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Discerning Granger-causal chain between oil prices, exchange rates and inflation rates: Evidence from Turkey

Yusuf Ensar Citak[1] and Mansur Masih[2]

Abstract

The purpose of this study is to investigate the Granger-causal relationship between oil prices, exchange rates and inflation rates using Turkey as a case study. Revealing this relationship will give us a roadmap to cure fragile Turkish economy. Standard time-series approaches are used to investigate this relation. Our empirical findings tend to indicate that there is a long run relationship between these variables and that the CPI appears to be the variable leading exchange rate and oil prices. The results are plausible and have strong policy implications.

Key Words:

Oil Price, Exchange Rate, CPI, PPI, Turkey, cointegration, exogeneity, endogeneity

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1. Introduction

A number of developing countries rely on export based development model for economic growth. Their ability to export mostly depends on their competitiveness in the international market, more particularly relies on their production costs. In this sense, oil price is one of the important factors that can affect future production plans of the market. Energy prices and purchase power of the currency affects the importing performance of the countries. Some of the previous studies show increasing oil prices as number one reason in the global economic slowdown.

As a consequence of this heavy dependence on oil, a large number of researchers have attempted to estimate relation between oil and economic variables. Several studies made about developed countries found that increase in the oil prices decreases the output. On the other hand some other studies find that this relationship is more limited in developing countries. (Vincent & Bertrand, 2011; Arize, Osang, & Slottje, 2000)

Other studies have shown that this result extends to other variables including GDP, inflation, monetary policy, current account deficits the balance and terms of trade and employment and wages, To the extent that oil prices affect the above variables, they should affect exchange rates, as well (Atems, Kapper, & Lam, 2015). On the other hand some of studies found compelling linkages between oil price and economic growth, while (Lardic & Mignon, 2008) says if the oil price increase is long-lasting, it can give rise to a change in the production structure and have an impact on unemployment.

For developing countries like Turkey, there are few studies which focuses on oil prices and exchange rates. Turkey is oil dependent country and that's why all economic activities affected by oil prices and exchange rate.

Decreasing oil prices in recent years provides some advantage for the Turkish economy. But at the same time, especially in 2016, Turkish Lira saw one of the dramatical depreciations in its history and closed the year as most depreciated currency against US dollar in the world. When we take into account fragile Turkish economy, understanding the nature of oil price, exchange rate and consumer prices relationship will give us an idea about to economical roadmap.

As a conclusion of this research, we found consumer price is the leading variable and followed by exchange rate, oil prices and producer prices (given by causality order). We found our conclusion consistent with Purchasing Power Parity (PPP) theory.

i. *The objective of this study:*

The main aim of this paper is to investigate empirically the long run relationship between the oil price volatility, exchange rate and consumer price in Turkey by using the time series technique.

ii. *Question of this study:*

This study aims to answer two main questions:

What is the relationship between oil prices and exchange rate in Turkey as oil importing country?

What is the effect of these relation on Turkish economy?

iii. *The contribution of this paper:*

There is not much papers written about the relation between exchange rate and oil prices focusing on Turkey as a specific country. First contribution is to fill this gap. Secondly, to examine this relation with the light of recent developments in the economy. That's why we used most recent data from the March 2007 to April 2017.

Section 2 reviews the literature review related with oil prices and exchange rate. It is followed by the data and methodology in section 3. Section 4 discusses the empirical results and final section gives the conclusion remarks and policy implications.

2. LITERATURE REVIEW

It has been well proven by the literature that there is strong connection between oil prices and exchange rates. Especially for the countries, whose economies are dependent on oil either in importing side or in exporting side. Classical demand – supply approach in the economy states that when the price of an importing (exporting) goods rises (falls), if demand is very inelastic, it results deterioration in the trade balance, which decrease the value of the currency. In many studies, terms of trade are commonly approximated by the real oil price. This specific article find that oil price shocks can explain the 10% of the short-term variations in the exchange rate as well as 20% of the long-term exchange rate variations in 16 OECD countries. (Chen, Liu, Wang, & Zhu, 2016)

Oil is one of the most important production factor and it is in the center of various industrial activities. For this reason, oil price shocks have had a significant impact on real economic activities especially, after the 1970's. Impacts of the oil shocks can be seen more clearly after the oil crisis in 1973 and 1979. Consequently, price fluctuations in the oil prices has become a subject in numerous researches and empirical studies. Jawadi et al. investigated these shocks from the two different currency perspective; United States Dollar ($) and Euro (€). They find a negative relationship between these two currencies and oil prices. More precisely, appreciation in the currencies (especially $) cause depreciation in the oil prices. Which looks in line with the last couple years USD and oil relationship. (Jawadi, Louhichi, Ameur, & Cheffou, 2016)

According to another study written by the Uddin et al., an oil-exporting country may experience a currency appreciation when oil price rise and depreciation when oil prices fall; whereas, the fundamentals are reverse in the case of an oil-importing country. Both the supply and demand channels take part in the making of a transmission apparatus through which oil prices impact the real exchange rate. Again another article from the same authors, more deeply examines the relationship between oil prices in Japan and Japanese Yen. They find that over the time, strength of the relationship between these two variables keeps changing. Conclusion from the previous state is that, Japan should emphasize oil prices shocks, in order to establish more steady currency.(Uddin, Tiwari, Arouri, & Teulon, 2013)

Since energy is an essential input to the production process, then higher oil prices lead to the increase of production cost and reduce in the amount of the expected profits for non-oil related companies. On the other side, oil price increase is expected to raise the overall trade deficit for oil importing countries. A growing trade deficit will generate expectations of future depreciation of the current exchange rate accompanied by higher inflation rate.

The relationship between oil prices and exchange rates has received much attention, a frequently given explanation is based on the potential impact of oil shocks in driving term of trade movements, which would therefore justify the effect on the exchange rate. (Aloui, Safouane, & Aïssa, 2016)

3. DATA AND METHODOLOGY

i. Sources of Data and Variables

This study employs monthly data from March 2007 to April 2017 (Last 10 years). Exchange rate data collected from Central Bank of The Republic of Turkey (TCMB). All other variables are extracted from datastream.

Table 1: List of Variables

Variable	Definiton
EX	Exchange Rate, Turkish Lira to US Dollar
OI	Oil Price Brent quoted in TL
CP	Consumer Product Price Index
PP	Producer Product Price Index

ii. Economic Methodology

In the first step, Philips-Perron test applied to control the stationarity of the variables. Then VAR order examined to pass next step. This study employs the Engle-Granger and Johansen multivariate cointegration approaches to test if there is any cointegration among the variables. The main difference between Engle-Granger and Johansen test is, E-G can answer only 'is there any cointegration?' question, but on the other hand, Johansen can answer the availability of the cointegration as well as number of the cointegrations. After finding the cointegration, Long Run Structural Modelling (LRSM) applied to test the long-run relation between employed variables and their theoretical underpinnings. Doing this by imposing restrictions on the long-run relation.

After that, Vector Error Correction Model (VECM) used to check exogenous and endogenous variables without any ranking. It means, VECM only tells us the exogeneity and endogeneity of the variable but not the order in the group. Another result VECM gives is that, the speed of the short-run adjustment towards long term equilibrium by the size of the error correction coefficient. In the next step, VDC method applied to find exogeneity and endogeneity of the variables with their ranking within the group. Other words, which one is most exogeneous, which one is more endogenous. Next, the Impulse Response analyze has been applied to examine effects of shocking one variable to other variables. Finally, Persistence Profile used to test effects of system-wide shock on all variables and needed periods for the variables to get back their equilibrium points again.

4. EMPRICAL RESULTS AND DISCUSSION

i. Unit Root Test:

Most finance variables are non-stationary in their raw form. This means that choosing these variables to perform an ordinary regression, will give us misleading results. Because statistical tests are not valid when non-stationary variables applied. If the variables are non-stationary and cointegrated , the ordinary regression without the error-correction term(s) derived from the cointegrating equation is misspecified. Nevertheless, if the variables are non-stationary and not cointegrated, ordinary regression can be estimated with differenced variables. Taking difference makes non-stationary variables stationary. But the problem in this case, conclusion can be done only in a short-term period. Because taking the difference removes the theoretical part from the variables, we cannot make any comment on long-run relationship.

We begin our empirical study by testing the variables to see are they stationary or not. All variables expected to be I (1) form, in order to proceed to next step. In other words, we expected variables to be non-stationary in their log forms and stationary in their differenced forms. Stationary the variables where the mean, variance, and covariance with its lags are constant. The autocorrelation coefficients die down very quickly after only 2 or 3 significant lags. Shocks are transitory, a non-stationary the variable where the mean, variance, and covariance with its lags are not constant or it grows over time, the autocorrelation coefficients tend to be unity. Shocks are permanent.

In this study we employed Philips-Perron test to examine stationarity and non-stationarity.

Table 2: PP Test Results

PP-TEST									
Log Form	Variable	T-Stat	C.V.	Result	Differenced Form	Variable	T-Stat	C.V.	Result
	LEX	-2.5168	-3.4273	NS		DEX	-10.8421	-2.8641	S
	LOI	-1.8763	-3.4273	NS		DOI	-7.5456	-2.8641	S
	LCP	-2.2874	-3.4273	NS		DCP	-10.3741	-2.8641	S
	LPP	-1.7768	-3.4273	NS		DPP	-6.244	-2.8641	S

Note: The null hypothesis for the Philips-Perron (PP) test is that the variable is non-stationary. In all cases of the variable in level form, the test statistic is lower than the critical value and hence we can't reject the null. Conversely, in all cases of the variable in differenced form, the test statistic is higher than the critical value and thus we can reject the null and conclude that the variable is stationary (in its differenced form)

Results of the Philips-Perron test was as expected, all log forms are non-stationary and all differenced forms are stationary.

ii. VAR Order

In order to advance cointegration test, before that we need to identify Vector Auto Correlation (VAR). This is the number of leg will be used in the next step.

Table 3: Var Order

Order	AIC	SBC	P-value
1	1093.6	1066.3	[.026]
0	1063.6	1058.1	[.000]

Note: Leg order has been selected based on highest value of AIC and SBC. According to both leg order is one.

As we can understand from the table, our VAR order is 1.

iii. Cointegration Test

After we have found the VAR order as 1, we are ready to proceed next step. Which is cointegration test. We can explain cointegration through one illustration which is written by Michael P. Murray in one of his article called "A drunk and Her Dog: An Illustration of Cointegration and Error Correction. Suppose you see two drunks wandering around and they no idea about each other. That's why, there is no meaningful relationship in their movements and paths. This example for explaining the no cointegration. On the other hand, imagine a drunk with her dog. This time there's a connection. Again, also in this time their path is unpredictable and random walk (because of the drunk woman). But this time we have dog which will not go far away from his owner to avoid losing her, we can say that, two stay close together. In other words, distance between them is predictable.

Thus, in cointegration test, we are looking for answers of these questions; are there any variables which are moving together? If the answer is yes, how many?

We applied two methods to test cointegration. First one is Engle-Granger (E-G) Cointegration Test. E-G answers the first question which is the existence of cointegration. But unfortunately, it is not answering the second question. As a result, according E-G we have one cointegration.

Table 4: Engle & Granger Cointegration Test

	T-statistics	C.V.	Result
ADF(1)	-4.9658	-4.1926	There is cointegration

Note: Null: Residual are Non-Stationary. Alternative: Residual are Stationary

In order to learn number of cointegrations we are going to test our variables using Johansen Cointegration Test. There are two main sub tables under the Johansen Cointegration Test. First one is Maximal Eigenvalue, second one is Trace.

Table 5: Johansen Cointegration Test

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix				
Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r=0	r=1	42.2384	31.7900	29.1300
r<=1	r=2	18.2587	25.4200	23.1000

Cointegration LR Test Based on Trace of the Stochastic Matrix				
Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r=0	r>=1	72.4463	63.0000	59.1600
r<=1	r>=2	30.208	42.3400	39.3400

Note: The statistics refer to Johansen's log-likelihood maximal eigen value and trace test statistics based on cointegration with unrestricted intercepts and restricted trends in the VAR. From the above results, we select one cointegrating vector based on the eigen value and trace statistics at 95% level. The underlying VAR model is of order 1 and is computed using 1304 daily observations

Both sub tests should indicate the presence of the cointegration, otherwise we would accept the null hypothesis which there is no cointegration. Based on the tests above, there is one cointegration which means all the variables reach the equilibrium in the long-run.

iv. *Long Run Structural Modelling (LRSM)*

In this phase of our study, we try to quantify theoretical relationship among other variables. Cointegration that we find in the previous step indicates the long-run relationship among the variables. But it may not include the theoretically relevant coefficients. Using LRSM can help us to identify theoretical relationship through imposing exact identifying and over identifying restrictions on the cointegrating vector.

Table 6: Exact and Over Identifying Restriction of Cointegrating Vector

Variable	Exact Identification	Over Identification
LEX	1 (*NONE*)	1 (*NONE*)
LOI	0.28405 (-0.29793)	0.26629 (-0.024826)
LCP	1.01120 (-0.94576)	0.00000 (*NONE*)
LPP	-1.86330 (-0.475)	-1.51720 (-0.35275)
Trend	-0.00312 (-0.0046006)	0.00130 (-0.0020879)
CHSQ(1)	None	1.1417 [0.285]

Note: Numbers in Parenthesis are Standard Error and numbers in Bracket are P-values. The above output shows the maximum likelihood estimates subject to exactly identifying (Panel A) and over-identifying (Panel B, C & D) restrictions. The 'Panel A' estimates show that all the variables are significant except stock market of Brazil and India (SE are in parenthesis). However, the over-identifying restrictions is accepted (P-value > 5%).

In order to estimate therotically meaningful long-run coefficients, we impose exactly identifying restriction A1=1 on variable LEX and one over identifying restriction A3=0 on LCP.

After imposing exactly identifying restriction on LEX (A1=1) and imposing over identification on LCP (A3=0), we find that all variables are significant. Also when we checked the p-value of the over identification, it shows that our restriction is correct.

v. Vector Error Correction Modeling (VECM)

Cointegration, however, cannot tell us the lead-lag relationship amongst the variables in particular which variable is leading and which variable is following. To see which variable endogenous and which variable exogenous, vector error correction modelling technic was applied.

Table 7: Error Correction Models

ecm1(-1)	Coefficient	Standard Error	T-Ratio [Prob.]	C.V.	Result
LEX	-0.20025	0.074897	-2.6736[.009]	5%	Endogenous
LOI	-0.50328	0.19486	-2.5828[.011]	5%	Endogenous
LCP	0.024906	0.015425	1.6147[.109]	5%	Exogenous
LPP	0.054996	0.020376	2.6991[.008]	5%	Endogenous

Note: Numbers in Bracket are P-values. Here null hypothesis, variable is exogenous and alternative hypothesis, variable is endogenous. We reject null if p-value of test statistic is less than 5%

Observing the significance of error correction coefficients, consumer price turn out to be only exogenous variable. Apart from that, exchange rate, oil prices and producer price seems endogenous. The coefficient of the error correction term indicates the speed of short term adjustment to bring about long term equilibrium. The error correction model has another feature that differentiate between short-run and long-run Granger causality. The error correction model represents for the long-run relationship amongst the variables.

vi. Variance Decomposition (VDC)

From the VECM, we took the result that consumer price is exogenous and other variables are endogenous. However, we have not been able to say anything about the relative endogeneity and exogeneity of the variables. As the VECM is not able to assist us in this regard, we employed variance decomposition (VDC) in order to determine relative endogeneity or exogeneity of the variables in the cointegrating relationship. VDC decomposes the variance of forecast error of each variable into proportions attributable to shocks from each variable in the system, including its own. The least endogenous variable is thus the variable whose variation is explained mostly by its own past variations.

We have two methods to measure relative exogeneity and endogeneity, one of them is orthogonalized VDC other one is generalized VDC. The difference between orthogonalized and generalized variance decomposition is that in orthogonalized, the first variable that we put will probably be the most exogenous variable, because the order of variable influence the result. That is the limitation of this method. Yet in generalized that assumption relaxed which order of variable does not influence the result. The second difference when one variable is shocked in orthogonalized, other variables are switched off, however, in generalized when one variable shock, others are allowed to change. They claim that the result is mainly due to the shock not because of another variable. Third difference, orthogonalized VDC is taking variables with the restrictions applied version from LRSM. In other words, orthogonalized VDC takes theoretical underpinnings into consideration. However, for generalized VDC this consideration is not taken into account. That's why I believe that generalized VDC is more objective than orthogonalized version.

Table 8: Orthogonalized VDC

Horizon 15		LEX	LOI	LCP	LPP	Total	Rank
	LEX	87.79%	8.02%	0.66%	3.54%	100.00%	1
	LOI	26.76%	70.91%	0.37%	1.96%	100.00%	3
	LCP	8.02%	5.35%	85.98%	0.65%	100.00%	2
	LPP	24.17%	36.83%	6.12%	32.88%	100.00%	4

Horizon 30		LEX	LOI	LCP	LPP	Total	Rank
	LEX	85.37%	9.60%	0.79%	4.24%	100.00%	1
	LOI	29.31%	68.07%	0.41%	2.21%	100.00%	3
	LCP	8.73%	5.72%	84.83%	0.72%	100.00%	2
	LPP	25.65%	37.64%	5.76%	30.95%	100.00%	4

Horizon 45		LEX	LOI	LCP	LPP	Total	Rank
	LEX	84.45%	10.20%	0.84%	4.50%	100.00%	1
	LOI	30.20%	67.07%	0.43%	2.30%	100.00%	3
	LCP	8.97%	5.84%	84.43%	0.75%	100.00%	2
	LPP	26.15%	37.91%	5.64%	30.30%	100.00%	4

Horizon 60		LEX	LOI	LCP	LPP	Total	Rank
	LEX	83.97%	10.52%	0.86%	4.64%	100.00%	2
	LOI	30.66%	66.57%	0.44%	2.34%	100.00%	3
	LCP	9.10%	5.90%	84.23%	0.76%	100.00%	1

LPP	26.40%	38.05%	5.58%	29.97%	100.00%	4

Because of the reasons that I explained in the previous paragraph, I will skip this step to next one.

Table 9: Generalized VDC

		LEX	LOI	LCP	LPP	Total	Rank
Horizon 15	LEX	77.53%	16.00%	1.45%	5.03%	100.00%	1
	LOI	20.75%	64.74%	0.93%	13.59%	100.00%	3
	LCP	6.52%	2.66%	76.29%	14.53%	100.00%	2
	LPP	16.18%	17.85%	8.57%	57.40%	100.00%	4

		LEX	LOI	LCP	LPP	Total	Rank
Horizon 30	LEX	75.19%	18.17%	1.55%	5.09%	100.00%	2
	LOI	22.70%	63.03%	0.93%	13.34%	100.00%	3
	LCP	7.09%	2.82%	75.55%	14.55%	100.00%	1
	LPP	17.15%	18.10%	8.34%	56.41%	100.00%	4

		LEX	LOI	LCP	LPP	Total	Rank
Horizon 45	LEX	74.30%	18.99%	1.59%	5.12%	100.00%	2
	LOI	23.38%	62.44%	0.93%	13.25%	100.00%	3
	LCP	7.28%	2.87%	75.30%	14.55%	100.00%	1
	LPP	17.48%	18.18%	8.27%	56.07%	100.00%	4

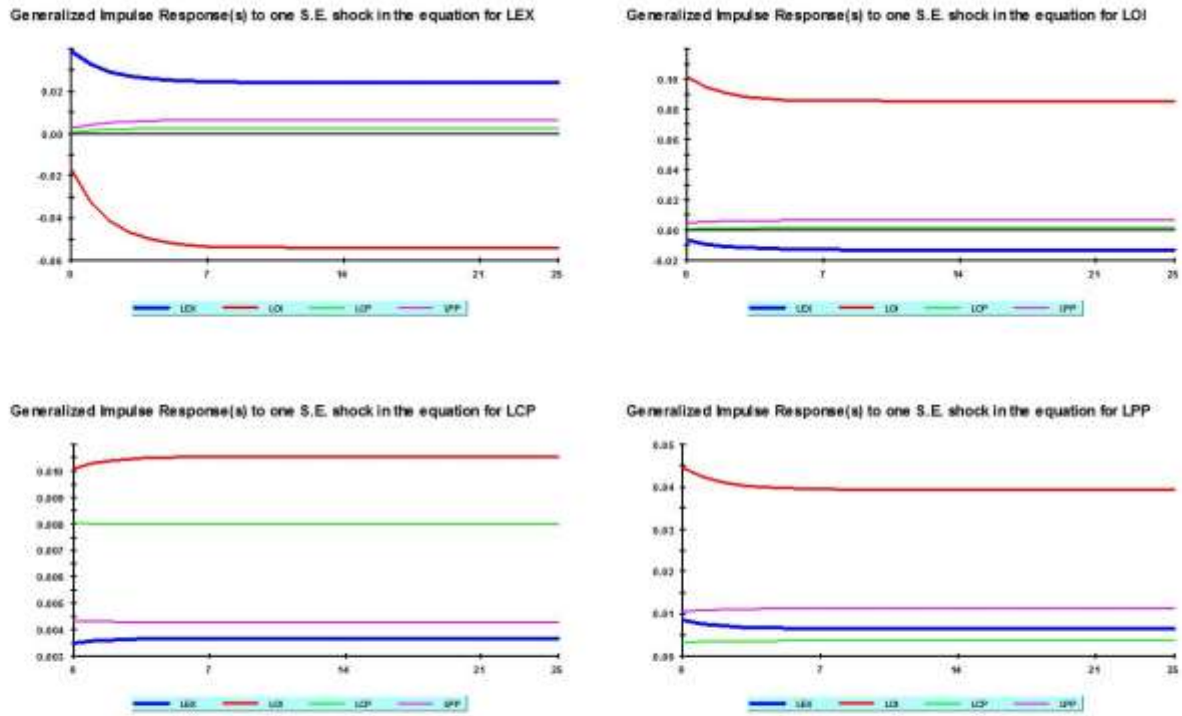
		LEX	LOI	LCP	LPP	Total	Rank
Horizon 60	LEX	73.84%	19.42%	1.61%	5.13%	100.00%	2
	LOI	23.72%	62.13%	0.94%	13.21%	100.00%	3
	LCP	7.38%	2.90%	75.17%	14.55%	100.00%	1
	LPP	17.64%	18.22%	8.23%	55.91%	100.00%	4

The generalized variance decomposition analysis shows that, in the horizon number 15, the contribution of owns shock towards explaining the forecast of error variance of each variable are as follows: exchange rate (78%), oil prices (65%), consumer price (76%) and producer price (57%). The variable that is explained by its own past will be the most exogenous variable. In this case exchange rate looks the most leading but when we check other chosen horizons exchange rate becomes second in the ranking. Other three horizons 30,45 and 60 respectively, show that consumer price is the most leading variable which is consistent with our VECM. Also, consistent with the international finance theory. PPP states that change in the inflation effects exchange rate at the same percentage but negatively. In other words, percentage increase (decrease) in the inflation cause exact percentage depreciation (appreciation) in the exchange rate. Exchange rate effects the oil prices because Turkey is oil dependent country, automatically oil prices change in line with exchange rate. Change in the oil prices effects production price because oil is one of the most important production factors.

vii. Impulse Response Function (IFR)

The impulse response functions (IRFs) essentially produce the same information as the VDCs, except that they can be presented in graphical form. Here we have included the generalized impulse response to one SE shock in the equations.

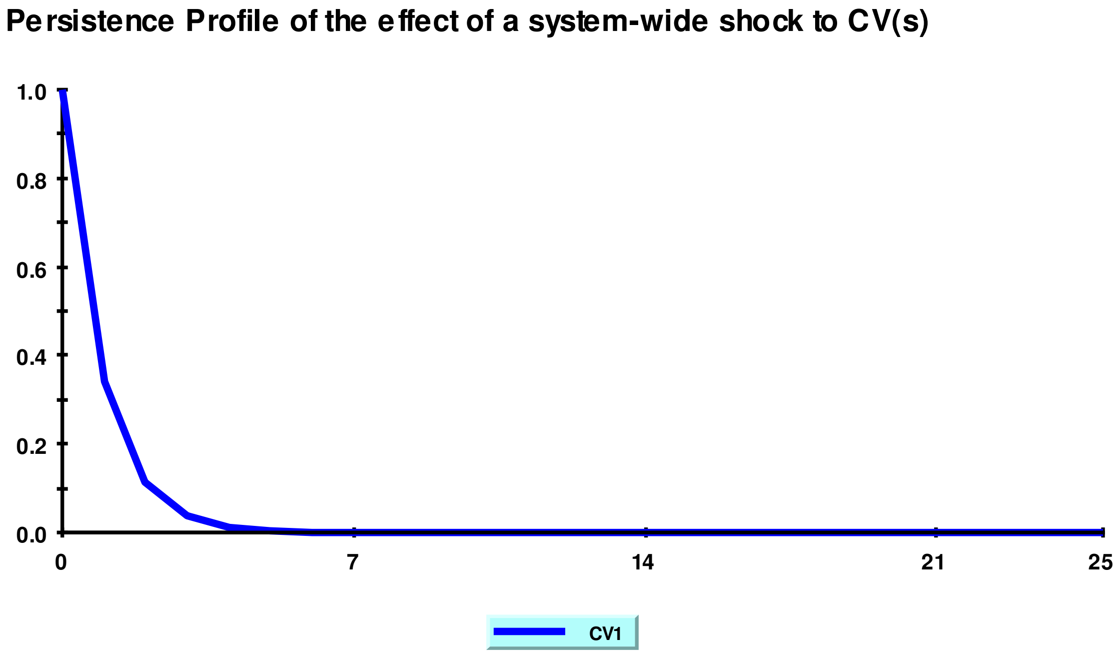
Figure 1: Generalized Impulse Response



viii. Persistence Profile (PP)

The persistence profile illustrates the situation when the entire cointegrating equation is shocked, and indicates the time it would take for the relationship to get back to equilibrium. Here the effect of a system-wide shock on the long-run relations is the focus (instead of variable-specific shocks as in the case of IRFs). The chart below shows the persistence profile for the cointegrating equation of this study.

Figure 2: Persistence Profile



The chart indicates that it would take approximately 5 months for the cointegrating relationship to return to equilibrium following a system-wide shock.

5. CONCLUSION

This study attempts to explore the lead lag relationship between oil prices, exchange rate, consumer price index and producer price index in Turkey as oil importing country. We employed time-series technics such as Johansen cointegration test, vector error correction model (VECM) and variance decompositions (VDC) including LRSM which is the improvements and contributions to standard cointegration technics. VECM and VDC results suggest that consumer price index is the only exogeneous variable and it is taking the lead in the long run. In this study, causality relationship from exogenous to endogenous as follows; CPI, exchange rate, oil price and producer price index. The underlying reason could be explained from the general economic perspective. Our findings are in line with the Purchasing Power Parity (PPP), which explains exact negative relationship between inflation (CPI in this case) and exchange rate. Increasing exchange rates automatically effects oil prices positively. Because Turkey is oil importing country and oil prices increase parallel with the purchasing power of the exchange rate. Oil prices effects factors of production and producer prices increase.

The policy implication can be derived from this study is that TCMB (Central Bank of Turkey) should pursue its inflation targeting. In this model inflation is exogenous among other variables, but in reality, it is relatively controllable by the TCMB. With controlling inflation, central bank can control exchange rate, oil prices and producer prices as well.

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