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Dynamic Relationships between Oil Price, Inflation and Economic Growth: A VARMA, GARCH-in-mean, asymmetric BEKK Model for Turkey

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Abstract

In this research, we examine the relationships among economic growth, inflation, and oil prices using monthly data from the period 1990 to 2017 for Turkey. To reveal the relations we use multivariate VARMA, GARCH-in-Mean, asymmetric BEKK model. We present evidence that oil price uncertainty increases economic growth uncertainty and inflation uncertainty. Moreover, decreased average economic growth is involved with high inflation and oil price uncertainty. We also find that economic growth uncertainty is influenced by mostly inflation uncertainty instead of its own. In addition, we show that the Holland hypothesis is valid for Turkey.

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1. Introduction

The price movements of oil, one of the most important energy sources, play a key role in accelerating or slowing the economic growth of countries. Due to this importance, oil and macroeconomic relations have been widely discussed in the literature (Hamilton, 1996; Hooker, 1996; Hamilton and Herrera, 2004; Killian and Vigfusson, 2011a; Killian and Vigfusson, 2011b). Elder and Sertelis (2010) stated that the increase in oil prices could have a variety of effects on the economy. The first of these is that high oil prices directly increase the general level of prices and thus disrupt the real money balances of consumers and firms, which in turn decreases total demand. Secondly, oil prices increase through the transfer of revenue from the oil importing country to the exporting country. On a company basis, estimating the uncertainty (volatility) in oil prices is equally important because the expectations of decision-makers are shaped by these estimates. As the uncertainty of oil price increases, companies delay their investments and change their terms of trade.

Volatility in oil prices seems to have dragged both importer and exporter countries into economic difficulties as it has a significant effect on macro variables that cause high inflation (Salisu et. al, 2017; Balcilar, Uwilingiye and Gupta, 2018), stagnation, low growth rates, unstable interest rates, current account deficits (Yalta and Yalta, 2017), high production costs, and unemployment (Hamilton, 1983; Carruth et. al, 1998; Kandemir Kocaaslan (2019)). Another important factor to be emphasized is the relationship dependency between petroleum and taxes. For instance, Turkey obtained 2.93 Turkish lira per liter of gasoline in tax income (EMRA, 2016). If the country is an importer of oil, volatility in oil prices affects macro indicators. Moreover, if oil prices are an important item in government budgets, volatility in oil prices is a determining factor in budget deficits (Narayan and Narayan, 2007). Table 1 provides a review of previous studies about oil price volatility.

In Turkey, as a developing country, fluctuations in oil prices affect the investment decisions of companies, especially within the industry. Since 2009, crude oil imports have continued on a positive trend in Turkey. Crude oil imports, which were 14 million tons (about 333 million barrels) in 2009, reached 25.7 million tons (about 610 million barrels) in 2017 (TUIK, 2018). Between the years 2009-2017, the constant fluctuations in oil prices had an effect on Turkey's economic growth. Thus, crude oil prices were \$60 dollars in 2009, while it was \$77 in 2010 and \$52 in 2017 (Statista, 2018). From 2009 to mid-2014, industrial production index growth was downward. On the other hand, energy prices in Turkey showed an increase of 30% compared to December of the previous year in October 2008. Energy prices, which fell sharply after this month, decreased by 3.04% in January 2015. After this month, there was a certain upward trend and prices increased by 21.34% in August 2018 (TUIK, 2018). Although these increases in oil prices are not remarkable, the excessive volatility in exchange rates is noteworthy as a result of increases in energy prices. The rise in energy prices is primarily reflected in producer prices and then extends from the industrial sector to the agricultural sector.

In this paper, the dynamic interactions among producer price index (PPI), economic growth, and oil prices were examined through a VARMA-GARCH approach for a medium-sized developing country like Turkey, using data from January 1990 to 2017. This study contributes to the literature in several ways. Firstly, using the VARMA, GARCH-in-mean, asymmetric BEKK Model allows for both first-moment and second-moment analysis (variance) as it is possible to examine how the dependent variable in the mean equations is affected by the level and volatility values among the independent variables. In addition, with the variance equation (inflation, economic growth, and return on crude oil prices) volatility, short-term and long-term shocks, and the asymmetric effects of these shocks can be obtained. Thus, both the average effect of oil prices on economic growth and producer price increases can be seen, as well as the effect of uncertainties in oil prices on average and variance. For policymakers and researchers, these results would be able to show the effects of the uncertainty increases in oil prices on i) decreases in industrial production and ii) increases in producer prices. Furthermore, the contribution of uncertainty in oil price uncertainty (positive or negative) can be seen in iii) direct industrial production and iv) uncertainty in producer prices. Second, most studies in the literature examining the relationship between inflation and economic growth for Turkey deal with first-moments analysis. Also, Aydın and Acar (2011) and Oksuzler and Ipek (2011) examined the effect of crude oil prices on economic growth and inflation for Turkey. These studies investigated the dynamic relations between oil price, economic growth, and inflation using first-moment analysis (mean). In this study, inflation is also included because of its effects on economic growth as seen through the Keynesian perspective. As mentioned above, it is essential to address the uncertainty in oil prices for a country that imports 25 million tons (nearly 610 million barrels) of crude oil. Even with this aspect, it is thought that this study will greatly contribute to the literature. Finally, testing the hypotheses of both Cukierman-Meltzer, increasing inflation uncertainty affects inflation positively, and Holland, rising inflation uncertainty has a negative effect on inflation, makes the study even richer.

The remainder of the paper is organized as follows: Section 2 provides the model and the econometric methodology. The results are discussed in Section 3. Finally, Section 4 provides some concluding comments.

Table 1. Literature Review

Author/ Date	Countr(ies)y	Methodology	Result(s)
Alao and Payaslioglu (2021)	Oil exporting Countries	GARCH	The study revealed that dynamic linkages between oil prices and industrial production persistently co-move.
Sun and et. al (2021)	Malaysia	CGE	Oil prices changes affect the economic performance of Malaysia between -5.22% and 3.00% with a 90% probability.
Koirala and Ma (2020)	USA	GARCH	Oil price uncertainty affects negatively U.S employment. For the sectoral base, oil price uncertainty affects mostly the iron sector.
Maheu et. al (2020)	USA	GARCH	This paper shows that oil shocks affect real growth on the conditional variance
Maghyereh et. al (2019)	Turkey and Jordan	SVAR-GARCH-M	Increasing in oil price uncertainty decreased 0.81 and 1.01% in the industrial production of Jordan and Turkey, respectively.
Elder (2019)	USA	SVAR-GARCH-M	It has been determined that the uncertainty in oil prices affects economic activity negatively.
Thiem (2018)	USA	SVAR-GARCH-M	In the average equation, it is determined that shocks in oil prices reduce the increase in industrial production by 0.004%, while in the variance equation, the volatility in oil prices increases the uncertainty in industrial production.
JO (2014)	Global economic activity	Time-Varying Volatility -VAR	It has been claimed that uncertainty in oil prices will have negative consequences on global economic activity.
Pinno and Serletis (2013)	USA	GARCH-M-BEKK	As a result of the findings, it has been determined that the volatility in oil prices reduces the growth in industrial production by 2.90% per month.
Yoon and Ratti (2011)	USA	GMM-IV	The key result is that rising energy market volatility influences firm-level investment decisions by reducing the growth on investment.
Wadud, and Ali Ahmed (2013)	Canada	SVAR	It has been determined that uncertainties in oil prices cause a decrease in production in sectors such as total manufacturing industry, durable and non-durable goods manufacturing,

			mining, construction and retail sales, as well as total industrial production.
Kilian and Vigfusson (2011a, 2011b)	USA	VAR	It has been determined that energy price shocks reduce economic activity.
Bhat et. al (2018)	India	SVAR	It was determined that the increases in oil prices decreased the industrial production in the first two months, became stagnant in the third month and the impact of the shock ended within six months.
Elder (2018)	USA	SVAR-GARCH-M	As a result of the empirical findings, it was determined that the volatility in the oil price in 1980: 1-2009: 12 period decreased industrial production by 0.048% and manufacturing industry production by 0.050%.
Elder and Serletis (2010)	USA	SVAR-GARCH-M	According to the findings obtained from the empirical analysis, it has been determined that the volatility in oil prices affects the domestic product level negatively (-0.022) and statistically significant.

Note*: SVAR: Structural Vector Autoregressive Regression, GARCH-M: Generalized Autoregressive Conditional Heteroskedasticity-Mean, GMM-IV: Generalized Method of Moments-Instrumental Variables, CGE: Computable General Equilibrium*

2. Methodology and Data

2.1. The VARMA, GARCH-M, and asymmetric BEKK Model

In recent years, especially due to rational expectations and sticky prices, positive and negative changes in variables create different effects. For example, increases in oil prices are reflected in producer prices within a few months, while price decreases take much longer to be reflected. It can be argued that the most important reason for this is due to stocking and export agreements between firms. Therefore, it was preferred to use an asymmetric econometric method in this study. In this research, the ideas of Grier et. al (2004), Rahman and Sertelis (2012), and Ndoricimpa (2014) were followed to capture the effects of inflation and oil price uncertainty using an asymmetric VARMA GARCH-M BEKK model. The mean equation for volatility relations can be written as follows:

$$R_t = \mu + \sum_{i=1}^{f} \Gamma_i R_{t-i} + \Psi\sqrt{h_t} + \sum_{j=1}^{g} \Theta_i \varepsilon_{t-j} + \varepsilon_t$$

$$\varepsilon_t \sim (0, H_t) \ \ and \ \ H = \begin{pmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{pmatrix} \qquad (1)$$

$$R_t = \begin{bmatrix} R_{1,t} \\ R_{2,t} \\ R_{3,t} \end{bmatrix}; \ \varepsilon_t = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{2,t} \end{bmatrix}; \ \sqrt{h_t} = \begin{bmatrix} \sqrt{h_{11,t}} \\ \sqrt{h_{22,t}} \\ \sqrt{h_{33,t}} \end{bmatrix}; \ \mu_t = \begin{bmatrix} \mu_{1,t} \\ \mu_{2,t} \\ \mu_{3,t} \end{bmatrix};$$

$$\Gamma_i = \begin{pmatrix} \Gamma^{(i)}{}_{11} & \Gamma^{(i)}{}_{12} & \Gamma^{(i)}{}_{13} \\ \Gamma^{(i)}{}_{21} & \Gamma^{(i)}{}_{22} & \Gamma^{(i)}{}_{23} \\ \Gamma^{(i)}{}_{31} & \Gamma^{(i)}{}_{32} & \Gamma^{(i)}{}_{33} \end{pmatrix}; \Psi = \begin{pmatrix} \Psi_{11} & \Psi_{12} & \Psi_{13} \\ \Psi_{21} & \Psi_{22} & \Psi_{23} \\ \Psi_{31} & \Psi_{32} & \Psi_{33} \end{pmatrix} and \ \ \Theta_i = \begin{pmatrix} \Theta^{(i)}{}_{11} & \Theta^{(i)}{}_{12} & \Theta^{(i)}{}_{13} \\ \Theta^{(i)}{}_{21} & \Theta^{(i)}{}_{22} & \Theta^{(i)}{}_{23} \\ \Theta^{(i)}{}_{31} & \Theta^{(i)}{}_{32} & \Theta^{(i)}{}_{33} \end{pmatrix}$$

Each variable is computed as $\mathrm{Rt}_{\mathrm{i,t+1}} = 100 * \ln\left(\frac{\mathrm{P}_{\mathrm{i,t+1}}}{\mathrm{P}_{\mathrm{i,t}}}\right)$, where P states industrial production index, producer price index, and oil price. When the variable is computed as Rt, these become industrial production growth (economic growth), inflation, and oil price return. R represents the 3x1 matrix of economic growth, inflation, and oil price return in the mean equations. Γ indicates the effects of one period lagged variables on the dependent variable, $\sqrt{h_t}$ indicates the volatility parameter in the mean equation, and Θ indicates the moving average parameter. Equation (2) shows the variance equation of the asymmetric BEKK-GARCH (1,1) model introduced by Grier et al. (2004).

$$H_t = C'C + \sum_{j=1}^{p} B_j' H_{t-j} B_j + \sum_{k=1}^{q} A_k' \varepsilon_{t-k} \varepsilon_{t-k}' A_j + D' \xi_{t-1} \xi_{t-1}' D \qquad (2)$$

Equation (2) shows H, the 3x3 conditional variance-covariance matrix; C, the 3x3 upper triangular constant coefficient matrix; and A and B, 3x3 matrices, including short-term shocks and long-term fluctuation parameters. $\zeta_t = (\xi_{t-1} \xi_{t-1}')$ is added to the variance equation to consider asymmetric effects. Rahman and Sertelis (2012) stated that the effects of asymmetric parameters may vary by region. For example, in Canada, increasing oil prices would be considered a positive economic indicator. However, this is not the case for Turkey, where rising oil prices may create unfavorable conditions in terms of both growth and inflation because of "oilism[1]".

The VARMA GARCH-M BEKK model is estimated using the quasi-maximum likelihood (QML) method by assuming the conditional distribution of a joint Gaussian log-likelihood function with t-distribution. Then, the log-likelihood function with t-distribution takes the following form:

$$L_t = \ln\left[\frac{\Gamma\left(\frac{v+n}{2}\right)v^{\frac{n}{2}}}{(vn)^{\frac{n}{2}}\Gamma\left(\frac{v}{2}\right)(v-n)^{\frac{n}{2}}}\right] - \frac{1}{2}\ln\left|H_t\right| - \frac{1}{2}(v+n)\ln\left(1+\frac{\varepsilon_t' H_t^{-1}\varepsilon_t}{v-2}\right) \quad (3)$$

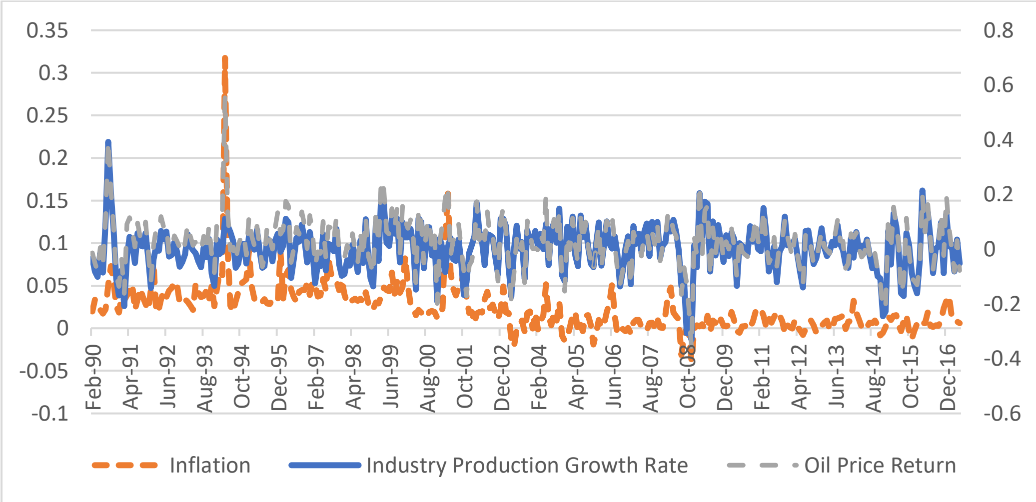
Here n represents R_t series in the mean equation, ε_t is the residuals obtained from the mean, equation, v is the degree of freedom and $\Gamma(.)$ is the gamma function. The BFGS algorithm was used to determine parameters by maximizing equation (3). As well, all estimates were performed under RATS 9.1. Possible biased standard errors have been corrected using the robust standard errors.

2.2. Data

In this study, the volatility relationships among economic growth, inflation, and oil prices were examined using monthly data from the period 1990 to 2017. As the previous studies regarding the effects of oil price volatility in Turkey were examined, it was observed that various indicators were used instead of economic growth in many studies. For example, Chontanawat et. al (2006), and Soytas and Sari (2006) used GDP per capita for economic growth, whereas Sari et. al (2008), and Thoma (2004) employed the industrial production index instead of economic growth. Moreover, Senyüz (2002), Altug et. al (2012), and Senyüz et. al (2014) used the industrial production index for Turkey as an indicator of economic growth. Following the abovementioned studies, the industrial production index was used instead of economic growth in the present study. On the other hand, the producer price index for was utilized for price level because oil price and industrial production are connected with producer price directly. The industrial production index and inflation series were taken from the Central Bank of the Republic of Turkey (CBRT), and oil prices were taken from the International Energy Agency (IEA). WTI spot prices for oil prices were evaluated by multiplying by the exchange rate. When oil price and exchange rate are multiplied, exchange rate effects on economic growth and inflation can also be seen. Figure 1 depicts the time-varying conditions of the series.

Figure 1. Inflation, Oil Price Return and Industry Production Growth

[1] "ism" a suffix coming from Greek, stating that a distinctive practice, system, or philosophy, typically a political ideology or an artistic movement. (www.dictionary.com)



From Figure 1, it is understood that inflation and oil prices have the same pattern over time. This is not surprising given that Turkey is considered to be an oil-dependent country. For example, in 2016, Turkish crude oil imports amounted to nearly 25 million tons (about 610 million barrels) (EMRA, 2016). Although this figure decreased by 0.43% compared to the previous year, the weight of oil-import is still quite high in foreign trade. On the other hand, as the exchange rate increases oil prices increase. In this context, the increase in oil prices increases the cost of industrial production; yet, it is affected by domestic inflation. Table 2 presents the descriptive statistics obtained by taking the logarithmic first differences of the series.

Table 2. Descriptive Statistics

Statistics	Egrowth	Inflation	Oilprice
Mean	0.342	2.322	2.465
Std. Dev.	3.48	2.854	9.338
Skewness	0.056	3.949	0.365
Kurtosis	4.256	35.107	4.141
Jarque-Bera	247.731	17697.499	241.780
	(0.000)	(0.000)	(0.000)
Q (12)	110.430	974.320	67.073
	(0.000)	(0.000)	(0.000)
LM-Arch (12)	6.615	0.769	0.546
	(0.000)	(0.682)	(0.883)
ADF	-12.803***	-9.445***	-15.073***
Correlation			
Egrowth	1.000		
Inflation	0.036	1.000	
Oilprice	0.086	0.564	1.000

Note: **, ** and *** are statistically significant at 10%, 5% and 1% respectively. Q is statistics of Ljung-Box for the null hypothesis of no autocorrelation for a series. The LM-statistic tests a set of series for multivariate ARCH effects.*

According to Table 2, the average values for economic growth, inflation, and oil price are 0.34, 2.32, and 2.46, respectively. Moreover, oil price has the highest standard deviation. The skewness values of the series reflect that the coming probability of positive values is higher than the negative values. The value of the criterion indicates a fat-tail distribution in the series. In the Jarque-Bera statistic obtained from the skewness and kurtosis values, the null hypothesis is rejected, and the series is not normally distributed. The autocorrelation and ARCH effects of the series were tested by Ljung and Box (1979) using the Q statistic and by Engle (1982) using the LM test. As a result of their findings, a serial autocorrelation was found in the series, and the other series (except economic growth) were found to have an ARCH effect. The stationary situation of the series was tested using the unit root test proposed by Dickey and Fuller (1979), and no unit roots were found in the series.

3. Results and Discussion

Using equations (1) and (2), the mean and variance equations among economic growth, inflation, and oil prices were obtained by the quasi-maximum likelihood method. On the one hand, Hwang and Valls Pereira (2006) claimed that robust standard errors should be used for samples with a small frequency in the prediction of GARCH models. This study includes 327 observations in which robust standard error values are used. At the same time, using the Student's t-distribution proposed by Bollerslev (1987), the prediction values were tested to be made more resistant. Schwartz Information Criteria were used to select the optimal lag length. According to the Schwartz Information Criteria, optimal lag length for the mean equation is one, namely $f = g = 1$. Moreover, one lag length was used for the ARCH and GARCH models ($p = q = 1$). Hansen and Lunde (2005) suggested that GARCH (1,1) models have exposed good forecast performances in comparison with another GARCH model. Table 3 shows the diagnostic test results of the standardized error terms from the VARMA GARCH-M BEKK.

Table 3. VARMA, GARCH-in-Mean, Asymmetric BEKK model

Estimate	Egrowth	Inflation	Oilprice
Conditional mean equation			
Constant (μ)	-0.068	-0.307***	-2.364***
	(-1.114)	(-22.949)	(-62.643)
Γ_{i1}	-0.053	0.007	-0.242***
	(-1.367)	(0.497)	(-5.100)
Γ_{i2}	0.024	1.054***	0.350***
	(1.283)	(226.035)	(26.029)
Γ_{i3}	-0.042***	-0.175***	0.405***
	(-4.222)	(-60.218)	(42.445)
ψ_{i1}	0.409***	0.296***	-0.240***
	(20.379)	(69.749)	(-20.621)
ψ_{i2}	-0.235***	-1.143***	-2.131***
	(-6.017)	(-125.011)	(-84.238)
ψ_{i3}	-0.028***	0.119***	0.651***
	(-4.821)	(91.617)	(184.822)
Θ_{i1}	-0.361***	0.027*	0.168***
	(-9.258)	(1.827)	(4.067)
Θ_{i2}	-0.211***	-0.417***	0.757***
	(-3.949)	(-16.955)	(11.278)
Θ_{i3}	0.069***	0.205***	-0.321***
	(6.161)	(49.782)	(-25.089)
Conditional variance equation			
c_{1i}	1.440***		
	(22.007)		
c_{2i}	0.573***	0.897***	
	(13.408)	(23.438)	
c_{3i}	4.294***	1.458***	3.678***
	(23.096)	(5.233)	(11.816)
a_{1i}	0.152***	-0.012	-0.449***
	(3.795)	(-0.590)	(-3.636)
a_{2i}	-0.334***	0.555	-0.069
	(-3.322)	(15.087)	(-0.533)
a_{3i}	0.085***	0.023***	0.350***
	(4.600)	(3.921)	(9.956)
b_{1i}	0.459***	0.018	0.539***
	(26.162)	(0.668)	(6.052)

b_{2i}	0.571***	0.334***	-0.793***
	(6.399)	(10.812)	(-3.867)
b_{3i}	-0.199***	0.019***	0.642***
	(-65.224)	(7.571)	(32.026)
d_{1i}	0.530***	-0.027	0.232*
	(12.982)	(-0.758)	(1.810)
d_{2i}	-0.444**	-0.085	3.570***
	(-2.166)	(-1.014)	(8.794)
d_{3i}	0.101***	0.007	0.537***
	(3.615)	(0.777)	(12.339)
Diagnostic tests			
Q(6)	20.785	3.486	12.767
	(0.002)	(0.745)	(0.046)
Q(12)	31.068	5.775	16.829
	(0.001)	(0.927)	(0.156)
Q^2(6)	10.111	0.077	1.262
	(0.120)	(0.999)	(0.973)
Q^2(12)	12.641	0.508	2.546
	(0.395)	(1.000)	(0.997)
MV Q-statistic (6)	54.545 (0.453)		
MV Q-statistic (12)	114.083 (0.325)		
MV Q^2-statistic (6)	34.073 (0.984)		
MV Q^2-statistic (12)	127.494 (0.097)		
LM test on std. residuals(6)	297.71 (0.000)		
LM test on std. residuals(12)	795.14 (0.000)		
LM test on std. seq. residuals(6)	470.15 (0.000)		
LM test on std. seq. residuals(12)	1863.81 (0.000)		
Hypotheses testing			
Diagonal VARMA	$H_o : \Gamma_{ij} = \Theta_{ij} = 0$ i,j =1,2,3 and i ≠ j		0.000
No GARCH	$H_o : a_{ij} = b_{ij} = d_{ij} = 0$ i,j =1,2,3		0.000
No GARCH-M	$H_o : \Psi_{ij} = 0$ i,j =1,2,3		0.000
No Asymmetry	$H_o : d_{ij} = 0$ i,j =1,2,3		0.000
Diagonal GARCH	$H_o : a_{ij} = b_{ij} = d_{ij} = 0$ i,j =1,2,3 and i ≠ j		0.000

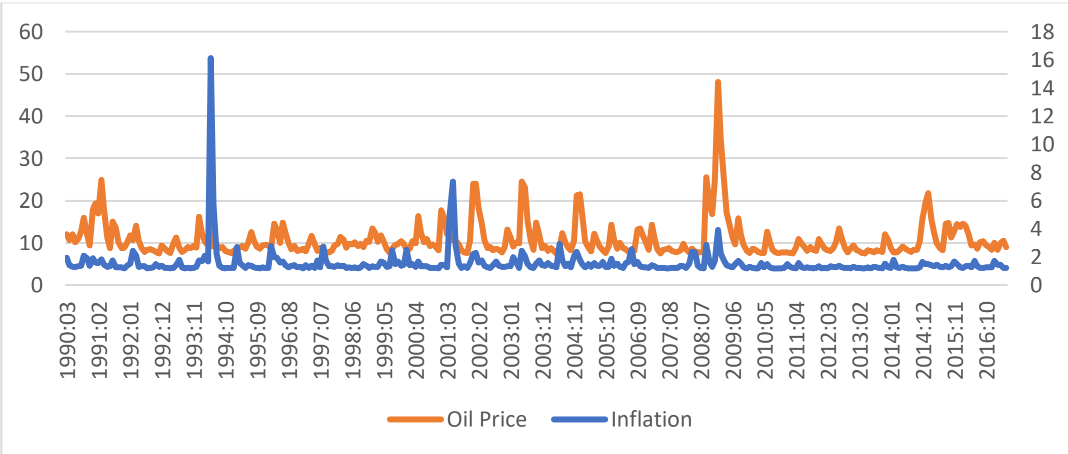
*Note: *, ** and *** are statistically significant at 10%, 5% and 1% respectively. Q and Q^2 are statistics of Ljung-Box for the null hypothesis of no autocorrelation for a series in question on standardized and standardized squared residuals, respectively. MV Q-statistic and MV Q^2-statistic are Hosking's multivariate portmanteau Q-statistics on the standardized and standardized squared residuals, respectively in diagnosing the null hypothesis of no autocorrelation in all series for lag one through specified lags. The LM-statistic tests a set of series for multivariate ARCH effects. Under the null hypothesis that the series is mean zero, not serially correlated with a fixed covariance matrix.*

From Table 3, it is understood that Ljung and Box (1979) Q statistics results for the squares of the standardized error terms and the error terms indicate that there is no serial autocorrelation at 12 lags. The results of Hosking's multivariate portmanteau Q-statistics are also consistent with Ljung and Box (1979) Q statistics. On the other hand, the findings from the LM test show that there is a conditional heteroscedasticity problem in the error terms and the squares of the error terms.

From Table 3, the volatility (uncertainty) in economic growth significantly affects economic growth positively and is statistically significant (0.409). Ndoricimpa (2014) reported similar results for Algeria, Gabon, and Libya. Black (1987) argued that there would be a positive relationship between volatility and economic growth. The reason for this situation is attributable to the positive relationship between risk and return (Caporale and Kierman, 1998).

In recent years, Turkey has attracted a great deal of attention from investors with high growth rates. Turkey's economy in 2017 grew by 7.4%, placing it in the position of the second fastest-growing country among the OECD countries. In addition, several macroeconomic risks (current account deficit, inflation, international investment position; etc.) are negatively owned by Turkey's economy (OECD, 2018). Besides these, Turkey’s geopolitical position increases the country’s financial risk even more. All of this begs the questions of why volatility seems to lead to economic growth. It could be said that Turkey’s young population and high demand for consumption of goods attract risk-taking investors. Thus, foreign direct investment was an average of $2.2 billion per year between 1995 and 20005, and an average of $14.86 billion per year between 2006 and 2017 (YASED, 2018). On the other hand, increases in uncertainty (0.296) that occur in economic growth pressurize producer prices upwards. The decrease and increase in economic growth can be interpreted as dangerous for economies. Policymakers need to be able to close the gap of sustainable growth with other countries. The Central Bank, which controls the price mechanism, calculates predictable inflation rates according to sustainable growth figures and determines the interest rates accordingly. The release of economic growth in response to increases and decreases reduces the ability to control inflation by weakening the decision-making ability of central banks through changes in bond yields. Cecchetti and Krause (2001) implied that Central Banks are focused on reducing the fluctuation of inflation and output around their target levels.

Figure 2. Conditional Standard Deviations



The uncertainty of inflation and oil prices has a negative and statistically significant effect on the economic growth ($\psi_{i2} = -0.235$ and $\psi_{i3} = -0.028$) for inflation and oil prices, respectively) in the mean equation. In Figure 2, the conditional standard deviations of inflation and the price of oil are given. An average shock to inflation (1.527) and oil price (10.677) shrinkage reduces economic growth by 0.358% (0.235x1.527)[2] and 0.298% (0.028x10.677), respectively (see Rahman and Sertelis, 2012). According to real options theory, in cases where uncertainty is high, firms may delay investments due to high costs. The irreversibility of investments will cause a decrease in investments in economic conditions where uncertainty is high. Bernanke (1983) argued that uncertainty would reduce investments because the investment was irreversible. Henry (1974); Bernanke (1983); Brennan and Schwartz (1985); Elder (1995, 2004); Bloom et. al (2007); Elder and Serletis (2010, 2011); Elder (2018, 2019); Kandemir Kocaaslan (2019) empirically found that uncertainty reduces investments in the scope of real options theory. These results are even more meaningful when economic growth (industrial production index) in the last month was -1.49% is considered. Nkomo (2006)

[2] It is estimated as the parameter multiplied by the average conditional standard deviation of the variable.

indicated that oil price shocks affect economic growth through the inflated import for South Africa. Like South Africa, Turkey is also an oil-dependent country. Hasanov (2011) also obtained similar results between the output gap and inflation uncertainty for Turkey. Aydın and Acar (2011) observed that oil price reduces economic growth in the short-term. In the long-run, its effects are limited. Moreover, the results of oil price effects on economic growth are in line with those reported by Rahman and Sertelis (2012). OECD (2018) suggested that increasing oil prices upwardly suppress the current account of Turkey. Here, it can be said that the pressure on the current account deficit causes an increase in the inflation rate. In this way, the increases in oil prices both affect producer prices directly and increase the exchange rate on the current account deficit and pressurize the producer prices by affecting other input prices.

At the same time, inflation is affected negatively and is statistically significant due to its own uncertainty. Holland (1995) claimed that inflation uncertainty negatively affects inflation (Holland hypothesis). As a result, the Holland hypothesis is valid for Turkey. Holland (1995) attributed the negative impact of inflation uncertainty on inflation to the effective monetary policy of the central bank during uncertainty periods. Turkey's inflation rate reached record levels in 1990. After 2006, inflation was reduced to single-digit figures in the context of open inflation targeting policy. When this period was examined in the scope of this study, attention can be drawn to the fact that the validity of the Holland hypothesis in Turkey corresponds to theoretical expectations. Nas and Perry (2000) and Thornton (2007) support the Holland hypothesis for Turkey through the findings they obtained. However, the Cukierman-Meltzer hypothesis, as proposed by Cukierman and Meltzer (1986), is invalid for Turkey.

Figure 3. Conditional Correlations between Economic Growth and Inflation

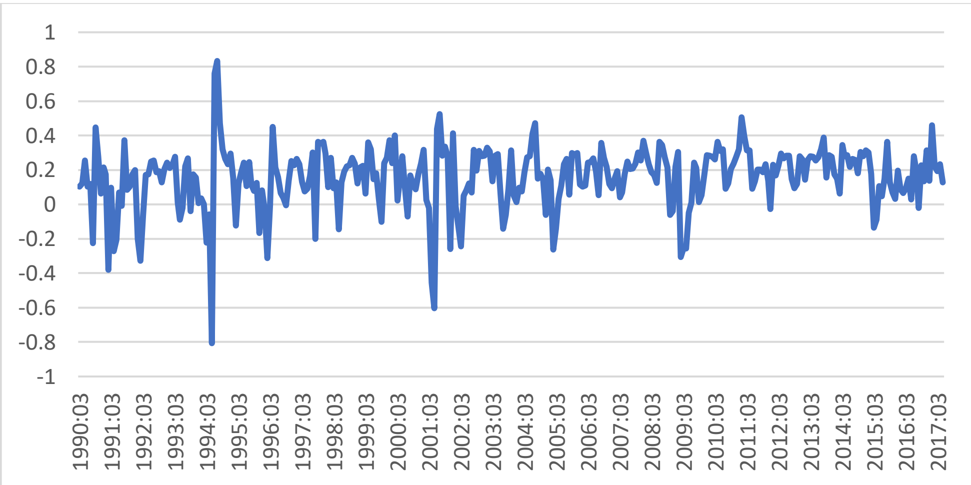
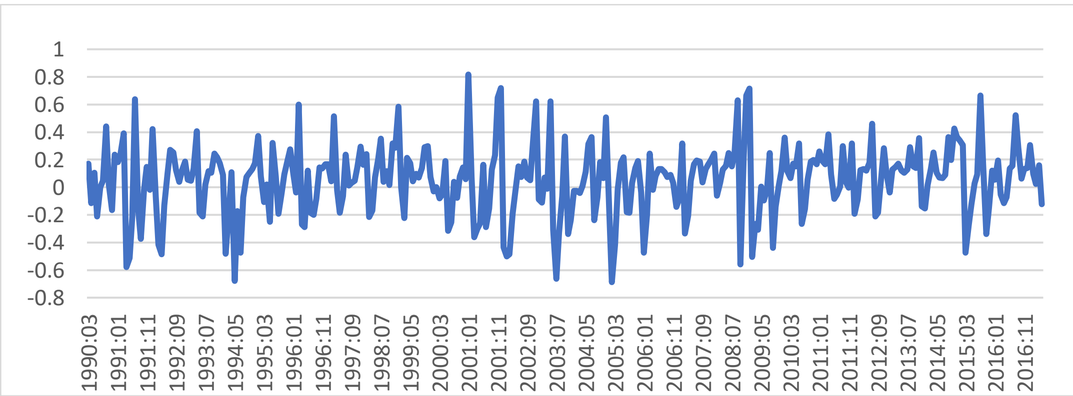


Figure 4. Conditional Correlations between Economic Growth and Oil Price



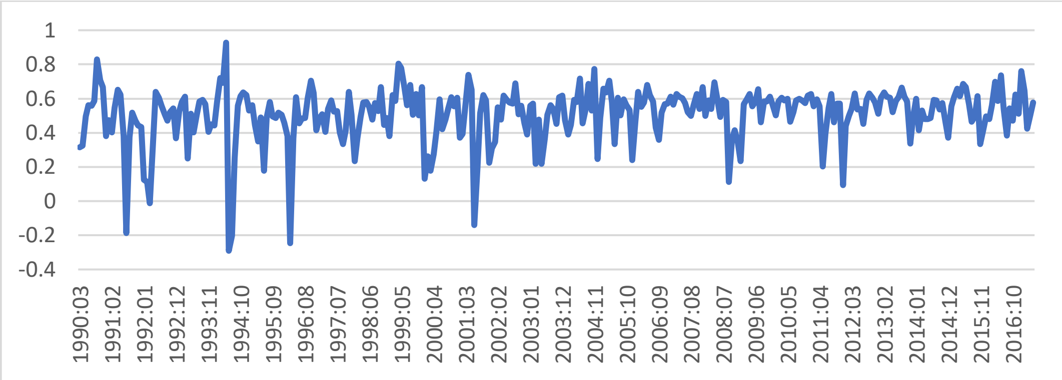
Moreover, oil price volatility has been found to suppress upward inflation. An average shock to oil price (10.677) increases inflation by 1.270% (0.119x10.677). Uncertainty in oil prices increases producer prices due to both the supply channel and the import of energy products. As stated above, volatility in oil prices directly affects producer prices. The price of oil, which is an important input in terms of production, becomes uncertain due to supply and demand shocks. While a positive supply shock will decrease the oil price and affect producer prices with a downward trend, negative shocks increase producer prices. Demand shocks also have similar effects on producer prices. The most important growing oil prices are reflected directly from the entry of Turkey's industrial producer prices. On the other hand, rising producer prices are reflected in consumer prices, causing volatility in real exchange rates. It can be said that the increase in energy prices functions as a type of acceleration mechanism in the market. Alom et al. (2013); Filis and Chatziantoniou (2014); Guerrero-Escobar et al. (2019) have all shown that energy commodity prices have a significant impact on inflation.

Looking at the variance equality in Table 3, the uncertainty of economic growth (volatility) is positively affected by its short-term shocks. In other words, bad news about economic growth will increase the uncertainty of economic growth. Meanwhile, that the conditional variance of economic growth is affected by the conditional variance of inflation rather than its own conditional variance is indicative of how serious the inflation uncertainty problem is in Turkey. Moreover, the conditional variance of oil prices negatively affects the conditional variance of economic growth. Rahman and Sertelis (2012) obtained similar results for Canada.

In Figures 3, 4, and 5, conditional correlations among economic growth, inflation, and oil price volatility have been plotted. The average conditional correlation between economic growth volatility and inflation uncertainty is 0.158 meaning that increasing inflation uncertainty is followed by economic growth uncertainty (or vice versa). On the other hand, the average conditional correlation between economic growth volatility and oil price volatility is 0.05, which is extremely low. However, the average conditional correlation between inflation uncertainty and oil price volatility is 0.508. Thus, it can be said that increasing oil price volatility initially affects inflation uncertainty then economic growth via contagion inflation.

In the last part of Table 3, hypotheses that reveal the dynamic relations between economic growth, inflation, and oil prices were tested using the Wald test. The hypothesis that $H_o : \Gamma_{ij} = \Theta_{ij} = 0 \;\; i,j = 1,2,3$ was rejected at a significant level of 1%. Accordingly, there are dynamic relations between economic growth, inflation, and oil prices. Moreover, the hypothesis that $H_o : a_{ij} = b_{ij} = d_{ij} = 0 \;\; i,j = 1,2,3$ was rejected at a 1% significant level meaning that variance distributions of the variables were not homogeneous. Finally, the rejection of the hypothesis that $H_o : d_{ij} = 0 \;\; i,j = 1,2,3$ at a high significance level of 1% indicated that it has asymmetrical relations between variables. For instance, the significance $d_{31} = 0.10$ ($p < 0.01$) in the economic growth indicates an asymmetric spillover effect from oil price return to economic growth uncertainty, which means negative shocks in oil price returns would result in larger volatilities in economic growth.

Figure 5. Conditional Correlations between Inflation and Oil Price



4. Conclusion

Previous empirical research concerning the relationship between oil price and macroeconomic (economic growth, inflation, unemployment, etc.) variables in Turkey has primarily been conducted using first-moment (mean) analysis. In this study, both first-moment (mean) and second-moment (variance) analyses were examined using the VARMA-GARCH-in mean, asymmetric BEKK model, and it was determined that oil prices affected economic growth and inflation as both mean and variance (volatility). These results suggest that the concept of “oilism” can be reasonably applied to Turkey. Turkey imports enormous amounts of oil and oil products. As well, the petroleum dependency of Turkey's industrial sector is at the highest possible level. Therefore, volatility in oil prices will suppress producer prices and increase costs. Moreover, increases in the price of gasoline and diesel affect consumer prices. All of which indicate that oil price uncertainty (volatility) is a major factor affecting the Turkish economy.

The findings reveal a set of important policy recommendations for Turkey. First, because Turkey covers petroleum demand through imports, oil price volatility will directly change macroeconomic balances. Therefore, Turkey should primarily be directed toward the production and consumption of alternative energy sources (biofuels, ethanol, etc.). Thus, economic growth and inflation will not be affected as much by oil price volatility, and economic growth will be boosted by developments in the biofuel and ethanol production sector. Second, the validation of the Holland hypothesis for Turkey suggests that CBRT should have a strong anti-inflationary effect. Finally, inflation uncertainty will decrease if the CBRT puts inflation in a steady-state, which will contribute to economic growth.

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