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Impacts of Realized Volatility of Oil Price over Macroeconomic Activities in Turkey

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Abstract

Since 1973 oil crises, especially, small open economies need to consider sudden and highly volatile movements in currencies and current account deficits. Although, there have been a lot of considerations in the Middle East and Eastern European countries on political, geographical, and currencies risks, oil prices have been breaking new historical deep price records since second quarter of 2014, especially last quarter of 2015 toward first quarter of 2016. Turkish economy, experiencing serious current account deficit problems especially since 2002, has been worth of investigating this process, while oil prices have been declining and their increased volatility effect occur. Considering 2003M1-2015M7 period, rate of export meeting import, real exchange rate index, realized volatility in oil prices computed from transformed on monthly basis of OPEC basket price, industrial production index, and consumer price index are performed to analyze these effects, and causality relationship among these variables. According to test results enabled from unit root test with structural break and without break, ARDL bound test are employed and afterwards co-integration test was sorted out among variables. One of the most important results of the study is that when oil price volatility increase following the decline in oil prices, total import figures decrease more sharply than total export one; thus, rate of export meeting import increases. Another crucial result is that there is a negative relationship between real exchange rate index and rate of export meeting import because of low oil substituents for real economy. As expected, inflation has an adverse effect on foreign trade ratio. As a result, because of lower pressure of energy-induced inflation, economy policy makers will have some ability to change their priorities from inflation issues and policy tools for economic stability towards other structural problems in the economy during the periods of increased oil price volatility.

Key Words: Oil Price Volatility, Trade Balance, Macroeconomic Activities, ARDL Bound Test

Introduction

Most of sudden oil price shocks and return volatility exert destructive influence on output or named GDP, unemployment, inflation, exchange rates, and trade imbalances which are generally

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accepted as key indicators for an economy. In pursuit of exchange rate movements and cost items changes, these effect spreads as systemic risks penetrating whole economy. First of all, these unexpected movements become important issue on sectoral behaviors and then, bypass rational behavior and damage market efficiency. This study examines daily OPEC basket price transformed into the monthly volatility, and their effects on industrial production index, real exchange rate index, consumer price index.

Especially, after 1980s because of the monetary and fiscal policy decision and their implementation delays, the forecast difficulty of animal spirits of investors cause oil price changes follows oil price volatility after several periods, that’s why in most of the researches oil price volatility impacts on macroeconomic activities became mostly used variables instead of oil price changes (Hooker 1996; Rotemberg and Woodford 1996, Sauler and Awerbuch, 2003 s.12; Hamilton, 1983, 2000).The main reason for the use of oil price volatility in this study comes from the importance of the oil price volatility, which is created by oil shocks, has a major impacts on consumers decisions and producers investment decisions which have huge share in general national income equation.

As mostly known by policy makers (monetary or fiscal) and investors, volatility in financial and commodity markets frequently related with the risks because of its additive effects on uncertanity and following that postponed investment decisions (Guo and Kliesen, 2005). Besides, the oil prices in Turkey are determined in the free market. Such liberalization implementation inevitably reduces the effectiveness of policy makers’ intervention tools (Aydın and Acar, 2011). At this point all the results obtained from this study will reflect effects of the volatility concerning all sectors and thus, general economy.

Especially, after the second quarter of 2014, incremental volatility created by particularly downside and sudden price movements in oil and other energy commodity prices has yielded remarkable results for countries which have fragilities in exchange rates and balance of payments such as Turkey. Therefore, channeling effects described here causes indirect influences on the macroeconomic activities as mentioned above. For instance, according to Rasche and Tatom (1977), between 1973-1974 the upward trends in prices initially affected volatility and thus, cost of the firms leading a slowdown in the productivity of capital and labor, and finally reduced the US economy’s potential output approximately % 4-5 (Rasche and Tatom, 1977). Aydın and Acar

(2011) states that the primary effects of oil shocks is a reduction on consumption and decline on net investment inflows gradually works through Turkish economy.

According to related studies by Hamilton (1996), Hooker (1996), and Sauler and Waterbuch (2003) movements in oil price had upward trending movements during the period 1948-1985, but after 1986, up and down swings in prices caused to increase volatility significantly. Following up the increases in oil price volatility, according to Sauler and Awerbuch (2003) implemented monetary and fiscal policy measurements need to intervene the market along with interest rate and expenditure changing or switching policy tools and then, this situation causes an increase in uncertainty and investments devolutions.

In literature, as known *"Asymmetry In Effects"* which represents nonlinear effects of oil price upside and downside movements effects on economy has been widely investigated by (Mark,1989; Hooker 1996; Hamilton, 1996; Hamilton, 2000) for different periods. They find that oil price increases had a negative impact on economy but could not reach a marked impact that decreases in prices had a significant result on economic performance-enhancing. While Ferderer (1996) names these effects as *"Asymmetric Puzzle",* according to test results obtained from his investigation of which channel create effects of oil shocks on the real side of the US economy, there are three different channels. These can be listed as counter inflationary monetary policy, sectoral shocks, and uncertainty.

The emergence of the oil shocks can usually be based on conflicts about political, geographical conditions domestically or internationally, these oil shocks and conflicts led to supply constraints on capital, labor and energy inputs, a demand or supply side shocks on energy inputs can be a pioneer steps for the cost reduction policy in labor markets for short run and readjustments of firms profitability for mid/long term (Hamilton, 2000). Of course, these effects are not linear, as previously mentioned, price increases and decreases penetrate an economy in different magnitudes because of "*Asymmetry Effect*".

The increased cost of the other inputs and huge pressure on balance of payments deficits can be counted as the indirect effects of oil price shocks due to the rising energy prices (Aydın and Acar, 2011). Gokce (2013) study coincide with empirical evidence that a shock to live volatility in oil prices in the long run will cause a decline over -0.0164 in GDP.

Data and Methodology

As mentioned above, as a structured problem of Turkey's economy heavily dependent on energy import, especially in terms of oil, and in order to investigate of oil price impacts on growth rate we used unit root tests intended for stationary of variables indicate that variables have different stationary level so ARDL Bound approach were founded reliable for co-integration analysis for the period of 2003M1-2015M7.

Here, the study uses data such as X/M ratio (monthly), oil price realized volatility (monthly), inflation/CPI (monthly) and real exchange rate index (which is calculated by Central Bank of Turkey as a basket of currencies) or monthly converted exchange rate data obtained from (http://www.oanda.com/currency/average), and interbank rate change ratio from highest to lowest as determinants of trade deficits. All the data were transformed into logarithmic forms. The main reason to choice this data range is that a new politic term (Justice and Development Party came to power in 7 August 2002) has started since this party has been longest party remained in power in Turkish political history.

Data

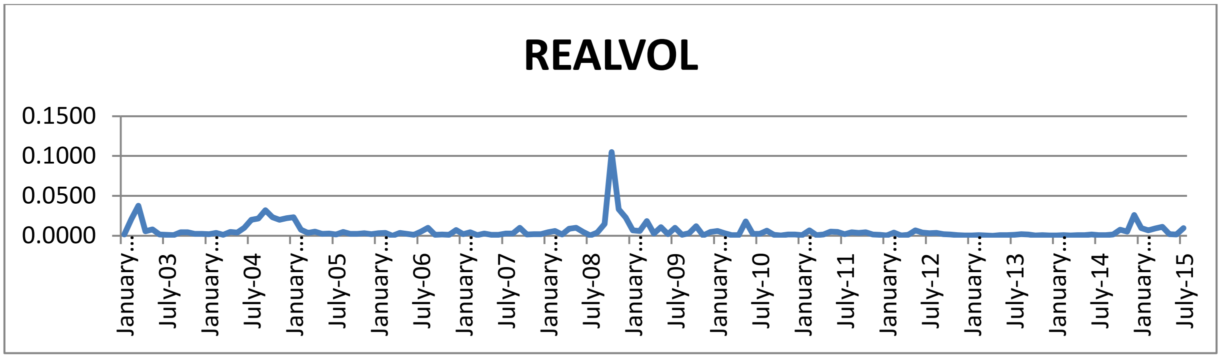
In order to gauge Turkey's output growth, the covered period has benefited from the Industrial Production Index (IPI) data published monthly not free from the effects of seasonal effects and logarithmically transformed by Turkey Statistics Institute, in the name of the monthly conversion made for realized volatility series, and realized volatility series converted monthly working to be eligible with frequency range. However, inclusion of IPI negatively affected the significance of whole model and therefore, it is kept out of model. If anyone demands test result of the case of inclusion of IPI into the model, we can provide test results.

OPEC basket price series has been received from The Organization of Petroleum Exporting Countries official website. OPEC basket price realized volatility series has been calculated from daily realized variance at the recommondation of Merton (1980) formula as a indicator of risk which is measurable part of uncertanity in the markets (Merton, 1980). And these daily realized volatility series were transformed into the quarter realized volatility at the recommondation of Andersen et. al.(2003)'s formula which follows sum of squared of realized volatility procedure. (Andersen et. al. 2003; Merton, 1980).

REALVOL$_t$ = $\sum_{i=1}^{i_t}(RETURN\_REALVOL_i)^2$

After the calculation of daily returns, the sum of squares of converted monthly returns give us the quarterly realized volatility of required period (We can provide workfile up on request.).

Figure 1: OPEC Basket Price Realized Volatility, 2003 M1-2015M7

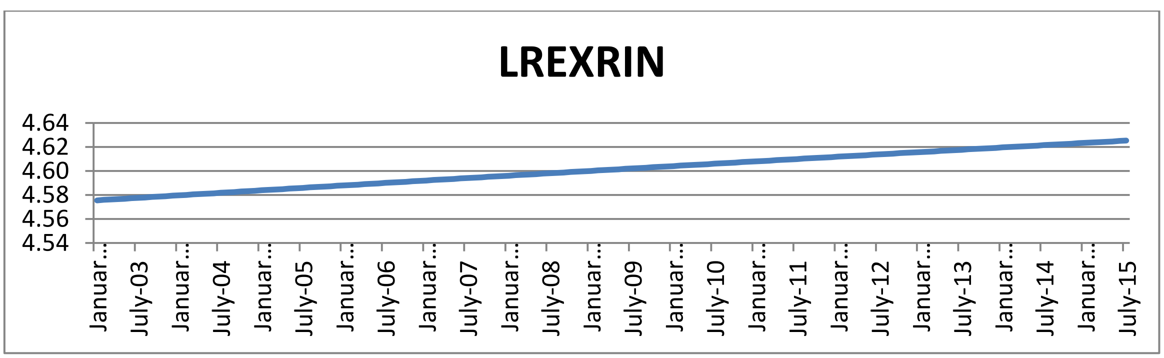


Source: http://www.opec.org/opec_web/en/data_graphs/40.htm

One of exports to imports ratio, an important indicator showing the fragility of the country's openness case is considered in the literature as appropriate. Therefore, this ratio is calculated and made the logarithmic transformation based upon the data on foreign trade indices published monthly by the Statistical Institute of Turkey,

In order to see the effect of foreign currency on exports to imports ratio, the study benefits examining the real exchange rate index published by the Central Bank of Turkish Republic. Logarithmic transformation of real exchange rate index was carried out.

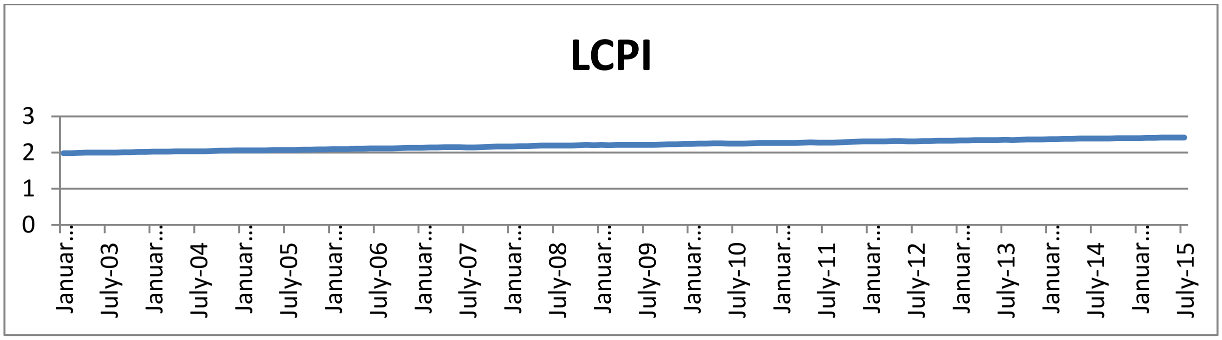
Figure 2: Real Exchange Rate Index, 2003M1-2015M7



Source: http://www.tuik.gov.tr/PreIstatistikTablo.do?istab_id=1544

As known well, the consumer price index, especially relative cheapness and expensiveness of imported goods prices compared to domestic prices, leaves significant impacts on exports to import ratio. Therefore, logarithmic transformation of the consumer price index published by Statistical Institute of Turkey was included in the analysis.

Figure 3: Consumer Price Index-2003M1-20015M7



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Unit Root Test Results

Before estimating the co-integration method that will be implemented for the series is necessary to check from which level they are co-integrated. For this purpose, to determine I(d) value for each series, the study benefits a bunch of test such as followings: the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) that autoregressive process allowed as permitting delays as AR (p), and unlike other unit root tests, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (1992) developed an alternative unit root test which reverse the alternative and null hypothesis' arguments, depending on the difficulty of critical value to reject. Phillips-Perron (PP) developed a unit root test which can test the existence of the relationship between the non-parametric and error terms. PP Unit Root Test is developed for improvement of some of the weaknesses of the Ziwot Andrews test, determining the trend of the average in the breaking years and common breaks in both series (Perron, 1988 and 1997).

Classical unit root tests can make decisions on the stability of the series in cases where the existing structural breaks. In Eviews 9 econometric program, a sudden change in the average year break and dummy variables for breaking year are determined with Break Point Additive outlier unit root test.

Table 1: ADF Unit Root Test Results (Intercept)

ADF Test Variable	Test Statistics Level	First Difference	Critical Values %95 Confidentality	Decisions
	(Intercept)			
LROEMI	-4.55	-13.15	-2.8824	I(0)
LREXRIN	-3.61	-9.22	-2.8824	I(0)
LCPI	-0.66	-9.25	-2.8824	I(1)
REALVOL	-7.62	-9.67	-2.8824	I(0)

Table 2: ADF Unit Root Test Results (Intercept+Trend)

ADF Test Variable	TEST STATISTICS Level	First Difference	Critical Values %95 Confidentality	Decisions
	(Intercept+Trend)			
LROEMI	-4.54	-13.11	-3.4428	I(0)
LREXRIN	-3.73	-9.35	-3.4428	I(0)
LCPI	-4.44	-9.25	-3.4428	I(0)
REALVOL	-7.75	-9.64	-3.4428	I(0)

Table 3: KPSS Unit Root Test Results (Intercept)

KPSS Test Variable	TEST STATISTICS Level	First Difference	Critical Values %95 Confidentality	Decisions
	(Intercept)			
LROEMI	0.14	0.04	0.463	I(0)
LREXRIN	0.29	0.22	0.463	I(0)
LCPI	1.47	0.34	0.463	I(0)
REALVOL	0.25	0.18	0.463	I(0)

Table 4 : KPSS Unit Root Test Results (Intercept+Trend)

KPSS Test Variable	TEST STATISTICS Level	First Difference	Critical Values %95 Confidentality	Decisions
	(Intercept+Trend)			
LROEMI	0.07	0.02	0.146	I(0)
LREXRIN	0.28	0.036	0.146	I(1)
LCPI	0.28	0.18	0.146	I(0)
REALVOL	0.05	0.18	0.146	I(0)

Table 5: Philips Perron Unit Root Test Results (Intercept+Intercept)

PP Test Variable	TEST STATISTICS Level	First Difference	Critical Values %95 Confidentality	Decisions
	(Intercept)			
LROEMI	-7.463	-21.79	-2.880	I(1)
LREXRIN	-3.31	-9.22	-2.880	I(1)
LCPI	-2.44	-15.44	-2.880	I(0)
REALVOL	-7.65	-73.12	-2.880	I(1)

Table 6: Philips Perron Unit Root Test Results (Intercept +Trend)

PP Test Variable	TEST STATISTICS Level	First Difference	Critical Values %95 Confidentality	Decisions
	(Intercept+Trend)			
LROEMI	-7.49	-21.73	-3.44	I(1)
LREXRIN	-3.28	-9.23	-3.44	I(0)
LCPI	-3.49	-25.57	-3.44	I(1)
REALVOL	-7.74	-82.90	-3.44	I(1)

As seen from the KPSS and Phillips Perron test results, the variables in our model has a different level of co-integration at I(0) and I(1). Thus, the ARDL Bound Testing Aprroach stands applicable. After a determination of experienced sudden deviations from the average variable, an extra test has been applied as a test procedure in which Additive Outlier Test with Breakpoint and dummy variable are added to the period range.

Table 7: The Detection of Constant Breaking Year With Additive Outlier Breakpoint Unit Root Test

LROEMI	
Break Specification	Intercept Only
Break Type	Additive Outlier
Break Selection	Minimize Dickey-Fuller t-statistic
Break Date:	2010M6
t statistics(0.05 critical value and(prob. value)	-7.881647 (-4.859812) (<0.01)

**Vogelsang (1993) asymptotic one-sided p-values*

Dummy10 variable in our model indicates a breakage in the average in May 2010 as the Additive Outlier Test with Breakpoint over LROEMI average as noted by Bruman and Otto (1988) in Eviews 9 program. When there is a determination of a breakage on average belonged to a period, other observations except May 2010 are marked as of 0 (Bruman and Otto, 1988).

ARDL Bound Approach Test Results

ARDL method examines long-term relationship between the variables in the model through F test concept not only in the case of variables or series having only I(0) or I(1) as noted in Paseran et al. (2001) but also in the case of co-integration in different levels (Pesaran et al., 2001: p.295-296).

According to Paseran et al. (2001),

"*The conditional ECMs (12) – (16), derived from the underlying VAR(p) model (2), may also be interpreted as an autoregressive distributed lag model of orders (p,p,...,p) (ARDL(p,...,p)). However, one could also allow for differential lag lengths on the lagged variables y_{t-i} and x_{t-i} in (2) to arrive at, for example, an ARDL(p,p_1,...,p)*[2] *model without affecting the asymptotic results derived in this section. Hence, our approach is quite general in the sense that one can use a flexible choice for the dynamic lag structure in (12) – (16)*[2] *as well as allowing for short-run feedbacks from the lagged dependent variables, Δy- i, i= 1,...,p, to Δx_t in (7)* (Pesaran et al., 2001)

In the name of determination of appropriate length of delays and for this reason, of the number of variables to be placed in the model, the Akaike (AIC) information criterion is used to search for top 20 models. In the ARDL approach, it will be initially benefited from the Unrestricted Error Correction Model (UECM) in the name of estimating the following long-term coefficients and afterwards, determining the appropriate length of the delay (Keskin, 2008)

$$\mathrm{dlroemi} = \mathrm{c} + b1\sum_{i=1}^{m}\mathrm{dlroemi}_{t-i} + b2\sum_{i=1}^{m}\mathrm{dlrexrin\ t-i} + b3\sum_{i=1}^{m}\mathrm{dlcpi\ t-i} + b4\sum_{i=1}^{t}\mathrm{drealvol\ t-1} + b5\mathrm{lroemi\ t-1} + b6l\mathrm{rexrin\ t-I} + b7\ \mathrm{lcpi\ t-1}$$

In this model, d is the series of the taking first difference; c is constant coefficients; b1 and b2 are short-term coefficients because they are handled through taking difference; b2, b3, b4, b5, b6, b7

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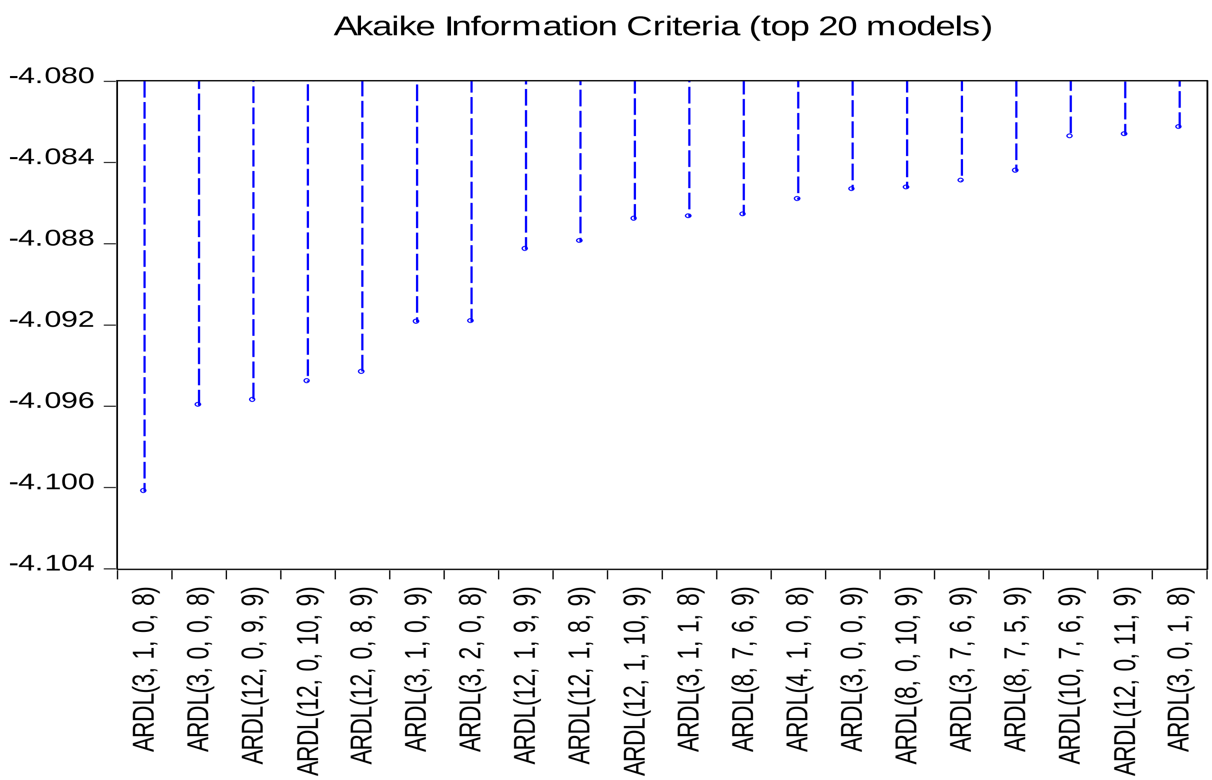
2 *Please see Appendix for Case I (12)- Case IV(16) formulas.*

represent long-term coefficients since there is no taking difference process. After determining the level of stability for variables with the unit root tests applied above, determination of the appropriate length of delay and thus, of the number of variables to be placed in the model, the Akaike (AIC) information criterion is used to search for top 20 models.

Figure 4: Determination of Proper Lag Structure For ARDL Bound Test



From the perspective of dynamic delay length, ARDL (3,1,0,8) is preferred when autocorrelation disappears for UECM and AIC information criterion is taken into consideration. For studies which were used ARDL approach, the most important coefficients diagnostic test is Breusch-Godfrey Serial Correlation LM Test because the most important problem to cope with is the existence of autocorrelation among lag values of error terms. As seen below in Table 8, we handle this problem with optimal leg length selection.

H_0 *=There is no autocorrelation between error terms*

H_1 *=There is autocorrelation between error terms*

Table 8: Breusch Godfrey Serial Correlation LM Test

Lag length (2)	0.743(0.68)

**Results contain F statistics outside of paranthesis and Chisquare prob value in paranthesis.*

As seen, autocorrelation is no longer an issue in the model since it also contains short-term coefficients preferred for UECM. At this stage, F test is applied for overall significance test for whole model over length of the delays for ARDL Bound Testing approach and should be compared with the upper and lower critical table values that the Paseran et al. (2001) presented in their article.

Table 9: ARDL Bound F Test Statistic With Lower and Upper Bound Values

		Critical Values(%5)	
k	**F statistic**	**Lower Bound Values**	**Upper Bound Values**
3	5.102	3.38	4.23

Because F statistic calculated on the overall significance of the model is higher than the upper and lower critical table values placed in Paseran et al. (2001), we can infer that there can be a long-term co-integration among exports to import ratio, real exchange rate and consumer price index.

Tablo 10: ARDL-Long Term Coefficients and Error Correction Model

Cointegrating Form

Variable	Coefficient	t-Statistic	Prob.	
D(LROEMI(-1))	-0.375201	0.088321	-4.248134	0.0000
D(LROEMI(-2))	-0.189006	0.079416	-2.379942	0.0188
D(LREALVOL)	0.002386	0.004631	0.515180	0.6073
D(LREXRIN)	-0.304596	0.213292	-1.428073	0.1558
D(LCPI)	3.610644	0.878732	4.108924	0.0001
D(LCPI(-1))	-1.155972	0.938671	-1.231498	0.2204
D(LCPI(-2))	-0.924667	0.924052	-1.000666	0.3189
D(LCPI(-3))	-2.694341	0.924990	-2.912831	0.0042
D(LCPI(-4))	0.856613	0.905723	0.945779	0.3461

D(LCPI(-5))	-1.194918	0.913563	-1.307975	0.1933
D(LCPI(-6))	-0.646608	0.909775	-0.710734	0.4786
D(LCPI(-7))	-2.586221	0.905549	-2.855972	0.0050
D(DUMMY10)	0.041628	0.022914	1.816743	0.0717
C	-2.814584	0.544257	-5.171421	0.0000
CointEq(-1)	-0.405627	0.078419	-5.172525	0.0000

As expected, error correction term value (-0.405627) is between 0 and -1 and was found to be negative. The probability values seem very significant. Investigation on a monthly basis between the variables and hence, the case of achieving a balance at high level are possible.

Table 11: Long Run Coefficients

Variable	Coefficient	t-Statistic	Prob.
LREALVOL	0.026611	1.643462	0.1028
LREXRIN	-0.704310	-2.356044	0.0200
LCPI	5.171426	2.792398	0.0061
DUMMY10	0.099411	1.188722	0.2368
@TREND	-0.014952	-2.770672	0.0064

The model enables to find a positive relationship between exports to imports ratio and realized volatility of oil prices. This empirical finding means that increased volatility can be signal of the fall of oil prices due to risk perception of markets and therefore, means that there is an improvement in our trade balance.

Because all variables in Granger causality model were moving through the VAR model, they are considered internal and symmetrical, and are investigated bidirectional or unidirectional causality, if there is no causality, it is concluded that the variable is statistically independent (Dasgupta, 2009).

Table 12: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: LROEMI

Excluded	Chi-sq	df	Prob.
LREALVOL	9.088633	2	0.0106
LREXRIN	0.104785	2	0.9490
LCPI	0.717086	2	0.6987
DUMMY10	1.620713	2	0.4447
All	10.96666	8	0.2036

Dependent variable: REALVOL

Excluded	Chi-sq	df	Prob.
LROEMI	0.254406	2	0.8806
LREXRIN	1.484173	2	0.4761
LCPI	3.657702	2	0.1606
DUMMY10	0.389846	2	0.8229
All	5.092207	8	0.7477

Dependent variable: LREXRIN

Excluded	Chi-sq	df	Prob.
LROEMI	1.810612	2	0.4044
LREALVOL	5.636219	2	0.0597
LCPI	1.623067	2	0.4442
DUMMY10	0.577886	2	0.7491
All	8.990469	8	0.3431

Dependent variable: LCPI

Excluded	Chi-sq	df	Prob.
LROEMI	1.751637	2	0.4165
LREALVOL	0.464777	2	0.7926
LREXRIN	1.956236	2	0.3760
DUMMY10	3.290570	2	0.1930
All	7.699220	8	0.4634

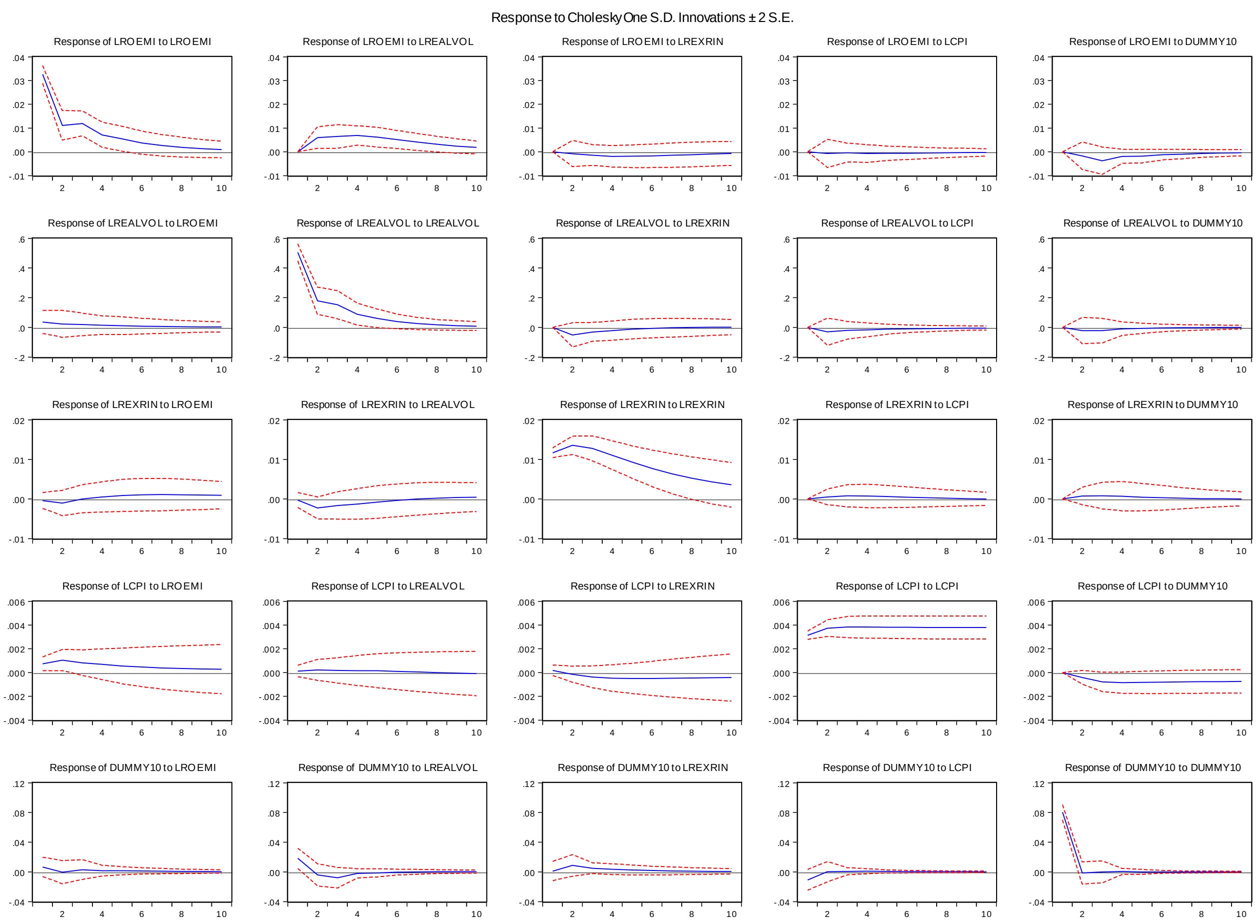
In examination of Chi-square values in Table 12, or in cases of probability value of less than 0.05, it can be concluded that there are Granger causality between variables.

The existence of mutual causality can be investigated by means of making mutual control among variables that have one-way causality. When table values in Table 12 are examined, LOREMI as a dependent variable has one-way causality with REALVOL, and realized volatility Granger causes of the export to import ratio. Even this result is such as to support the main hypothesis guiding the article itself. As expected, LOREMI variable does not Granger causes REALVOL variable. Because Turkey does not have enough amount of consumption or production volume that may affect oil price volatility is the fact. And moreover, LOREXRIN as a dependent variable has one-way causality with REALVOL, and realized volatility Granger causes of the export to import ratio.

Impulse Response Functions

In order to analyze the response of variables against one sided innovations with two standard unit error of themselves by benefiting Cholesky decomposition (degree of freedom adjusted) method, we implied Monte Carlo simulations with 100 repetitions for maximum 10 periods(months) adjustment period.

Figure 5: Impulse Resposes to Cholesky One Sided Innovations to 2. Satndard Error



According to results in Figure 5, all variables in the model are to be influenced by the results of most of their own innovations. Previously, as reflected by the coefficient obtained according to both ARDL long-term coefficient table and also the Granger test results, export to import ratio, LROEMI, exhibits positive sensitivity to LREALVOL that belongs to oil price volatility obtained from the OPEC basket prices. When bandwidth is examined, it will be apparent that positive two standard deviation innovations in LREALVOL loses its effect on LROEMI only 8 periods (or, months).

Two standard deviation innovations in LREALVOL causes an expanding bandwidth along with periods (or, months) over LREXRIN so that two standard deviation innovations on oil price volatility (due to slowness in correcting the speed of market perception and policy delays such as identification and implementation in policy) show their impact on the real exchange rate after 5 periods (or, months).

Conclusion and Further Studies

The study is divided into two parts. In the first part, OPEC basket prices are converted to monthly realized volatility, and in the second part investigates causality relationship through ARDL approach among the (REALVOL)the real exchange rate index (LREXRIN), Exports to Imports ratio (LROEMI) and the Consumer Price Index (LCPI). The biggest advantage of the ARDL bounds testing approach is to allow co-integration at different levels of stability. For this purpose, ADF, Phillips Perron and KPSS unit root tests intended at which level variables are co-integrated were used and thus, it is identified co-integration in different stagnation like I(0) and I(1). According to F critical table values of the ARDL bounds testing, it has been determined co-integration with a long-term among the variables listed above. The key findings of the study is have expected theoretical results among oil price volatility, (LREALVOL), exports to import ratio, (LROEMI), and real exchange rate index, (LREXRIN).

Currently, aftermath 1973 oil crisis, most of the countries, notably U.S.A. (app. 714 million barrels capacity, Department of Energy's Office of Petroleum Reserves (OPR)), has established government-controlled Strategic Petroleum Reserves (http://energy.gov/fe/services/petroleum-reserves; accessed Feb. 8th 2016). Countries who heavily dependent on petroleum products can refer this way as an ability in order to response to the sudden oil crisis. By the way, as alternative protection of oil shocks can be a diversification of oil suppliers and taking long or short positions in derivative markets against risks.

Consequently, as mentioned earlier, especially crude oil, natural gas and the most of commodities are traded as financial products in recent years. For this reason, decision makers such as politic actors of state agencies and managers of private sectors must seriously consider highly volatile market trends, particularly, because they have features of main raw materials. Shocks/innovations originated from oil and natural gas markets must be considered to minimize risks, as well as they should consider their pairwise causality between macroeconomic indicators like economic growth, current account deficit and unemployment. Therefore, they must determine optimal hedge strategies and benefit from derivative products efficiently in line with the midterm program objectives. In addition, for this purpose, regulators can make policies which enable to improve financial deepening. This study can humbly be a pioneer for further or any related studies which can be built on to research for the causes of crude oil and natural gas volatility and pairwise causality between macroeconomic indicators following the collapse of prices from $110 to $46 since June of 2014 and afterwards, there has been further decline on the prices about $30, especially in Feb. 2016.

Appendix

Pesaran et al., 2001: p.295-296 ;

Case I (no intercepts; no trends) c_0 =0 and c_1 = 0. That is, μ=0 and γ= 0. Hence, the ECM (8) becomes

$$\Delta y_t = \pi_{yy} y_{t-1} + \boldsymbol{\pi}_{yx.x} \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\psi}_i' \Delta \mathbf{z}_{t-i} + \boldsymbol{w}' \Delta \mathbf{x}_t + u_t \tag{12}$$

Case II (restricted intercepts; no trends) $c_0 = -(\pi_{yy}, \boldsymbol{\pi}_{yx.x})\mu$ and c_1 =0. Here, γ= 0.The ECM is

$$\Delta y_t = \pi_{yy}(y_{t-1} - \mu_y) + \boldsymbol{\pi}_{yx.x}(\mathbf{x}_{t-1} - \boldsymbol{\mu}_x) + \sum_{i=1}^{p-1} \boldsymbol{\psi}_i' \Delta \mathbf{z}_{t-i} + \boldsymbol{w}' \Delta \mathbf{x}_t + u_t \tag{13}$$

Case III (unrestricted intercepts; no trends) $c_0 \neq 0$ and c_1=0. Again, γ= 0. Now, the intercept restriction $c_0 = -(\pi_{yy}, \boldsymbol{\pi}_{yx.x})\mu$ is ignored and the ECM is

$$\Delta y_t = c_0 + \pi_{yy} y_{t-1} + \boldsymbol{\pi}_{yx.x} \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\psi}_i' \Delta \mathbf{z}_{t-i} + \boldsymbol{w}' \Delta \mathbf{x}_t + u_t \tag{14}$$

Case IV (unrestricted intercepts; restricted trends) $c_0 \neq 0$ and $c_1 = -(\pi_{yy}, \boldsymbol{\pi}_{yx.x})\mu$

$$\Delta y_t = c_0 + \pi_{yy}(y_{t-1} - \gamma_y t) + \boldsymbol{\pi}_{yx.x}(\mathbf{x}_{t-1} - \gamma_x t) + \sum_{i=1}^{p-1} \psi_i' \Delta \mathbf{z}_{t-i} + \mathbf{w}' \Delta \mathbf{x}_t + u_t \qquad (15)$$

Case V (unrestricted intercepts; unrestricted trends) $c_0 \neq 0$ and $c_1 \neq 0$ Here, the deterministic trend restriction $c_1 = -(\pi_{yy}, \boldsymbol{\pi}_{yx.x})\mu$ is ignored and the ECM is

$$\Delta y_t = c_0 + c_1 t + \pi_{yy} y_{t-1} + \boldsymbol{\pi}_{yx.x} \mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \psi_i' \Delta \mathbf{z}_{t-i} + \mathbf{w}' \Delta \mathbf{x}_t + u_t \qquad (16)$$

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