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Examination of The Impact of Exchange Rate and Petroleum Prices On Inflation with The VECM Model: The Case of Türkiye

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Abstract

In the study, the influence of EXC and OIL on INF was investigated by using the annual data of Türkiye between 1995 and 2020. VECM model was preferred in the examination. In accordance with the findings obtained at the end of the examination, there is a strong positive affair amongst the variables and there is a long-period affair amongst the variants. The rate of adjustment towards long-term equilibrium is as fast as 56%. Exchange rate and petroleum prices affect inflation rates in the long run. In addition, while enhancements in the exchange rate alone affect inflation in the short period, enhancements in petroleum prices alone do not affect inflation in the short period. However, when the exchange rate and petroleum price increase together, it also affects inflation in the short period.

Döviz Kuru Ve Petrol Fiyatlarının Enflasyon Üzerine Etkisinin VECM Modeli İle Analizi: Türkiye Örneği

Öz

Çalışmada Türkiye'nin 1995 ile 2020 yılları arasındaki verileri kullanılarak döviz kuru ve petrol fiyatlarının enflasyon üzerindeki etkisi araştırılmıştır. Çalışmada VECM modeli kullanılmıştır. Araştırmanın sonunda elde edilen bulgulara göre değişkenler arasına pozitif yönlü güçlü bir ilişki bulunmaktadır ve değişkenler arasında uzun dönemli bir ilişki bulunmaktadır. Uzun dönem dengesine doğru ayarlama hızı %56 gibi hızlı bir orandır. Döviz kuru ve petrol fiyatları uzun dönemde enflasyon oranlarını etkilemektedir. Ayrıca kısa dönemde döviz kurunda yaşanan artışlar tek başına enflasyonu etkilerken, petrol fiyatındaki tek başına artışlar enflasyonu kısa dönemde etkilememektedir. Fakat bununla birlikte döviz kuru ve petrol fiyatı birlikte arttığında, kısa dönemde de enflasyonu etkilemektedir.

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1. Introduction

Inflation problem is one of the main macroeconomic problems of countries. In a country where there is inflation, that is, there is an increase in the general level of prices, many important economic problems can be seen along with it. For this reason, it is very important to understand the points that cause inflation in order to facilitate the solution of the inflation problem. When we look at the basis of inflation, it can be seen that the inflation caused by intense demand can be seen, and increasing costs can also cause inflation. In times when demand increases and supply cannot keep up with the increasing demand, demand-driven inflation can be seen, and increases in production costs can also cause cost-driven inflation.

Countries with high inflation levels may experience economic instability. In a country with an unstable economy, the trust in the economy is shaken, but different economic problems can be seen along with it. Especially when inflation reaches high levels, it can become staggering and distrustful for the economy, and disruptive to other economic indicators. For this reason, determining which factors are effective on inflation in the solution of the inflation problem is important in adapting the policies of the national economies to solve this problem.

One of the factors causing inflation is the type of inflation based on cost. Especially in countries like Türkiye that imports important elements in production such as raw materials, intermediate goods and energy, the exchange rate has a large share in determining the production costs (Köse and Ünal, 2021: 1-3). In addition, petroleum is among the indispensable basic inputs of the industry. Since Türkiye cannot produce enough petroleum for itself, this item is also among the products most of which are imported.

One of the most fundamental macroeconomic difficulties of many countries in the world is the problem of inflation. Although various studies have been carried out on inflation for many years, many countries in the world are still trying to solve the problem of high inflation. Türkiye , which has struggled with inflation for many years, is still a country experiencing high inflation today. For this reason, it still maintains its importance to conduct a study on cost inflation, which is one of the most important sub-headings of inflation in Türkiye .

Therefore, in this study, an examination was made on the exchange rate and oil prices, which are thought to cause cost inflation in Türkiye , and solutions and policy suggestions were presented. In this respect, the study is expected to contribute to the high inflation problem, which is still unsolved today. For this reason, in this study, using the annual data of Türkiye between 1995 and 2020, the effect of European Brent crude petroleum barrel price and exchange rate on inflation has been tried to be examined in Türkiye . The VAR model was used in the study.

The research problem of the study can be expressed as that with this study, it will be tried to determine the influence of exchange rate and petroleum prices, which are one of the main elements of cost inflation, on inflation. In this way, it is aimed to contribute to the studies on the influence of exchange rate and petroleum prices

on inflation. The main research question of the study can be expressed as: What is the influence of alterations in exchange rates and petroleum prices on the country's inflation? Do these variables have an influence in the short and long term? The methodology to be used in the empirical analysis part of the study is as follows: Vector Autoregression (VAR) and Vector Error Correction Model (VECM) model, which is used to determine the influences of variables on each other, was used in the study. For this purpose, the influence of alterations in exchange rate and petroleum prices in Türkiye on Turkey's inflation has been determined.

2. Theoretical Background

In the classical approach, quantity theory is used to explain the relationship between the amount of money and the general level of prices. Although the quantity theory was subjected to many criticisms until the First World War, it continued to be accepted. According to the quantity theory, if the amount of money in the economy is increased without a change in the amount of production, it will cause prices to rise and money to depreciate. The reason for this is based on the most basic rule of economics. In general, the value of abundant goods in the economy decreases, while the value of scarce goods increases. When we think of money as a commodity, the abundance of money will only cause the currency to lose value unless the amount of production changes. In this way, it will lead to inflationary tendencies (Dinler, 2014:458).

Classical economists accept the full employment situation in the economy and state that increases in money supply will cause inflation. But Keynes opposed the classics that the economy would always be at full employment. According to Keynes, aggregate demand in the economy can be equal to aggregate supply and equilibrium can be achieved. However, he states that this balance can also be realized under underemployment conditions. Keynes states that the economy can reach equilibrium both in underemployment conditions, in full employment conditions and above the full employment equilibrium level. Keynes expressed the main cause of inflation as demand-driven factors rather than money supply. At the full employment level, inflation processes may occur if consumer demands exceed the supply while producing with maximum production capacity (Keynes, 1936:146-150

Monetarists, on the other hand, followed the same line as the classical. They stated that the velocity of circulation of money would not change in the short run, but could change in the long run. In this approach, the relationship between the amount of money and inflation rates was examined and it was stated that the main reason for inflation was the uncontrolled increase in the money supply. Friedman states that increases in money supply should be increased in a controlled manner so that they do not cause inflation. He saw inflation as a monetary phenomenon (Friedman,1989:3-20).

3. Literature Review

Mukhtarov et al. (2019) examined the affair between general level of prices, petroleum prices and exchange rates in Azerbaijan. In his study, the data of Azerbaijan between 1995 and 2017 were used. He preferred the vector error correction model (VECM) as the model. In accordance with the consequence of the study, there is a long-dated affair between the variants. In the long period, petroleum prices and exchange rates affect inflation positively and significantly. A 1% increment in petroleum price and exchange rate enhances general level of prices by 0.58% and 1.81%, serially.

Malik (2016) investigated the effect of alterations in petroleum prices on inflation in Pakistan. He used quarterly data which from the first quarter of 1979-19802 to the third quarter of 2013-2014. He analyzed his work within the framework of augmented Phillips curve. According to the results of the study, it has been specified that there is a strong affair amongst petroleum prices and inflation.

Sek et al., (2015) used annual data between 1980 and 2010 to measure the effect of petroleum price alterations on general level of prices on two sets of countries with high and low petroleum dependency. ARDL model was used in the study. In accordance with the results of the study, petroleum prices have a direct effect on general level of prices in the country group with low petroleum dependence. However, in countries with high petroleum dependence, it has an indirect effect on inflation as it affects the production costs of exporters. Another main factor affecting domestic inflation has been identified as the exchange rate.

Bawa et al., (2020) analyzed the effect of petroleum prices in Nigeria on inflation using datum which from the first quarter of 1999 to the fourth quarter of 2018. He used the NARDL method in his work. In accordance with the results of the research, petroleum prices increase general level of prices in Nigeria. In addition, when the exchange rate is subtracted from the model, a negative petroleum price shock causes higher inflation in Nigeria.

Mpofu (2011) investigated the influences of EXC and PET on INF in S.Africa using data between 1999 and 2010. Multiple correlation test and multiple regression model were implemented to research the variants. In accordance with the results of the study, exchange rate has a strong enhancer impact on inflation. petroleum prices, conversely, have a prominent detractive effect.

Karacan and Yardim Kilickan (2018) investigated the influence of EXC and OIL on INF in Türkiye using data between 2006 and 2017. The VAR model was used in the investigation. According to the results of the study, exchange rate and petroleum prices in Türkiye have an impact on general level of prices.

Koçak et al. (2017) investigated the affair between petroleum costs and inflation in Türkiye using quarterly data between 2003 and 2017. The VAR model was used in the research. According to the results of the study, there is a long-dated and positive affair amongst petroleum prices and inflation.

Shadab and Gholami (2014) investigated the influence of petroleum costs and exchange rate on general level of prices and other variables in Tehran using monthly data between 1376 AH (1956 Gregorian year) and 1391 AH (1971 Gregorian year). The VAR model was used in the research. In accordance with the results of the research, a long-dated causality affair was established amongst the variants.

Arku et al., (2021) analyzed the relationship amongst petroleum prices, exchange rate and inflation in Ghana using monthly data between 2000 and 2018. He used the ARDL model in his study. In accordance with the results of the research, there is a long-dated affair between crude petroleum prices and general level of prices. In addition, there is a negative affair amongst petroleum prices and exchange rates.

Brown et al., (1995) analyzed the influence of petroleum prices on inflation in the USA using the data between 1970 and 1994 in their study. The VAR model was preferred as the method in the study. According to the consequence of the research, the petroleum shocks experienced have a permanent effect on the price level. The increase in petroleum prices causes inflationary tendencies.

Al-Qenaie and Al-Shammari (2016) studied the causes of general level of prices in the group of petroleum exporting countries using the data between 1991 and 2014 in their study. They used panel data analysis in their studies. According to the results of the study, high inflation is associated with high petroleum prices and high exchange rates. Although the main inflation reasons of the countries differ, the main inflation reason of Algeria and Nigeria, which are included in the study group, was determined as exchange rate changes.

4. Methodology and Econometric Analysis

In the study, Turkey's data between 1995 and 2020 was used. Turkey's inflation rate between 1995 and 2020 was determined as the dependent variant, while the exchange rate and petroleum prices were determined as the independent variables. While inflation and exchange rate data were obtained from the World Bank database, petroleum prices were obtained from the economic research section of the Federal Reserve Bank of St. Louis (FRED) website as "Crude Oil Prices: Brent - Europe". Table 1 below shows the variants used in the analysis and their data used in the analysis.

Table 1. Variables and obtained data

Years	Inflation (% per annum)	Exchange rate	Petroleum Prices
1995	89,11	0,05	17,02
1996	80,41	0,08	20,64
1997	85,67	0,15	19,11
1998	84,64	0,26	12,76
1999	64,87	0,42	17,90
2000	54,92	0,63	28,66
2001	54,40	1,23	24,46
2002	44,96	1,51	24,99
2003	21,60	1,50	28,85
2004	8,60	1,42	38,26
2005	8,18	1,34	54,57
2006	9,60	1,43	65,16
2007	8,76	1,30	72,44
2008	10,44	1,30	96,94
2009	6,25	1,55	61,74
2010	8,57	1,50	79,61
2011	6,47	1,67	111,26
2012	8,89	1,80	111,63
2013	7,49	1,90	108,56
2014	8,85	2,19	98,97
2015	7,67	2,72	52,32
2016	7,78	3,02	43,64
2017	11,14	3,65	54,13
2018	16,33	4,83	71,34
2019	15,18	5,67	64,30
2020	12,28	7,01	41,96

Table 1 shows inflation, exchange rate and petroleum prices for Türkiye between 1995 and 2020. Table 2 includes the variables and their descriptive explanations.

Table 2. Descriptive explanations of variables

Variables	Descriptive Disclosures
INF	Inflation, consumer prices (% per annum).
EXC	Official exchange rate (LCU per US dollar, period average).
OIL	Crude Oil Prices: Brent - Europe, Dollars Per Barrel, Annual, Non-Seasonally Adjusted

Source: (World Bank Data Bank, 2022) and (Federal Reserve Bank of St. Louis (FRED), 2022)

Table 2 contains detailed explanations of the variables used in the study on the official websites from which they were obtained. The affair amongst inflation, exchange rate and oil prices can be expressed statistically as follows.

$$INF = \propto + \beta_1 EXC_t + \beta_2 OIL_t + \ u_{it}$$

The coefficient $\propto$ in the equation symbolizes the constant term. The β coefficients show the affair amongst the dependent variant and the independent variant. uit can be expressed as an error term. Considering the lag lengths, the equation is expressed as follows according to the VECM model (Kutlar, 2019:12);

$$dINF_t = \propto_{11} + \sum_{i=0}^{n} \beta_{1i} EXC_{t-i} + \sum_{i=0}^{k} \beta_{2i} d\ OIL_{t-i} + \sum_{i=0}^{l} \beta_{3i} dINF_{t-i} + u_{1t}$$

$$EXC_t = \propto_{21} + \sum_{i=0}^{n} \beta_{4i} dOIL_{t-i} + \sum_{i=0}^{k} \beta_{5i} dINF_{t-i} + \sum_{i=0}^{l} \beta_{6i} EXC_{t-i} + u_{2t}$$

$$dOIL_t = \propto_{31} + \sum_{i=0}^{n} \beta_{7i} dINF_{t-i} + \sum_{i=0}^{k} \beta_{8i} EXC_{t-i} + \sum_{i=0}^{l} \beta_{9i} dOIL_{t-i} + u_{3t}$$

In the equations, d represents the first difference, and u1, u2 and u3 represent the error correction terms. n, k, and l are the number of lag lengths (Kutlar, 2019:12).

4.1. Findings

The analyzes and findings obtained on the inflation, exchange rate and oil prices data of Türkiye between 1995 and 2020 are as follows.

4.1.1. ADF Unit Root Test Results

Augmented Dickey Fuller (ADF) unit root tests were implemented to determine whether the series are stationary or not.

Table 3. ADF unit root test for inflation

Interpolated Dickey Fuller			Number of obs: 24	
	Test Statitics	%1 Critical Value	%5 Critical Value	%10 Critical Value
Z(t)	-3,201	-3,750	-3,000	-2,630
MacKinnon approximate p-value for Z(t) =0,0199				

Table 3 shows the unit root analysis results of the inflation variable. In the analysis, it was desired to examine whether the inflation variable is stationary. Analysis results showed that this variable is not stationary. For this reason, it has been determined that it is necessary to take the first-degree difference in order to make the variable stationary. With the ADF Unit Root Analysis implemented to the inflation variable, it was understood that the series were not stationary. For this reason, the first differences of the series were taken and made stationary.

Table 4. ADF unit root test for exchange rate

Interpolated Dickey Fuller			Number of obs: 25	
	Test Statitics	%1 Critical Value	%5 Critical Value	%10 Critical Value
Z(t)	-5,000	-3,750	-3,000	-2,630
MacKinnon approximate p-value for Z(t) =0,0000				

Table 4 shows the unit root analysis results of the exchange rate variable. In the analysis, it was desired to examine whether the inflation variable is stationary. Analysis results showed that this variable is stationary. For this reason, it has been determined that it is not necessary to take the first difference in order to make the variable stationary. ADF Unit Root Analysis was implemented to the exchange rate variable and it was specified that the series were stationary.

Table 5. ADF unit root test for oil prices

Interpolated Dickey Fuller			Number of obs: 23	
	Test Statitics	%1 Critical Value	%5 Critical Value	%10 Critical Value
Z(t)	-3,640	-3,750	-3,000	-2,630
MacKinnon approximate p-value for Z(t) =0,0050				

Table 5 shows the unit root analysis results of the oil prices variable. In the analysis, it was desired to examine whether the oil prices variable is stationary. Analysis results showed that this variable is not stationary. For this reason, it has been determined that it is necessary to take the first-degree difference in order to make the variable stationary. With the ADF Unit Root Analysis implemented to the oil price variable, it has been understood that the series are not stationary. For this reason, the first differences of the series were taken and made stationary.

4.1.2. Appropriate Lag Length for VECM Model

For the predictions to be made, it's necessary to determine the lag length. Accordingly, five lag values were given to find the most appropriate lag length, and the most appropriate lag length was tried to be determined accordingly.

In Table 6, it was tried to determine the appropriate lag length for the variables according to the VECM method. The lag length has been extended to five lags. Except for the FPE information criterion, the AIC and HQIC information criteria represent the most appropriate lag since it is the minimum at the 4th lag. In addition, the P statistic at the 4th lag is less than 5%.The appropriate lag length for the VECM model has been determined as 4.

Table 6. Appropriate lag length for VECM model

Selection-order criteria Sample: 2001-2020					Number of obs = 20			
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-523,706				1,5e+19	52,6706	52,6998	52,82
1	-509,86	27,692	9	0,001	9,4e+18*	52,186	52,3027	52,7835
2	-508,143	3,4351	9	0,945	2,1e+19	52,9143	53,1184	53,9598
3	-499,464	17,358	9	0,043	2,7e+19	52,9464	53,238	54,44
4	-476,786	45,356*	9	0,000	1,1e+19	51,5786*	51,9576*	53,5203
5	-468,34	16,893	9	0,050	3,2e+19	51,634	52,1005	54,0237

4.1.3. Johansen Co-Integration Analysis

The Johansen Co-Integration test was used to specify the co-integration affair amongst the variables (Johansen & Juselius, 1990:165-178).

Table 7. Johansen co-integration analysis in VECM

Johansen test for cointegration					
Trend: constant Sample: 2000-2020			Number of obs: 21 Lags: 4		
Maximum rank	parms	LL	eigenvalue	Trace statistic	%5 critical value
0	30	-538,51447	.	63,3520	29,68
1	35	-515,94437	0,88346	18,2118*	15,41
2	38	-507,49907	0,55261	1,3212	3,76
3	39	-506,83845	0,06098		

For rank=1, the null hypothesis is rejected. At the 5% significance level, the value of the trace test exceeds the critical value. In Johansen Co-integration analysis, it can be said that there are at least one co-integration relationships, since the trace statistic is higher than the second-degree critical value. There is a long-dated affair amongst the variants. In other words, the variables move together in the long run.

4.1.4. Vector Error Correction Model (VECM)

Parameter forecast was done with vector error correction model (VECM). According to the Vector Error Correction Model (VECM), there is a long-term significant affair amongst the variants. Correct adjustment to the long-term balance takes place at a rapid rate of 56%. In other words, changes in EXC and OIL affect INF in the long period.

Table 8. Vector error correction model (VECM) estimation

Vector error-correction model					
Sample: 2000 - 2020			Number of obs	=	21
AIC	= 52,47089				
Log likelihood = -515,9444			HQIC	=	52,84871
Det(Sigma_ml) = 4,39e+17			SBIC	=	54,21176

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_dINF	11	2,81322	0,9162	109,2689	0,0000
D_EXC	11	3,4e+07	0,7127	24,80131	0,0097
D_dOIL	11	28,9048	0,3241	4,794445	0,9407

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_dINF						
_ce1	,5642345	,086576	6,52	0,000	,3945487	,7339202
L1. dINF						
LD.	-1,34941	,2085048	-6,47	0,000	-1,758072	-,9407483
L2D.	-1,231528	,1449001	-8,50	0,000	-1,515527	-,9475293
L3D.	-,8697825	,1757853	-4,95	0,000	-1,214315	-,5252496
EXC						
LD.	-3,96e-07	6,36e-08	-6,22	0,000	-5,21e-07	-2,71e-07
L2D.	-2,60e-07	4,93e-08	-5,27	0,000	-3,56e-07	-1,63e-07
L3D.	-9,28e-08	2,47e-08	-3,77	0,000	-1,41e-07	-4,45e-08
dOIL						
LD.	,0107624	,0346119	0,31	0,756	-,0570756	,0786003
L2D.	,0174259	,0328535	0,53	0,596	-,0469658	,0818177
L3D.	-,029705	,0354698	-0,84	0,402	-,0992246	,0398146
_cons	1,261756	,6218849	2,03	0,042	,0428838	2,480628

When the short-term relations are examined, the alterations in the exchange rate affect the inflation rates in the short term. Changes in oil prices, conversely, do not affect inflation in the short period, but affect inflation rates in the long period.

4.1.5. Granger Causality Wald Test

Granger Causality Wald Test was used to specify the causal affair amongst the variables (Granger et al., 2000:337-354).

Table 9. Granger causality wald test

Equation	Excluded	F	df	df_r	Prob > F
dINF	EXC	10,443	4	8	0,0029
dINF	dOIL	1,0655	4	8	0,4331
dINF	ALL	6,3292	8	8	0,0086

According to the outcomes of the Granger Causality Wald Test, which was conducted to specify the causality affair between the variables, increments in the exchange rate alone affect inflation in the short period, while increases in oil prices alone do not affect general level of prices in the minuscule period. However, when the exchange rate and oil price increase together, it also affects inflation in the minuscule period. In the extended period, both the EXC and OIL affect INF.

5. Conclusion and Recommendations

Inflation is among the main problems of many countries, whether developed or developing countries. Cost-based inflation is one of the factors that make up the inflation process. In the study, the influence of EXC and OIL on INF was tried to be investigated by using the annual data of Türkiye between 1995 and 2020. The VECM model was used in the analysis phase of the study. First of all, Augmented Dickey Fuller (ADF) unit root tests were performed to measure the stationarity levels of the variables. In accordance with the ADF Unit Root Analysis, while the EXC is stationary at the level, the INF and OIL variables become stationary after the first difference is taken. Then, the appropriate lag length for the vector error correction model (VECM) was tried to be reached and it was determined as 4. In addition, the Johansen Co-Integration test was used to determine the co-integration affair amongst the variants and it was seen that there was a long-period affair amongst the variants. Parameter estimations were made with the vector error correction model (VECM). Accordingly, there is a strong positive affair between the variants. In addition, a long-period significant affair was detected amongts the variants. Toward the long-run equilibrium, the adjustment takes place as fast as 56%. In other words, changes in EXC and OIL affect INF in the long run. Granger Causality Wald Test was used to specify the causal affair between the variables. While increases in the exchange rate alone affect inflation in the short period, increases in oil prices alone do not affect inflation in the short period. However, when the exchange rate and oil price increase together, it also affects general level of prices in the short-dated. In the long-dated, both the EXC and OIL affect INF.

Based on these results, the necessity of reducing foreign dependency in energy is felt significantly. In an environment where the world is evolving towards renewable energy, Turkey's investments in renewable energy may bring a solution in the long run. Although establishing a renewable energy infrastructure is costly and is expected to increase the foreign exchange deficit in a certain period, it may be advantageous for Türkiye to turn to renewable energy sources such as solar, wind and biogas in the long run. In the long run, it will contribute to keeping the foreign currency payments for energy within the country by reducing energy dependence on foreign countries. In addition, the use of energy-saving machinery and equipment can be supported within the country, and tax deductions can be provided for energy-saving machinery, equipment and household goods. In addition to all these, supporting domestic production and encouraging the production and use of domestic products that can be substituted for imported raw materials or intermediate goods can be considered as another step.

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