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The Efficiency Evaluation of Exchange Rate and Interest Rate of Monetary Transmission Channels through the VECM Analysis: Application for Turkey

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Abstract

This study involves the test of the effectiveness of the exchange rate channel and interest rate channel, which are considered to be important in terms of impact on the economy in Turkey, based on the Mishkin classification with quarterly data covering the period 2009:Q1 to 2018:Q2. The variables used in our study were divided into two groups: endogen and exogen variables. Endogen variables include Gross Domestic Product (GDP), M1 narrow-scale money supply, discount interest rate, loans, deposits, and the US dollar (USD) and Turkish Lira (TL) exchange rate. Exogen variables include the prices of Brent-branded oil barrels, representing the energy sector, which is one of the major items in Turkey's current account deficit. For the Turkish economy, a vector error correction model (VECM) has been used to reflect both short and long term relationships. In the first step of the analysis, the seasonality process was performed; the variables with the sign of seasonality were adjusted trend and seasonality with the Census X12 method. In the next step, an Augmented Dickey-Fuller unit root test (ADF Test) implementation was carried out. Then, the appropriately lag length was estimated so that could be determined according to the appropriate delay numbers. In addition, the Lagrange Multiplier-LM test was applied to determine whether the error terms of the model are autocorrelated. In the next phase, Johansen-Juselius cointegration test was performed. The results showed that there was cointegration between all variables. At the last part of study, impulse-response analysis was applied to variables. As a result, the findings shows that the exchange rate channel is more effective in terms of the Turkish economy than the interest rate channel and has a longer-term effect compared to the interest rate channel.

Keywords

Monetary Transmission Channels, VECM, Exchange Rate Channel, Interest Rate Channel, Turkey Economy

JEL Codes: O24

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1. Introduction

The way in which monetary policies operate in terms of the impact of the real economy is interpreted differently in the economic world. Accordingly, there are different views about monetary transmission mechanisms. According to Ireland, the monetary transmission mechanism explains the macro level factors such as interest rate, money supply, employment and the level of influence (Ireland, 2006). According to another approach, if the economy is under effective and equilibrium condition, it is a matter that examines the excess supply and demand in the economy according to the monetary policy changes of the central bank, or the total consumption status in the economy in case of an adverse situation (Taylor, 1995).

1.1. Types of Transmission Channels

The monetary transmission mechanism is divided into two parts: indirect transmission and direct transmission. According to the direct transmission approach, there is a direct relationship between the amount of money and expenditure in the market; therefore, the expenditures increase with the increase in the base of money (Cengiz, 2009).

According to the indirect transmission approach, the change in the amount of money for the operation of the mechanism reaches the real markets indirectly through the fund market. According to the Mishkin classification, the transmission channels are the credit channel, the interest rate channel and other asset prices channel. The interest rate channel covers the channel in which the results of the change in the total amount of money are explained at the economic level. As the money supply increases through open market operations, the demand for financial assets increases, meaning that excess is formed and therefore the return decreases while their value increases. For this reason, investment will surge by taking into account the sensitivity of investments to interest rates, and with this, the amount of total demand will increase the level of production and employment even more. However, the functionality of the interest rate channel will no longer remain if demand reluctance increases as individuals and corporate levels choose to stay in cash when the process, described as a liquidity trap, comes into play (Oktar *et al.*, 2013).

The exchange rate channel, which is one of the channels of the monetary transmission mechanism, is subject to foreign trade and the functionality of this mechanism is based on the inflation effect. The exchange rate channel is also closely related to the interest rate channel (Oktar *et al.*, 2013). Even the exchange rate channel is thought to be a component of the interest rate channel. As a result of the decline in local interest rates ($ir \downarrow$), the exchange rate also covers the decline in interest rates, but local money-based deposits lose interest and consequently, interest on foreign exchange-oriented deposits increases. As a result, domestic currency deposits lose their attractiveness compared to foreign currency-based deposits. Thus the foreign currency gains value ($E \uparrow$). The depreciation of local currency increases the country's net exports ($NX \uparrow$) because it makes domestically produced commodities cheaper than foreign commodities. This increase in exports therefore triggers the total production ($Y \uparrow$) upward as well. This process is summarized as follows (Mishkin, 2004).

$$M \uparrow \Rightarrow ir \downarrow \Rightarrow E \uparrow \Rightarrow NX \uparrow \Rightarrow Y \uparrow$$

The aim of this study is to test the extent of the transformation effect of exchange rate and interest rate channels, which are considered effective for Turkey, on the economy of the country, and to express empirically which of these channels is more effective for Turkey based on the specified period interval.

2. Literature review

In the literature, many studies have been carried out regarding the channels of monetary transmission mechanism both in different countries and covering different periods. In the study conducted by Bernanke and Blinder (1992), it was observed that the interest rate channel yielded more effective results in the implementation of US monetary policy according to the results of the study based on the years 1959-1989 using the VAR model.

Barran *et al.* (1996), conducted a study on exchange rate channel, applying the VAR model to 9 European countries such as, France, Denmark, Austria, Finland, Germany, Italy, the Netherlands, Spain and the United Kingdom: it was observed that this channel useful for only in Spain. According to the findings of the regression analysis on the effectiveness of the exchange rate channel on the Slovak economy in 1999, Dovciak found that the exchange rate channel did not work effectively for Slovakia.

Mojon and Peerson (2001), in the analysis of the effective interest rate channel, using VAR model, on Netherlands, Spain, Italy, Ireland, France, Greece, Germany, Belgium, Finland and Austria (in a total of 10 European countries) has concluded that the channel is effective. In 2001, Ghunduz tested the effectiveness of the interest rate channel in his work that was done over Turkey obtained the conclusion that this channel is effective. Ganey *et al.* (2002) compared the efficiency of exchange rate and interest rate channels on 10 Central and Eastern European countries, and found that for most of these countries, the exchange rate channel was more effective and stronger than the interest rate channel.

Camarero *et al.* (2002) examined the monetary transmission channels on Spain with the structural VAR model for the period 1986-1998 in 2002. In this study, it was concluded that monetary constraint caused a weak downward reaction on prices, however, long and short term interest rates increased, total output decreased and it caused exchange rate appreciation. As a result of the 2004 study, Ahmed and Islam examined the monetary policy changes in Bangladesh and whether the bank loans and exchange rate channel in the economy affected the total output and prices by using the VAR analysis approach by using quarterly data from 1979 to 2005 and the results of the analysis indicated the weak availability of bank loans and exchange rate channels in the Bangladesh economy.

Ornek in his investigation of monetary transmission mechanism channels on Turkey through VAR analysis in 2006 on quarterly data for the period 1990-2006, obtained as a result that the interest rate channel and the exchange rate channel worked, whereas the stock price and bank credit channels did not yield meaningful results. In his 2007 research, Nagayasu analyzed the significance of the exchange rate channel with Japan's VAR analysis approach for the period 1970-2003. The empirical analysis concluded that the exchange rate channel was not sufficiently functional to affect the total output. In 2009, Boughrara focused on Morocco and Tunisia and, according to empirical findings, concluded that the asset price channel and the exchange rate channel worked effectively. The study of Jamilov and Huseynov (2013) was conducted on the Commonwealth of Independent States (CIS) and it was stated that the long-term money supply was effective on demand based on the data of 2000-2009. In 2011, Yaprakli in his study, covering Turkey economy in the period of 2006-2011 has tested the effectiveness of the exchange rate channel with VECM analysis, in Turkey, the obtained findings showed that the exchange rate channel was effective on inflation.

3. Methodology of research

In this study, the quarterly data set covering the periods 2009:Q1 - 2018:Q2 was used for analysis. The data was obtained from Turkey Statistical Institute (TUIK), Turkey Presidency of the Republic of Strategy and Budget Department and the

Central Bank of the Republic of Turkey (CBRT). The variables were divided into two groups as endogenous and exogenous variables. Internal variables included Gross Domestic Product (GDP), M1 narrow-scale money supply, discount interest, loans, deposits, and US dollar (USD) vs Turkish lira (TL) exchange rate. BRENT branded oil prices per barrel, representing the energy sector, which is an important part of Turkey's current account deficit, were entered as exogenous variables. In order to make logarithmic linearization of model parameters, logarithm of all variables was taken. In addition, due to the seasonality in the GDP series, trend and seasonality adjustment was performed according to Census X12 method.

In this context, in order to display both short-term and long-term relationship in Turkey's economy a vector error correction model was applied (vector error correcting model/VECM) were encouraged to use way. The general structure of the model is as follows:

$$\Delta y_t = \mu + \alpha \beta' y_{t-p} + A_1 y_{t-1} + \dots + A_{p-1} \Delta y_{t-p+1} + \delta X_t + u_t = \mu + \alpha \beta' y_{t-p} + \sum_{i=1}^{p-1} A_i \Delta y_{t-i+1} + \delta X_t + u_t \quad (1)$$

In this equation, Y_t is dependent and X_t is the independent variables vector. Accordingly, these variables are expressed in the following way for Turkey:

$Y_t = \{\log gsyh \log krediler \log kur \log m1 \log mevduatlar \log reeskont\}$

$X_t = \{\log petrol\}$

Here, the dependent variable vector of Turkey include informal gross domestic product, total loans drop to the economy, the USD/TL exchange rate, M1 narrow money supply, total and discount interest rates on deposits obtained from households and from other organizations. The dependent variable vector represents the energy sector which has a significant share of the current account deficit in terms of Turkey.

4. Empirical results

In the first step of the analysis, seasonality adjustment was carried out. For this purpose, variables with seasonal findings were categorized and trend adjusted by Census X12 method. In the next stage, the stationarity of the variables was investigated. For this, Augmented Dickey-Fuller unit root test (ADF Test) was performed. In order to determine the subsequent application stages according to the appropriate delay numbers, the appropriate delay length was estimated. Since the variables are free of trend, unit root tests are based on fixed but non-trend models.

Table 1. Unit Root Test Results

Variables (Level)	ADF Test			
	Intercept	Prob*	Trend&Intercept	Prob*
GDP	0.2385	0.9715	-1.9199	0.6241
Credits	-2.5533	0.1125	-1.7509	0.7060
Exchange Rate	1.5959	0.9993	-2.8044	0.2048
M1	-0.0147	0.9511	-3.1949	0.1011
Deposits	-1.4712	0.5369	-2.6481	0.2628
Oil	-2.1397	0.2310	-2.3607	0.3929
Discount Rate	-2.4599	0.1332	-0.9294	0.9416
Variables (1. Difference)				
	Intercept	Prob*	Trend&Intercept	Prob*
Δ GDP	-6.3503	0.0000	-6.3091	0.0000
Δ Credits	-3.0699	0.0385	-3.9599	0.0200
Δ Exchange Rate	-5.4030	0.0001	-5.9221	0.0001
Δ M1	-7.8625	0.0000	-7.7386	0.0000
Δ Deposits	-6.1366	0.0000	-6.3563	0.0000
Δ Oil	-7.3685	0.0000	-7.3672	0.0000
Δ Discount Rate	-4.0177	0.0036	-4.4704	0.0055

The fact that the module values indicated by points in Figure 1 presented below is seen to be less than -0.0 to 1.0 (which is defined as the reference value for the test of stationarity) also indicates that the first order difference of the series is stable. In order to determine the subsequent application stages according to the appropriate delay numbers, the appropriate delay length was estimated. Given the limited number of observations analyzed, the length of the delay tested was kept short. The result is presented in Table 2.

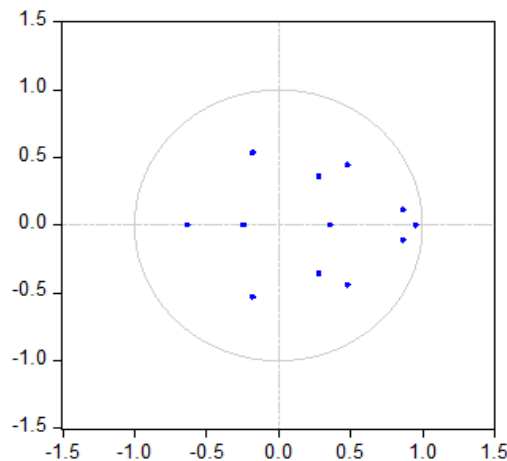


Figure 1. AR Characteristic Polynomial

Table 2. Lag Length Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	223.0207	NA	3.27e-13	-11.7234	-11.1955	-11.5391
1	427.5230	318.1146*	2.94e-17	-21.0846	-18.97325*	-20.34769*
2	468.0835	49.57401	2.82e-17*	-21.33797*	-17.6431	-20.0484

According to the results obtained from the lag length test table, regarding three of the five tests (Likelihood Ratio, Schwarz and Hannan Quinn test values), the first lag was found to be more appropriate, so the lag length was based on the continuation of the analysis. In addition, Lagrange Multiplier (LM) test was used to determine whether the error terms of the model in question were autocorrelated. Since the marginal significance level for LM test is greater than 0.05 for the first delay, H_0 hypothesis based on the assumption that there is no autocorrelation is accepted. As a result, LM test results show that there is no autocorrelation between error terms.

Table 3. LM Autocorrelation Test Results

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	46.03590	36	0.1220	1.346119	(36, 86.2)	0.1328

In the next step Johansen-Juselius cointegration test was performed. The results obtained are presented in Table 4 and show cointegration among all variables. In other words, the variables show a long-term equilibrium relationship. Therefore, it was concluded that the effect of monetary transmission mechanism in Turkey must be analysed using the VECM model, reflecting the effect of long-term stability.

Table 4. Johansen Cointegration Test Results

Hypothesis	Eigenvalues	Trace Statistic	Critical Value(%5)	Prob	Max.Eigen Statistic	Critical Value(%5)	Prob
$r=0$	0.815802	151.9876	107.3466	0.0000	60.90273	43.41977	0.0003
$r\leq 1$	0.700702	91.08485	79.34145	0.0050	43.42739	37.16359	0.0084
$r\leq 2$	0.467534	47.65745	55.24578	0.1962	22.68851	30.81507	0.3504
$r\leq 3$	0.302269	24.96895	35.01090	0.3855	12.95720	24.25202	0.6819
$r\leq 4$	0.273615	12.01175	18.39771	0.3082	11.50828	17.14769	0.2736
$r\leq 5$	0.013888	0.503466	3.841466	0.4780	0.503466	3.841466	0.4780

As can be seen in Table 5, as a result of cointegration analysis, the null hypothesis is rejected at $r = 0$ and $r\leq 1$ at 5% significance level and in the case of $r\leq 2$, $r\leq 3$, $r\leq 4$ and $r\leq 5$, the hypothesis H_0 is accepted.

After the analysis, variance decomposition test findings were examined. Here, a 10-period time interval was used, and the test was performed based on the Monte Carlo simulation and the Cholesky method. According to the results, in the first period of GDP variance decomposition is 100%, while this indicator decreases to 87% in the 2nd and 3rd periods, it continues to 85% in the 4th period and 84% in the period up to the 10th period. The other high level of disclosure of GDP after self-disclosure is seen in discount rates. The level of disclosure, which started with 7.48% in the second period, declined to 5.90% by the 10th period. In the following variables, this level moves to 3.26% in the first period and increases to 5.33% in the last period. While M1 money supply is 0% in the first period, it continues with 1.73% in the second period

and increases in the last period as in the exchange rate variable and provides approximately 3.42%. While the rate of self-disclosure of loans in the first period was 96.35%, it decreased by 70% in the second period and this decrease continued in the following periods and reached 45.05% in the last period. In other variables, the level of explanation of loans increased from 7.99% in deposits in the second period to 17.21% in the last period, and this increase was observed in exchange rate, GDP and M1 variables. On the other hand, as periods increase, the effect of discount interest rate decreases.

When the variance decomposition periods of the exchange rate are analysed, the self-exposure rate starts at 67.22% in the first period and decreased to 48% when the third period is reached. While the first level explanation rate was 0% for the other variables, this effect was seen as 15.42% in the GDP variable and this increase continued for ten periods. Credit variable behaves similarly: in the last quarter, it reached 21% but did not reach the increase in the third quarter.

Variance Decomposition using Cholesky (d.f. adjusted) Factors

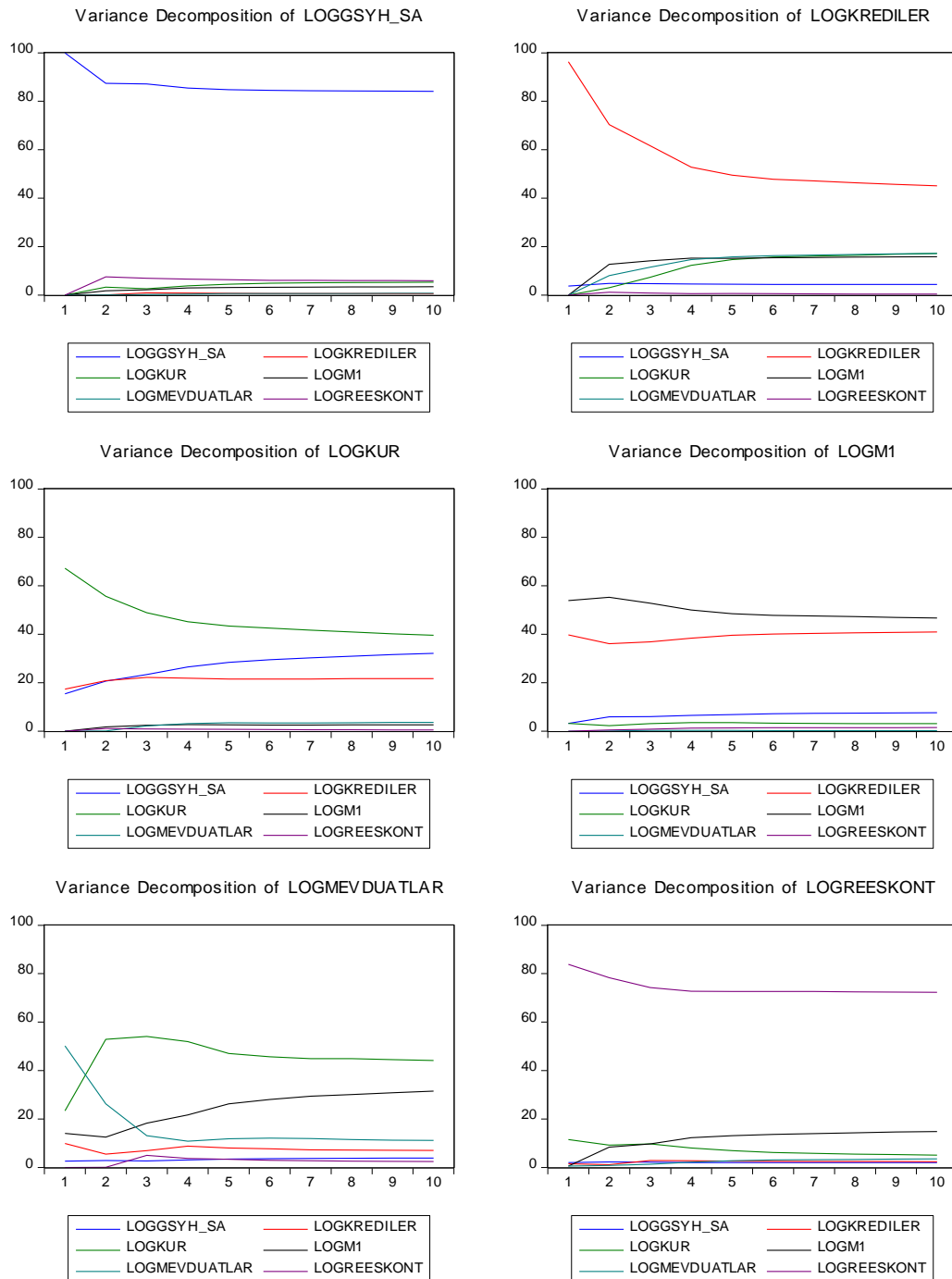


Figure 2. Variance Decomposition Test Results

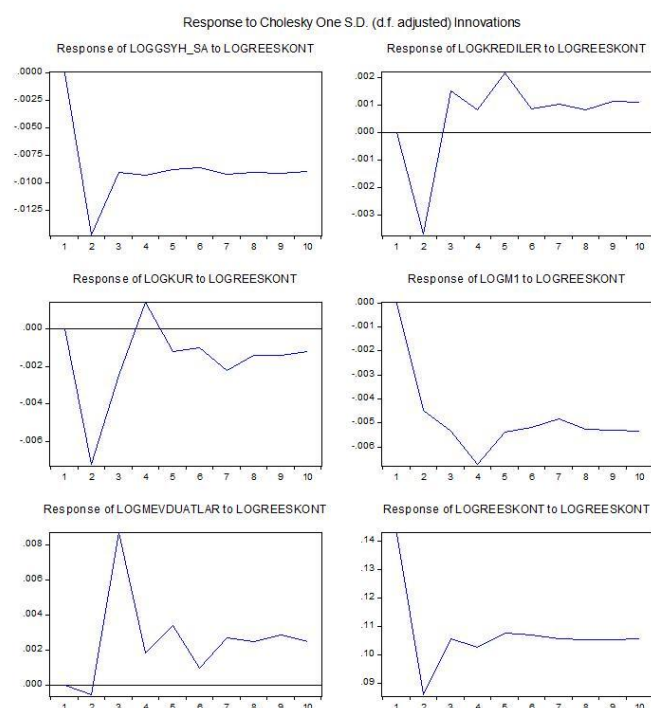
In the first term, GSYH, loans, and currency are also effective in explaining the money supply variable along with this variable itself. In the first period, the explanatory power of these variables is 3.17%, 39.71%, and 3.20%, respectively. While the explanatory rate in GSYH experienced an increase in the first period, it witnessed a reduction in the second and third periods in loans and the second period in currency, with the increase and constant trend in all remained periods. While the discount interest rate variable also increased, the rate of explanation of the money supply of deposits and discount interest rate variables is quite low. When the deposits are analysed, it is observed that while the self-disclosure ratio of the deposits is around 50% in the first period, there has been a strong decrease during all periods and this ratio has reached to 11% in the last period. It is seen that all variables, except discount interest variable, affect deposits in the first period. Apart from this variable itself, the exchange rate had a 23% effect on deposits, this effect increased to 54% in the third period and decreased to 44.10% in the following periods. While the effect of loans on deposits was 9% in the first period, it continued the increase-decrease trend in the following periods and it decreased by 6.99% at the end. On the other hand, it should be stated that this ratio is low although the ratio of deposits to GDP is increased from 2.58% to 3.9%.

The self-disclosure power of discount interest rate is high at 83.87% in the first period, but it has been reduced to 72.28% in the recent period. The point that draws attention here is that the rate of explaining the discount interest rate of the M1 money supply was 0.58% in the first period and reached a much higher disclosure power in the following period compared to the previous period of 8.32%. Likewise, the rate of explanation of M1 money supply increased in the following periods and reached to 14.82%. Another point is that the rate of disclosure in the exchange rate variable is approximately 11.52% in the first period and it decreases to 5.04 in the following periods. On the other hand, GDP and loans remain on average in general, but instead an upward trend is observed in deposits. Detailed analysis results are presented in the graph below and in Appendix 1. At the same time, the variance decomposition matrix, which is composed of 10-term averages, is calculated. Subsequently, the self-impact of loans was 56.25%, 49.68% in M1 money supply, 74.42% in discount rate and 46.52% in exchange rates. Detailed matrix results are expressed as matrix in the table below.

Table 5. Matrix of 10-Terms Variance Decomposition Means of Variables

Variables	GDP	Credits	Exchange Rate	M1	Deposits	Discount Rate
GDP	86,63	0,56	3,98	2,65	0,47	5,73
Credits	4,4	56,25	11,93	13,53	13,36	0,53
Exchange Rate	26,86	21,17	46,52	2,22	2,62	0,61
M1	6,55	39,34	3,14	49,68	0,2	1,09
Deposits	3,34	7,52	45,35	24,26	17	2,53
Discount Rate	2,03	2,28	7,32	11,54	2,41	74,42

In the final stage of the analysis, effect-response analysis was applied to the variables. The impulse-response analysis was used to test the effect of other variables on these shocks by applying a one-unit shock to the interest rate and then the exchange rate, respectively.



In the Impulse-Response analysis, 10-term effect-response test was applied according to Cholesky method. In response for one unit shock applied to the interest rate, the GDP variable decreased sharply negatively starting from the 0 level and continued until the end of the second period, from period 3, although the reaction was upward-prone, this increase did not last long and did not reach a positive level: including the period 3, the reaction to the shock continued being neutral. Similarly, a downward trend started from zero in response to a unit shock in loans and this trend continued until the second period and upward movement started after this period. In the middle of the third period, it continued its upward movement by exceeding the zero level. The one-unit shock to the local variable on the GDP variable had a longer effect on loans. Although there was a downward trend in some intervals in the following periods, it has managed to stay above the zero level in general. The movement in loans was found to be fully consistent with the bank loan channel theory.

Figure 3. Results of Impulse-Response Analysis against One Unit Shock Given to Interest Rate

Although the reaction in exchange rate revealed a decrease until the second period, it fluctuated in other periods. Although it appears to be positive between the 3rd and 4th periods, it also shows a negative trend in the long term. In addition, the fluctuation and response in exchange rates are maintained until the last period. The response of M1 narrow money supply shows slightly different results compared to other variables, while the effects in other series cover the shorter period compared to money supply, the decline in money supply series continues until the 4th period and then increases until the 7th period. Unlike other series, it does not provide a negative transition. This result is consistent with the monetary transmission theory we have mentioned before. In other words, the theory of monetary transmission mechanism is expected to have a negative linear relationship between monetary aggregates and interest rate.

In the deposit series, one-unit shock in discount interest rates has a positive effect except for the first two periods, but cannot maintain the high increase in the third period and shows a negative decrease after this period; however, from the 6th period onwards it does not rise again and fall below 0 level. After examining how other variables react to a unit of shock given to the interest rate, it is now discussed how other variables react to a one-unit shock to the exchange rate. In the same way, the responses of the variables over a period of 10 periods based on the Chelosky method are given in the following graph and interpreted.

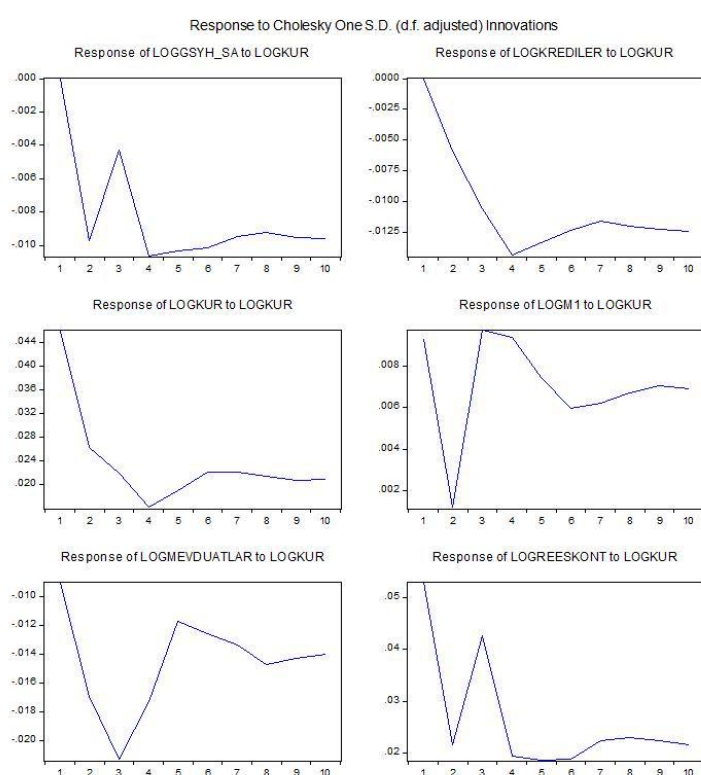


Figure 4. Results of Impulse-Response Analysis against One Unit of Shock Given to Exchange Rate

Deposits also show a downward movement due to the exchange rate effect, which, as stated in the previous explanations, suggests that the interest rate policies against exchange rate movements were caused by depreciation in local currency deposits and caused an upward movement with subsequent interest rate policies. This increase continues until the 5th period and then recovers with the decline again. On the other hand, the discount interest rate shows a downward decline in the reaction to the exchange rate shock. These findings, compared to the exchange rate channel of Turkey, show us that interest rates have more influence on the economy.

5. Results and conclusions

Monetary transmission mechanisms have gained importance in recent years and this shows how accurate and effective monetary policies are. Monetary transmission mechanisms have been subjected to various but similar classifications in the literature. However, in this study, our analysis was performed based on the Mishkin classification. The process, through which Turkey's economy is going recently, increases the importance of this analysis. Turkey is a country that is set to bring the current account deficit due to problems on the basis of origin. If you want this interest focused on whether the work

The reaction to the shock given to the exchange rate in gross domestic product starts with a decrease until the 2nd period and increases after the 2nd period until the end of the 3rd period but then decreases again. The reason for this is the life of GDP, the current account deficit of Turkey's economy and therefore it can be interpreted as negative impact of GDP on exchange rate shock. On the other hand, although GDP shows an upward trend in some periods, as can be seen in the graph, it cannot cross the zero line and continues at a negative level for 10 periods.

Likewise, a negative trend is observed in loans and this effect below the zero level continues until the 4th period. Although a positive line is seen from the 4th to the 7th period, it is seen that after the 7th period it has a slight negative slope. The impression of this reaction in credits also indicates that it is compatible with credit channel theory.

The M1 money supply offers a stronger response to the exchange rate shock. Following the harsh negative slope up to the second period, the upward slope is followed again stiffly. An upward impression is seen again after a decline until the 6th period. Moreover, these movements continue above zero level in M1 money supply.

done by the exchange rate also results-oriented analysis shows us how and at what level includes an impact for Turkey's economy. The process in which the Turkish economy has passed in recent periods increases the importance of this analysis. Since Turkey is a country with a current account deficit, it brings foreign currency problems on the basis of it. This study shows us how and at what level it has an impact on the Turkish economy, both on interest-oriented and exchange-rate-oriented analysis results.

In this study, VECM technique was used, since the use of the Vector Error Correction Model would yield more accurate and healthy results. The quarterly data set covering the periods 2009: 3-2018: 6 were used for analysis. The data was obtained from sources, such as Turkey Statistical Institute (TUIK), Turkey Presidency of the Republic of Strategy and Budget Department and the Central Bank of the Republic of Turkey (CBRT). The variables were divided into two groups as endogenous and exogenous variables. Internal variables included Gross Domestic Product (GDP), M1 narrow-scale money supply, discount interest, loans, deposits, and US dollar (USD) and Turkish lira exchange rate. BRENT branded oil prices per barrel, representing the energy sector, which is an important part of Turkey's current account deficit, were entered as exogenous variables. The variables used were first subjected to logarithmic transformation, then seasonally adjusted and then the stationarity test was made by making the series stationary. By measuring the appropriate lag lengths, the number of observations of the variables was taken into consideration and it was decided to perform the analysis with the lag length of the first order. No autocorrelation problem was encountered in the study. Then, the variance decomposition test and the means matrix covering the average of 10 periods were formed for all variables. Then, both the interest rate channel and the exchange rate channel effect-response analysis were performed and the results were interpreted.

According to the findings, although the effect of the interest rate channel on other variables is simulated in a shorter period compared to the exchange rate channel, ie it disappears, since the effect on the other variables is longer in the exchange rate channel, and the exchange rate channel is larger in terms of efficiency, it is obtained that the exchange rate channel is more effective agent than the interest rate channel for Turkey. The findings reveal that the exchange rate channel is more important than the interest rate channel for the Turkish economy. Since the exchange rate channel causes deep fluctuations almost in all variables, it appears that it has potential to move Turkey's economy into a serious crisis.

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