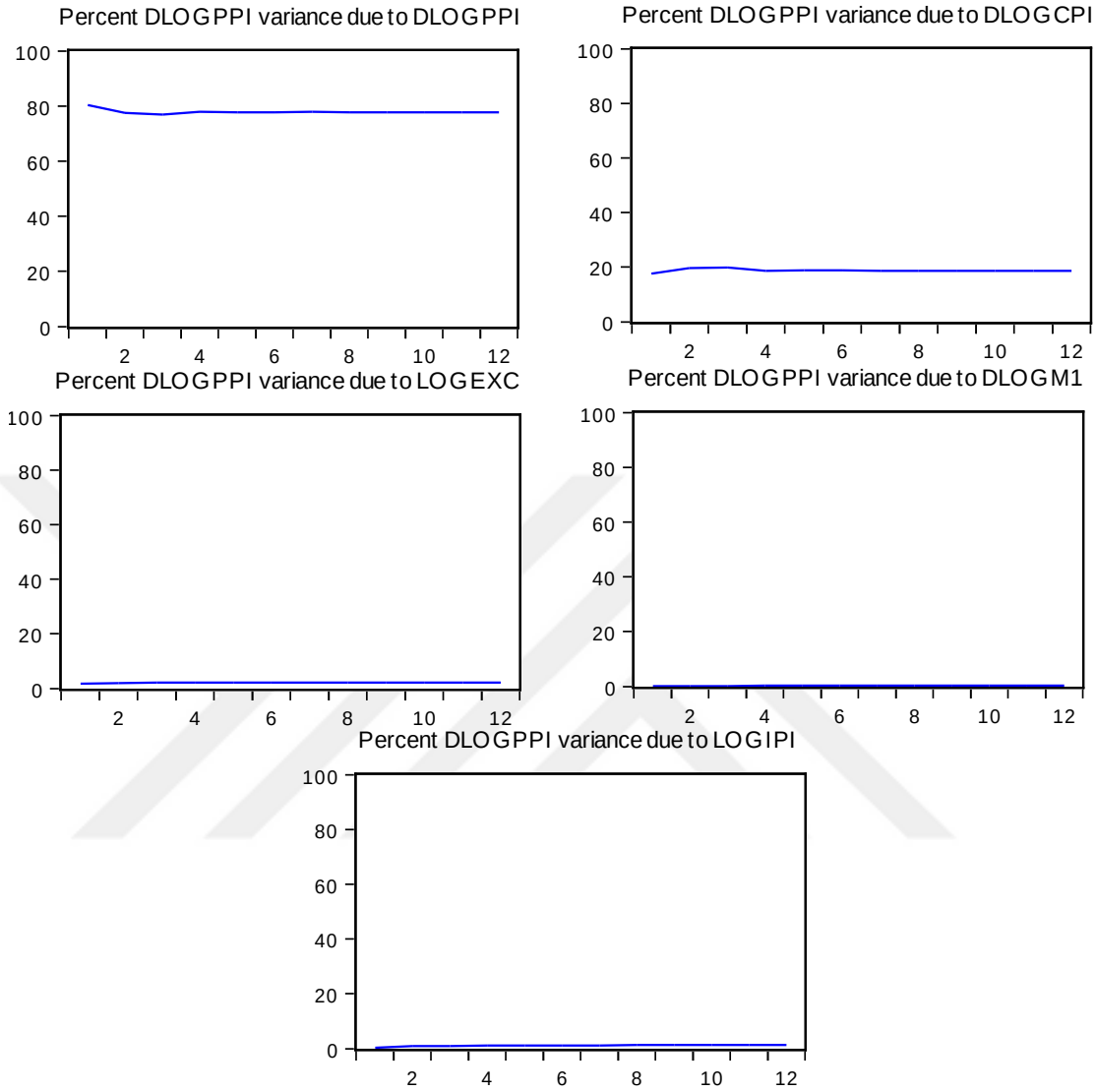


Note: Variance decomposition results were created by Cholesky decomposition.

Considering the Figure 11, the most effective shock on the money supply is itself. Between the first period and the twelfth period, it is seen that the producer price index, consumer price index, industrial production index and exchange rate, and affect supply of money at approximately the same ratio in the short and long run.

Figure 12

Variance Decomposition Analysis of PPI

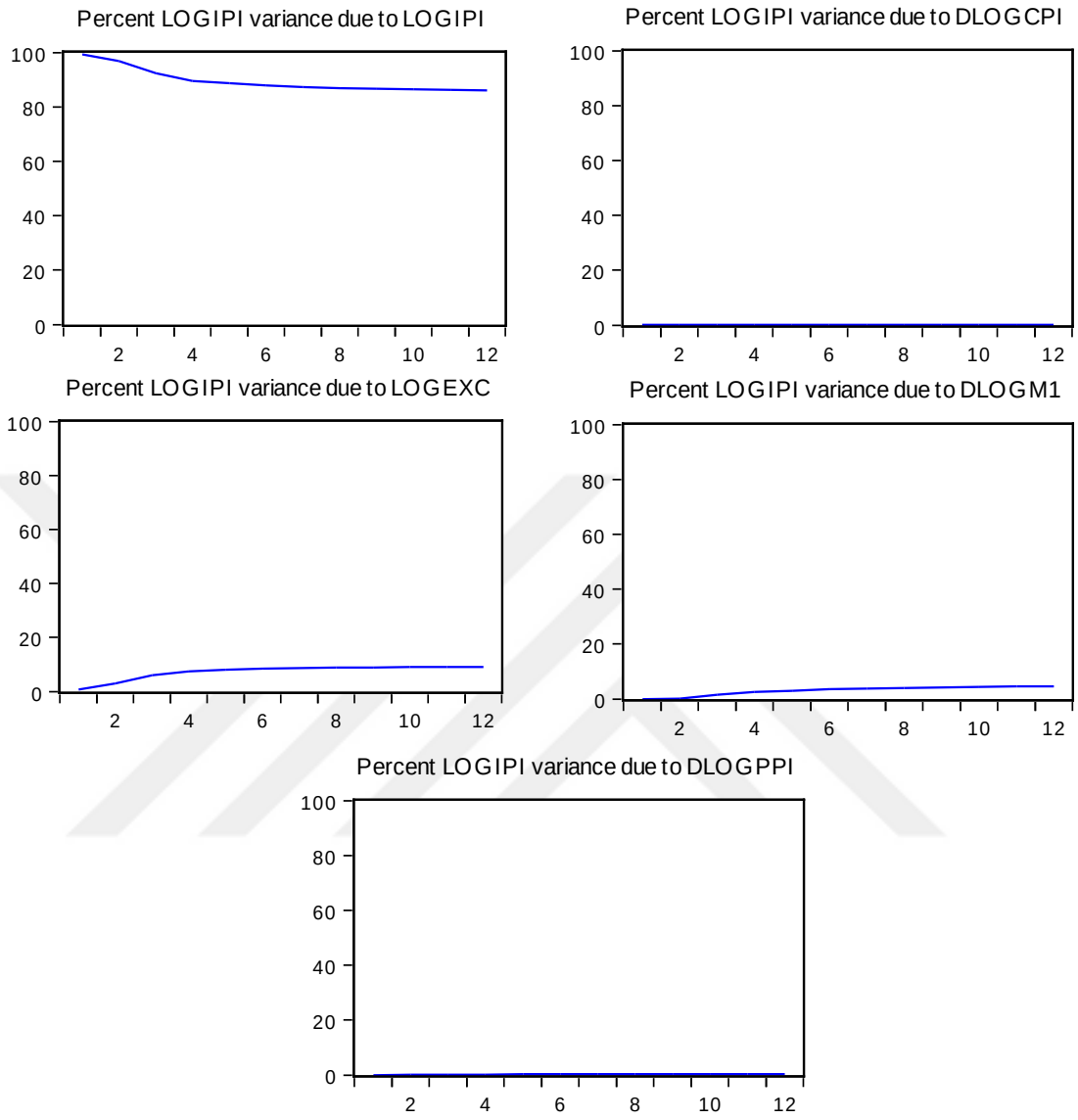


Note: Variance decomposition results were created by Cholesky decomposition.

According to Figure 12, it is seen in the first period, 17% of the PPI changes stemmed from the consumer price index. It is observed the rate of exchange, industrial production index a supply of money influence the index of producer price at approximately the same ratio in the short and long run between the first and twelfth periods. The effect of these variables on PPI does not change in the short, medium, and long term.

Figure 13

Variance Decomposition Analysis of IPI



Note: Variance decomposition results were created by Cholesky decomposition.

The industrial production index is most affected by its own internal shocks. Afterwards, it was observed that while these internal shocks decreased, the impact of the currency rate and money supply increased. In addition, it has been observed that the effects of producer price index and consumer price index affect the industrial production index at the similar ratio in the short run, medium and long run.

4.4. GARCH MODELS

In present research, the Standard GARCH (1,1) form of the GARCH model developed by (Bollerslev, 1986) was used by enriching the variance equation with explanatory variables.

The inputs of the GARCH model were determined according to the consequence of decomposition of variance analysis and function of impulse response analyses. Afterward, the contagion effects between the DCC GARCH model and, CPI and other variables were examined.

The rise in the supply of money and the rate of exchange are among the main factors of the general level of prices. In this context, while the exchange rate and inflation rates should be at low levels in the fight against inflation in terms of cost, to prevent demand inflation in countries like Turkey, it is essential to reduce the supply of money in the market or to increase the interest rates above the inflation and to give positive real interest. In this way, demand inflation can be prevented by discouraging people from more consumption and directing them to savings.

In the analysis of the decomposition of variance, although the impact of EXC and PPI on inflation variances increases, the endogenous structure in inflation variances remains quite strong. Looking at the CPI GARCH models, it is seen that the change in inflation is positive with the increase in money supply, but the changes in inflation is negative with the rise in the exchange rate. In addition, a lagged value of CPI also positively affects CPI. Although the producer price index is statistically significant, the rate of exchange and supply of money series is insignificant.

Table 6

GARCH Model Results

	CPI				EXC				MS			
	Equation of Mean		**Equation of Variance**		**Equation of Mean**		**Equation of Variance**		**Equation of Mean**		**Equation of Variance**	
	Coefficient	**Z-stats**	**Coefficient**	**Z-stats**	**Coefficient**	**Z-stats**	**Coefficient**	**Z-stats**	**Coefficient**	**Z-stats**	**Coefficient**	**Z-stats**
C	-0.004083	-2.827480			1.304261	34.58723			-0.030442	-2.393078		
REXC	-0.000155	-0.289610							0.017400	5.005614		
DRMS	0.007806	0.421134			0.034733	0.633132						
DRPPI	0.168209	18.56608										
DRCPI					0.071861	3.518298			0.028199	1.056792		
DRCPI(-1)			0.005690	17.34316								
α_0			0.000252	4.059840			0.001094	2.633044			0.000428	4.075970
α_1			0.396224	9.305726			1.043881	6.953117			0.860859	12.35826
β_1			0.672718	21.96541			0.089053	2.083127			0.324037	8.774124
Obs.	375				375				375			
R^2	0.256363				0.982701				0.375974			
DW	1.634885				0.063798				2.367037			

Source: own calculations in Eviews

According to the MS GARCH models, it has been observed that the change in the money supply is positive with the increase in the change in inflation. Looking at the cost part, when looking at the CPI GARCH models, it is concluded that PPI changes affect the inflation change positively. The issue that needs to be clarified with GARCH models is variance models, i.e., volatility behaviors rather than return equations. Since the sum of $\alpha_1 + \beta_1$ is very close to 1 in all three models, it has been concluded that the impact of previous shocks on the model variables is very dominant and palpable.

4.4.1.DCC-GARCH Models

Finally, the model of DCC GARCH assumes that the restricted correlation between two return series changes over time. Figure 14 shows the DCC-GARCH plots for CPI & EXC, CPI & MS, and CPI & PPI. In Table 7, ϱ_2 and ϱ_1 DCC coefficients are displayed.

Since cross correlations are governed by only two parameters, a DCC model should be applied to set of relatively similar series. According to the DCC-GARCH model characteristics, the dynamic conditional correlation coefficients should not be negative and their sum should be less than 1 to ensure stationarity.

If ϱ_2 is too nearly 1, the process will get close to being CC, in another saying the process converges to fixed correlation. It is possible for the DCC value to be "large" taking a value such as 1 and 2. In this case, ϱ_2 converges almost to $1 - \varrho_2$. When both ϱ_2 and ϱ_1 are little, that is to say there become clear to be no systematic correlation between the variables.

Francq and Zakoian (2010), have proposed two definitions of the GARCH process. The first definition is defined as semi-strong. There are constant coefficients of ARCH and GARCH; most importantly, these coefficients do not have to be positive. The second definition is the strong GARCH process. Here, the coefficient of the constant term must be positive, while coefficients ARCH and GARCH are not negative. The term ϱ_1 denotes the duration of short-term shocks on DCC; $\varrho_1 + \varrho_2$ shows the persistence degree of long-term shock on DCC.

The results of DCC-GARCH models, whose inputs were determined according to the impulse-response analyses results and decomposition of variance analyses made by establishing VAR models, are given below.

Table 7

DCC-GARCH Models

CPI-EXC				
	Coefficients	Z-Stats	Prob.	AIC
ϱ_1	0.438091	8.197080	2.22e-16	-1.886954
ϱ_2	0.0026311	0.333520	0.738742	
Observations	387			

Source: own calculations in Eviews

CPI-MS				
	Coefficients	Z-Stats	Prob.	AIC
ϱ_1	-0.030913	-7208.790	0.000000	-4.548526
ϱ_2	0.874413	7785.486	0.0000	
Observations	387			

Source: own calculations in Eviews

CPI-PPI				
	Coefficients	Z-Stats	Prob.	AIC
ϱ_1	0.130351	329566.9	0.000000	-3.146827
ϱ_2	0.876002	173156.6	0.0000	
Observations	387			

Source: own calculations in Eviews

In the CPI-EXC model, ϱ_1 and $\varrho_2$are positive and ϱ_1 is statistically significant at 5% level. However, ϱ_2 is not statistically significant, then GARCH process are not significant. If one of the coefficients is significant and the other is not, then it can be said that there is time-dependent cross-movement between CPI and EXC. Also ϱ_1+, ϱ_2 is less than 1. Therefore, it can be said that dynamic correlations follow a movement that returns to the mean. That is, the persistence level of short-term shocks between CPI and EXC is 0.43. In addition, since $\varrho_2 < \varrho_1$, the persistence degree of long-term shocks on dynamic conditional correlation seems lower than the persistence degree of short-term shocks. Therefore, in dynamic conditional correlation, long-term shocks are less affected by time-varying historical variances.

In the CPI-MS model, the coefficients of ϱ_1 and ϱ_2 are statistically significant at the 5% level. Although ϱ_1 and ϱ_2 are statistically significant since ϱ_1 has a negative coefficient, there is a semi-strong GARCH process. Since one of the coefficients is negative, the conditions for significance and stationarity cannot be met. Since only ϱ_2 has a positive coefficient and significant probability value, the coefficient of variance is substantial. Therefore, since the short-term shock persistence degree is not different from zero, it can be said that only the variance affects the dynamic conditional correlation. Also ϱ_1+, ϱ_2 is less than 1. Therefore, it can be said that dynamic correlations follow a movement that returns to the mean. In addition, the closeness of ϱ_1+, ϱ_2 to 1 indicates that the correlation exhibits a highly permanent structure. In other words, the effect of a shock experienced today can be observed even in the long term in correlation. In addition, a sum close to one indicates that shocks will reflect more quickly on the long-term equilibrium value after they occur.

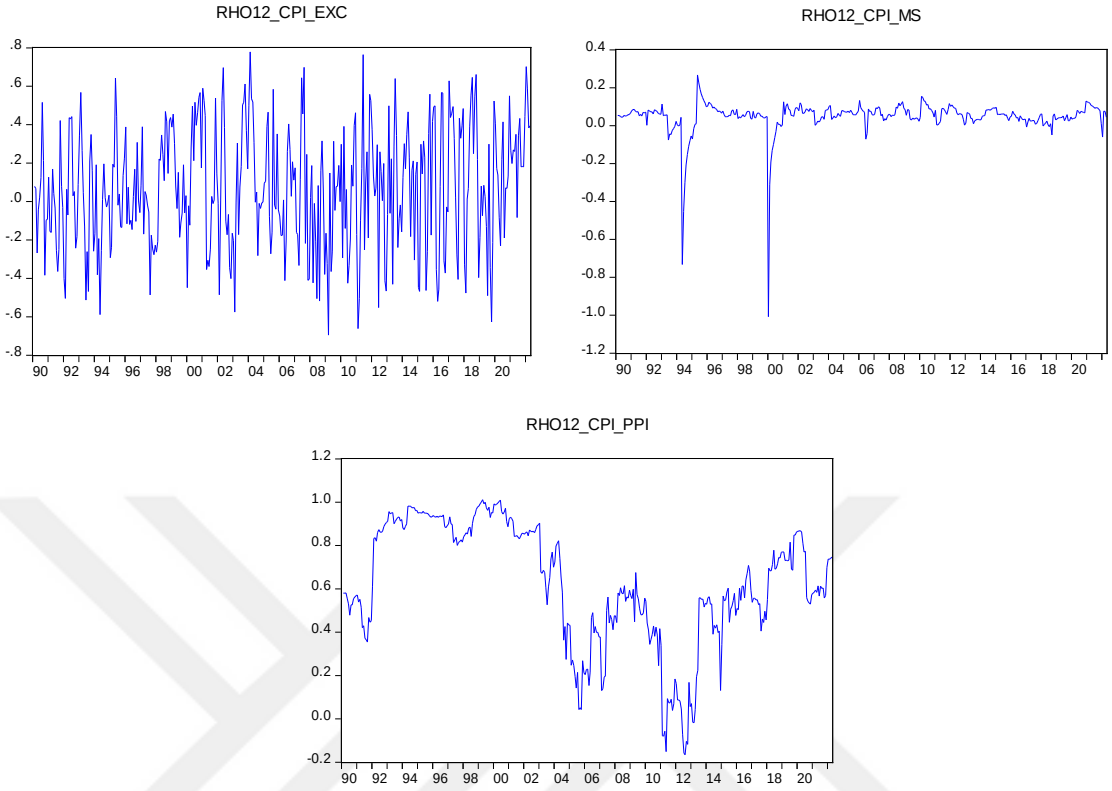
When the CPI-PPI DCC-GARCH model is examined, GARCH process is strong since the dynamic conditional correlation numbers are both positive coefficients and statistically significant. However, ϱ_1+,ϱ_2 is bigger than 1, also $\varrho_1+,\varrho_2<1$ is not met. In this situation, for DCC-GARCH model characteristics, stationary does not ensure. Since ϱ_1 indicates the permanence level of short-term shocks, the permanence degree of short-term shocks is 13% in the DCC GARCH model of CPI-PPI. In addition, since $\varrho_1<\varrho_2$, the persistence of short-term shocks on the dynamic conditional correlation is very low compared to the degree of variances, so the dynamic conditional correlation is more affected by the past variances depending on time.

When all DCC-GARCH models are examined, the model that does not meet the condition $\varrho_1+,\varrho_2<1$ is the CPI-PPI model. In the binary equations established between inflation, exchange rate, and money supplyϱ_1+,ϱ_2 is closer to 1 in the CPI-MS model. In other words, the long-term persistence degree of the CPI-MS model is greater than that of the CPI-EXC model. This indicates that the shocks in the CPI-MS will last for a more extended period.

The movement of the conditional correlation of CPI-EXC, CPI-MS, and CPI-PPI is depicted in Figure 14.

Figure 14

DCC-GARCH Graphs



When the CPI-EXC graphs are examined, it is seen that the correlations between the variables are volatile. After the correlation reaches the bottom and top, the opposite sign is repeated again.

It has been observed that in CPI-MS graph there are one-time spikes and the volatility is low and time-varying conditional correlations are more visible. The coefficients in the CPI-MS graph are between -0.1 and 0.2.

When DCC-GARCH models of CPI-EXC are examined, from 1990 to 2022:04, there seem to be significant fluctuations in the conditional correlation coefficient. While the dynamic conditional correlation is between the -1.0 and 0.2 bands in CPI-MS models, the correlation between the CPI-PPI models is in the -0.2 and 1.0 bands.

5. CONCLUSION

Fluctuations in exchange rates cause changes in domestic prices, and this change is observed at higher rates, especially in underdeveloped countries. This change is called the transition effect. Due to the decrease in inflation rates after 1990, this transition effect started to decrease. In Turkey, which was examined in the study, the transition to the floating exchange rate system after 2000 and the implementation of inflation targeting policies continue, although the effect of the transition effect has decreased.

In our study, the response of inflation to these shocks in the face of a one-unit random shock in PPI, MS, and EXC according to the inflation impulse-response analysis was examined for a 12-period period, and it was seen that the response of inflation to the EXC shock was positive for five periods and then the response faded. It was determined that the response of inflation to PPI, MS, and IPI lasted for four periods and then decreased. As a result of the impulse-response analysis of the exchange rate, it was observed that it responded positively to the endogenous standard deviation shock, while the reaction to inflation was positive and stable for twelve periods.

According to the results of the CPI variance decomposition analysis, it was determined that although the most effective shock in inflation was itself, the effect decreased over time, and 2% of the change in inflation from the second period was caused by the exchange rate. However, at the end of the twelfth period, as 4.83% of the change in inflation was due to the exchange rate and 3.72% was due to the PPI, it was concluded that the main reason for inflation was demand inflation. It has been concluded that the money supply and industrial production index do not have a serious effect on the change in inflation in the short run and the effects of these variables on

inflation show similarities in the short, medium and long run. In the results of EXC variance decomposition analysis, it was observed that approximately 8% of the change in exchange rate was caused by inflation and this effect decreased from the first period to 4% at the end of the twelfth period. This shows that inflation affects the exchange rate more in the short term, while its effect decreases in the medium and long term.

The GARCH models analyzed for CPI concluded that the exchange rate increase negatively affected the inflation change. Finally, the relationships between CPI-EXC, CPI-MS, and CPI-PPI were examined in DCC-GARCH models to determine the long-term relationships between the two series. According to the CPI-EXCH model, it was concluded that the short-term persistence time between the variables was 0.43%. As a result of CPI-MS models, a semi-strong GARCH process was found, and a strong GARCH process was found in CPI-PPI.

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APPENDIX A: LIST OF SYMBOLS / ABBREVIATIONS

ARCH: Auto Regressive Conditional Heteroscedasticity

GARCH: Generalized Auto Regressive Conditional Heteroscedasticity

GDP: Gross Domestic Product

ADF: Augmented Dickey-Fuller

DCC-GARCH: Dynamic Conditional Correlation Multivariate GARCH Model

VAR Model: Vector Autoregressive Model

LM: Lagrange Multiplier

CPI: Consumer Price Index

EXC: Exchange Rate

MS: Money Supply

PPI: Producer Price Index

IPI: Industrial Production Index

VECM: Vector Error Correction Model

SVAR: Structural Vector Autoregression Model

WPI: Wholesale Price Index