# The Impact of Oil Price Shocks on The Economy of Azerbaijan: A Vector – Autoregressive Analysis

written by Farid Zulfugarli Fərid Zülfüqarlı

**In the contemporary industrialized world, crude oil is still essential for economic development. Yet countries are affected by fluctuations in the price of this commodity differently, depending on their position in the supply chain. Notably, because they rely on oil exports, developing net–oil-exporting countries are more vulnerable to oil price shocks in the world market relative to developed net–oil-importing countries. The first substantial crude oil price shocks of 1970s, as a result of the OPEC oil embargo, kicked off the studies on oil price shocks and macroeconomic activity relationship in 1980s.**

I classify the existing literature in this area in three phases. The very first phase of the literature, that mostly established a negative-linear relationship between oil prices and real economic activity, includes, inter alia, Rasche and Tatom, 1977; Darby, 1982; Hamilton, 1983; Burbidge and Harrison, 1984; Gisser and Goodwin, 1986. Starting from the second half of the 1980s, studies on the linear relationship between oil price shocks and real economic activity lost their significance. The substantial decreases in oil prices from the mid-1980s were discovered to have smaller positive impacts on real economic activity than foreseen by the previous linear models. Hence, Mork (1989), Lee et al. (1995) and Hamilton (1996) presented three non-linear approaches such as asymmetric, scaled and net oil price increases, respectively, to analyze the correlation between oil price increases (decreases) and economic recessions (expansions). The third phase of the literature try to determine whether output responses to oil price increases and decreases are asymmetric. Although many studies (Mork 1989; Mory 1993; Mork 1994; Lee et al. 1995; Hamilton 1996; Ferderer 1996; Hooker 1996; 2002; Bernanke et al. 1997; Lee et al. 2001; Davis and Haltiwanger 2001; Hamilton 2003; Hamilton and Herrera, 2004; Jimenez-Rodriguez and Sanchez, 2005) reveal a reasonably well-accepted asymmetry in oil-price–macroeconomy relationship, Kilian (2009), Kilian and Vigfusson (2009; 2011) and Herrera et al. (2011, 2015) provided contradictory results by questioning the robustness of the inferences of these studies. In contrast, some recent studies (Rahman and Serletis 2010; Du et al. 2010; Hamilton 2011; Serletis and Istiak 2013; Kilian and Vigfusson 2013; An et al. 2014; Donayre and Wilmot 2016; and Bergmann 2019) also confirm the asymmetry/non-linearity in the oil-price–macroeconomy relationship.

The large body of literature concentrates on the US and other developed economies, while relatively few studies have explored effects on developing net–oil-exporting countries (Rautava 2004; Mehrara and Oskoui 2007; Farzanegan and Markwardt 2009; Berument et al. 2010; Iwayemi and Fowowe 2011; Emami and Adibpour 2012; Zulfigarov and Neuenkirch 2019). The general theme of the studies concentrating on developed economies is that positive and negative oil price shocks are negatively and positively correlated with economic activity, respectively, whereas the effect of the former is more significant than that of the latter. In contrast, the studies on small oil-exporting economies conclude that negative oil price shocks hamper economic growth, whereas positive shocks stimulate real economic activity.

This paper contributes to this scarce literature by extending the analysis of the relationship between oil price shocks and economic activity to the case of Azerbaijan. The central objective of this research is to find the best possible answer to the question: *What happens to the economy of Azerbaijan when oil prices go up and down in the global oil market?* To answer this question, I examine the impact of oil price shock on the economy of Azerbaijan both in linear and non-linear specifications in line with the existing literature. Besides, I examine the linear relationship between oil price innovations and the oil-gas and non-oil gas sectors of Azerbaijan.

The sample of the research from 2001 to 2018 pertains to a time in which oil prices happened to display considerably different rises and falls. For instance, the oil price hikes in 2008 followed by the global financial crisis resulted in a sharp decline in oil prices in 2009 and later the high oil price cycle of 2011 to 2013 was followed by a low oil price cycle lasting until the end of the sample period. Periods of rising oil prices led to substantial total output growth, high inflation, and national currency appreciation. On the other hand, periods of falling energy prices caused drastic economic slowdown, increasing inflation and depreciation of the national currency against the USD, which led to the devaluation of the national currency by roughly 50% in 2015. During this period, Azerbaijan achieved substantial economic growth due to its abundant energy resources and higher oil price windfalls. However, it also became highly dependent on resource revenues due to poor diversification. The non-oil sector is mainly driven by transfers from the oil and gas sector. The exposure of Azerbaijan's economy to oil price innovations makes the subject of this paper worthy of investigation.

To quantify the dependence of Azerbaijan on oil price fluctuations I employ vector autoregressive (VAR) models for the period 2001q2–2018q4. As a first step, I establish a baseline VAR and carry out Granger causality tests, and then obtain the impulse response functions and forecast error variance decompositions for (i) real GDP growth, (ii) the inflation rate, (iii) the central bank rate, and (iv) the exchange rate after innovations in the growth rate of world oil prices. In the second step, I split the overall GDP indicator into two production components such as GDP growth in oil and gas sector and in the remaining economy. Finally, I explore potential asymmetries with respect to oil price decreases and increases based on two different approaches (Mork 1989; Hamilton 1996).

My key findings are as follows: the results of linear specification show that oil price fluctuations have a statistically significant effect on aggregate output, inflation, interest rate, and the exchange rate of Azerbaijan leading to large output losses in the early periods, high inflation, tightened monetary policy and depreciation of exchange rate in the country. Oil-gas GDP and non-oil GDP growths decline after oil price shocks. Downswings (upturns) in the oil and gas sector also trigger downswings (upturns) in the non-oil sector as fluctuations in oil revenues affect the government’s capacity to subsidize the remaining economy. The results of non-linear specifications demonstrate that both negative and positive oil price shocks have a statistically significant effect on all the macro variables, but the impact is asymmetric. More specifically, oil price decreases are found to have larger adverse impact on all macro variables than positive effect of oil price increases. Finally, both positive and negative oil price shocks have an inflationary effect and lead to appreciation and depreciation of the exchange rate. Appreciation of the manat, taken together with higher inflation, indicate that the “Dutch Disease” applies to Azerbaijan.

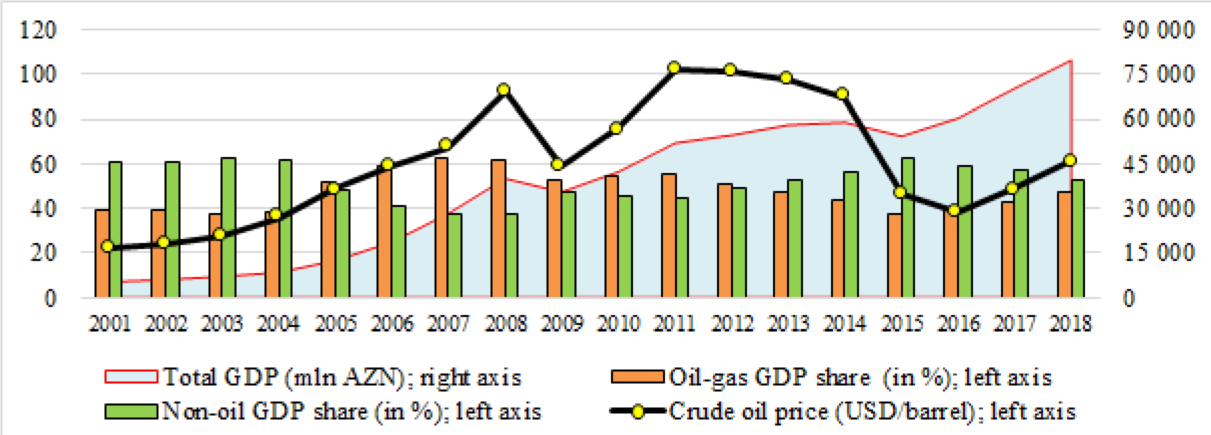
The remainder of this paper is organized as follows. Section 2 provides some background information on Azerbaijan. Sections 3 and 4 describe the data and econometric methodology; Section 5 provides the empirical results of the linear specifications; Section 6 presents empirical results obtained from the extension of the analysis to two non-linear specifications; Section 7 concludes.

## 2. Country Information

Azerbaijan’s development is closely related to the development of its on- and off-shore oil deposits. During 2001-2018 Azerbaijan’s total GDP along with oil-gas and non-oil GDP increased substantially (see Figures 1 and 2). The share of oil-gas (green bar, left axis) and non-oil (orange bar, left axis) sectors in total GDP (red line, right axis) changed several times in these periods due to large energy exports and higher oil price windfalls. Until 2005 non-oil GDP share of total GDP was higher than oil-gas GDP, but, since 2006, the proportion has changed significantly as the Baku-Tbilisi-Ceyhan pipeline started operating.

Oil-gas production accounted for the largest share of total output, which peaked in 2007, comprising 62.7% during 2005-2012. Thanks to large investments in the oil-gas sector, GDP growth averaged 16% a year through 2001-2009 (reaching a record 34.6% in 2006!). Rising global oil prices, higher public spending, and gains from oil-gas production increased the growth to an average of 27% a year during 2003 and 2009. In 2005 and 2008, oil revenues rose even more than expected because of the hikes in global oil prices, leading the country’s currency reserves to reach twice its foreign debt (18 billion USD) at the end of 2008. In 2009, the production of overall output declined as a result of slackening world oil prices; however, in subsequent years rising oil prices led to increasing production till 2014. The oil-gas output comprised 42% of the value added (of GDP), 90.7% of total gross exports and 83.9% of overall foreign investment in 2009 (Ciarreta and Nasirov 2012, 283).

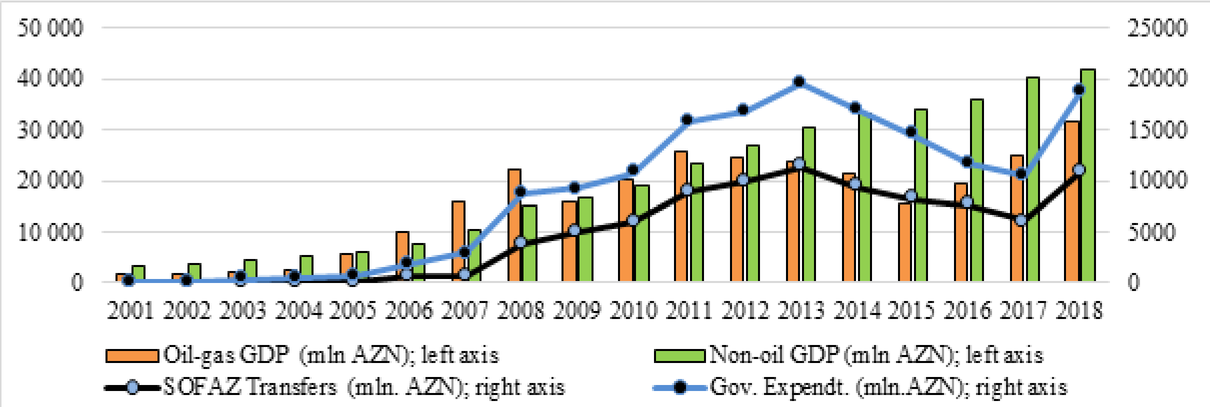
**Figure 1**: Oil Price, Total GDP in Azerbaijan, and Sectoral GDP Shares




*Source:* State Statistics Committee of Azerbaijan Republic (2019); US Energy Information Administration, Short-Term Energy Outlook (2018); Author's own calculations.

The oil price slump of 2014 caused a drastic economic slowdown with GDP growth dropping from 5.8% to 2.3% in 2014 and 1.1% in 2015, respectively. Similarly, oil GDP growth declined 2.9% in 2014, but was restored to 1.2% in the subsequent year, whereas non-oil GDP growth declined from 10% in 2013 to 1.1% in 2015. Moreover, foreign currency reserves shrank strikingly by 26.6% within three months, though the Central Bank of Azerbaijan (CBA) injected 3.96 billion USD to the economy in this period. The national currency, the manat (AZN), experienced two devaluations due to the depreciation of national currency by more than 50% in 2015. Following the second devaluation the CBA shifted to a floating exchange rate regime but did not cease administrative measures, portraying them as the transformation phase to a 'floating currency,' or 'regulated' floating currency (Bayramov and Abbas 2017, 154-155).

**Figure 2:** Oil-gas GDP, Non-Oil GDP, Government Expenditures, and SOFAZ Transfers




*Source:* State Statistics Committee of Azerbaijan Republic; SOFAZ Annual Report 2017, and SOFAZ Revenue and Expenditure Statement for January–December 2018.

As depicted in Figure 2, the non-oil sector (green bar, left axis) primarily depends on government expenditures (blue line, right axis) mostly driven by transfers from the State Oil Fund of the Republic of Azerbaijan (SOFAZ). Established in 1999 SOFAZ controls and manages currency and revenue flow from oil-gas activities. SOFAZ transfers (black line, right axis), along with the share of direct and indirect oil revenues, generated about 60.2% and 59.8% of 2018's and 2019's overall state budget revenues, respectively. It is clear that state budget revenues and expenditures are highly dependent on resource revenues.

Thus, since independence, Azerbaijan has achieved substantial economic growth thanks to abundant energy resources; however, it has also become highly dependent on resource revenues due to poor diversification and economic policy. High energy windfalls made the non-oil sector reliant on government expenditures, driven from oil revenues; hence the vulnerability of the whole economy to world oil price shocks.

**3. Data**

The choice of variables is one of the crucial decisions in constructing a VAR model. In conformity with the literature in the field, the VAR model of this paper includes the following endogenous variables: (i) real GDP growth (GDP), (ii) the consumer price index inflation rate (CPI), (iii) the central bank rate (CBR), (iv) the exchange rate (XR), and (v) the growth rate of Brent crude oil prices (OP). The data set of the research covers the period 2001q2–2018q4. The starting point is restricted by the disclosure of quarterly GDP data (since 2001) and the calculation of growth rates to the previous quarter.

I use quarterly Brent crude oil as the proxy of world oil price obtained in real terms from the US Energy Information Administration (EIA). The data of real economic activity measure, GDP, is acquired from the State Statistical Committee of the Republic of Azerbaijan (SSCA). Also obtained from SSCA, mining and quarrying production was chosen to represent oil-gas GDP (OG) and the remaining economy proxied non-oil GDP (NOG). The remaining variables, CPI, CBR and XR, are obtained from the International Monetary Fund (IMF). I use CPI as a proxy of inflation, and the exchange rate in AZN per US dollar. In the analysis, they are determined such that an increase in CPI implies a rise in inflation and an increase in XR implies an appreciation of the exchange rate that would be expected to hurt the external competitiveness of the country's economy.

I include the real oil price and GDP growth rates in the system to capture the response of GDP growth to oil price shocks. CPI and CBR growth rates are included to capture inflationary and monetary effects of oil price shocks on economic activity, while the XR variable is included to find out whether the "Dutch Disease" applies to Azerbaijan. The Dutch Disease is the phenomenon whereby overreliance on the export of a single commodity appreciates the value of the national currency, thereby adversely affecting other sectors of the domestic economy by making imports cheaper and exports more expensive.

In the econometric literature, one significant factor is that each of the considered endogenous variables must be stationary, particularly in the VAR models. The stationarity of the variables is tested by analyzing their order of integration through unit root tests such as the Augmented Dickey-Fuller (1979) (ADF) and Phillips-Perron (1988) (PP) tests. The null hypothesis of the tests is that there is a unit root in the series. The rejection of the null hypothesis implies that the series is stationary. The series are tested in levels with both tests. As reported in Table 1, the ADF test rejects the null hypothesis at the 10% significance level for the GDP, CPI and NOG series, whereas the rest of the series are non-stationary. But PP test results demonstrate that the unit root cannot be rejected even at the 10% significance level for all series, meaning that all the variables are non-stationary in levels.

**Table 1:** Results of unit root tests: Linear case

| **Series** | **In level** | **In first log-difference** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **ADF test** | **PP test** | **ADF test** | **PP test** | | | | | |
| t-stat. | prob.* | t-stat. | prob.* | t-stat. | prob.* | t-stat. | prob.* | |
| OP | -1.48 | 0.827 | – 1.69 | 0.745 | **-6.66*** ** | 0.000 | **-6.86*** ** | 0.000 |
| GDP | **-3.18*** | 0.098 | -2.54 | 0.307 | **-5.54*** ** | 0.000 | **-5.48*** ** | 0.000 |
| CPI | **-3.48*** | 0.051 | -1.75 | 0.717 | **-2.82*** | 0.061 | **-5.30*** ** | 0.000 |
| CBR | -2.21 | 0.206 | -2.01 | 0.283 | **-6.30*** ** | 0.000 | **-6.28*** ** | 0.000 |
| XR | -3.08 | 0.119 | -0.40 | 0.985 | **-1.78*** | 0.072 | **-8.23*** ** | 0.000 |
| OG | -2.91 | 0.168 | -2.37 | 0.393 | **-5.47*** ** | 0.000 | **-5.41*** ** | 0.000 |
| NOG | **-3.33*** | 0.070 | -2.76 | 0.195 | **-7.88*** ** | 0.000 | **-7.81*** ** | 0.000 |

*Note:* *, ** and *** implies that series are stationary at 10%, 5%, and 1% significance levels, respectively; CBR is in the first difference.

For the stationarity, the series depicted in Figure A1 were de-trended by taking the first log-difference and seasonality was eliminated by seasonal adjustment. ADF test results in first log-difference indicate that the OP, GDP, CBR, OG and

NOG series are stationary at the 1% level, whereas the CPI and XR series are stationary only at the 10% level. However, PP test results display that the unit root can be rejected at the 1% level for all series, namely, all series are stationary and *I* (1) (Table 1).

As in the linear case, I tested the stationarity of the transformed oil price series for the non-linear specifications via ADF and PP tests. The results presented in Table 2 display that all transformed oil price variables are stationary and *I* (1) process.

**Table 2:** Results of unit root tests: Asymmetric and Non-Linear cases

| **Methods** | **Transformed series** | **ADF test** | **PP test** | | |
|---|---|---|---|---|---|
| t-stat. | prob.* | t-stat. | prob.* | | |
| Mork (1989) | AOPI | **-7.91*****| 0.000 | **-7.91***** | 0.000 |
| AOPD | **-6.24***** | 0.000 | **-6.20***** | 0.000 | |
| Hamilton (1996) | NOPI | **-8.33***** | 0.000 | **-8.41***** | 0.000 |
| NOPD | **-6.56***** | 0.000 | **-6.41***** | 0.000 | |

*Note:* *** implies that series are stationary at 1% significance levels.

Thus, we can apply the differenced series in the analysis of the linear and non-linear VARs to shed light on the oil-price–macroeconomy relationship in the case of Azerbaijan.

## 4. Econometric Methodology

Pioneered by Christopher A. Sims (1980), the VAR model helps to determine and interpret economic shocks and to estimate their impacts on macroeconomic variables. In the VAR model, all variables are treated as endogenous and the current value of an endogenous variable is linearly dependent on its past values and the past values of all other endogenous variables. By adding oil prices to Sims's six-variable VAR model, Hamilton applied it to the analysis of the relationship between oil price shocks and economic activity (Hamilton 1983, 232). The VAR model has thus become a prominent method in the field of empiric analysis in the nexus of oil price shocks and macroeconomic activity.

The interpretation of coefficients of the estimated VAR model is usually difficult. Hence, I also calculate Granger causality tests[2], Impulse Responses Functions (IRF)[3] and Forecast Error Variance Decompositions (FEVD)[4] to examine the relationships between the variables of the system. My empirical strategy is based on a linear VAR model (Sims, 1980) of order p in conjunction with various endogenous variables, which can be written in its reduced form as follows:

$$y_t = \delta + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + u_t$$

(1)

where $y_t = (y_{1t}, y_{2t}, \cdots, y_{kt})'$ is a $K$ dimensional vector of endogenous variables, while $y_{t-i}$ is the relative lag values of order $i$. $\delta$ stands for the $K$-dimensional constant terms, $A_i$ are the $i^{th}$ $(K \times K)$ coefficient matrices of vector $y_{t-i}$ for $i = 1, 2, \cdots, p$, $u_t(u_{1t}, u_{2t}, \cdots, u_{nt})'$ is the $K$-dimensional white noise process which is the vector of unobservable i.i.d (identically and independently distributed) zero mean error term.

where *is* a dimensional vector of endogenous variables, while is the relative lag values of order . stands for the *K*-dimensional constant terms, are the *i*th coefficient matrices of vector for , is the *K*-dimensional white noise process which is the vector of unobservable i.i.d (identically and independently distributed) zero mean error term.

I estimate four different versions of Equation 1. In the first step, I estimate a baseline five-variable model with (i) GDP, (ii) CPI, (iii) CBR, (iv) XR and (v) OP. In the second step, I split the indicator for real GDP into two production components and estimate a six-variable model with (i) real GDP growth in the oil and gas sector, (ii) real GDP growth in the remaining economy, (iii) CPI, (iv) CBR, (v) XR and (vi) OP.

To examine the potentially asymmetric reactions to oil price decreases and oil price increases I build on the approaches by Mork (1989) and Hamilton (1996). Both specifications only vary in the definition of the oil price variable, whereas the entire model structure and macroeconomic variables remain the same. These specifications allow us to compare the linear with asymmetric and non-linear models to study various properties of the behavior of oil price shocks on macroeconomic activity.

The idea of the asymmetric effect of oil prices on economic activity was first proposed by Mork. To determine the asymmetric correlation, Mork defined rises and falls in oil price as separate endogenous variables by allowing for an asymmetric response to oil price changes. (Mork 1989, 741). His transformation can be described more technically as follows:

$$AOPI_t = \{OP_t \quad if\ OP_t > 0 \quad 0, \quad otherwise \tag{2}$$
$$AOPD_t = \{OP_t \quad if\ OP_t < 0 \quad 0, \quad otherwise \tag{3}$$

where $OP_t$ is the rate of change in world oil prices, while $AOPI_t$ and $AOPD_t$ are the positive and negative rate of changes in the oil prices.

where  is the rate of change in world oil prices, while  and  are the positive and negative rate of changes in the oil prices.

Hamilton (1996) defined net increases in oil price by comparing the price of oil in each quarter with the highest value observed during the previous four quarters. If the value for the present quarter is larger than the previous year's maximum, the percentage change over the preceding year's maximum is utilized. If the price of oil in quarter *t* is lower than it had been at some point during the previous four quarters, the series is set to be zero for date *t* (Hamilton 1996, 215-217). Du et al. (2010) extended Hamilton's (1996) method and also analyzed the effect of net oil price decreases in the case of China (Du et al. 2010, 4147). Thus, inspired by Hamilton (1996) and Du et al., (2010) we can describe both the net oil price increase and decrease as the following:

$$NOPI_t = max\{0, OP_t - max\{ OP_{t-1}, OP_{t-2}, \dots, OP_{t-4} \}\} \quad (4)$$

$$NOPD_t = min\{0, OP_t - min\{ OP_{t-1}, OP_{t-2}, \dots, OP_{t-4} \}\} \quad (5)$$

In the third and fourth step, I extend the baseline five-variable VAR and include Mork's (1989) and Hamilton's (1996) defined oil price variables as AOPI, AOPD and NOPI, NOPD, respectively, in the system, and treat them as separate endogenous variables. Thus, the third and fourth specifications of my VAR model contain the following variables: (i) GDP, (ii) CPI, (iii) CBR, (iv) XR, (v) AOPD (vi) AOPI and (i) GDP, (ii) CPI, (iii) CBR, (iv) XR, (v) NOPD, (vi) NOPI, respectively.

I set *p* = 3 since a VAR (3) sufficiently captures the dynamics in the model and is stable as all eigenvalues lie inside the unit circle, while at the same time the lag structure is as parsimonious as possible. Moreover, the results of the Ljung-Box Portmanteau test for autocorrelation demonstrates that a VAR (3) is free from autocorrelation and residuals are white noise processes. This research uses orthogonalized IRFs with Cholesky decomposition, accumulated responses, and variance decomposition. Therefore, we have to choose an ordering for the variables that the potential shocks to the system impact variables in the right direction because the orthogonalized variable ordering method transmits the assignment of instantaneous correlation only to particular series. Since Azerbaijan is a small country and does not have the economic or political power to influence global oil prices, we need to assume the oil price variable as exogenous in the first place. Secondly, the ordering of the variables should follow a sequence from most exogenous to least exogenous. Therefore, I order the oil price indicators first and allow a contemporaneous response of all other macroeconomic variables to oil price shocks.

The confidence intervals included in the graphs of IRFs emphasize the significance of relationship and can be calculated by using asymptotic distribution, bootstrap, and simulation methods. To the best of my knowledge, the vast majority of the literature in the field uses asymptotic methods for the confidence interval. Hence, I also use the asymptotic method for the significance of the confidence bands.

## 5. Empirical Results of Linear Specifications

### 5.1. Granger Causality Tests of Linear Specifications

Granger causality tests were performed to demonstrate the causal relationship between real oil prices and macro variables selected from Azerbaijan. The null hypothesis of the test is that there is no Granger causality between variables. When the null hypothesis is rejected, we can conclude that there is a causal relationship between variables.

Table 3 reports that, there is a statistically significant causality relationship between oil price fluctuations and on all macroeconomic variables. More explicitly, the probability value about 0.003 implies that the null hypothesis that “real oil prices do not Granger-cause the real GDP growth” can be rejected even at the 1% significance level. Moreover, the causal effect of oil prices on oil-gas GDP and the remaining economy are statistically significant. Namely, the p-values, roughly 0.004 and 0.011, imply that the null hypothesis can be rejected even at the 1% and 5% significance levels, respectively. Furthermore, oil prices Granger-cause CPI, CBR, and XR variables accordingly, and the null can be rejected even at the 1% significance level for all three macroeconomic variables.

**Table 3:** Results of pair-wise Granger causality test: Linear Case

| Null Hypothesis: | Tests with 4 lags | Robust. tests with 8 lags | | |
|---|---|---|---|---|
| F-Stat. | prob. | F-Stat. | prob. | |
| OP does not Granger Cause GDP | 4.52110 | **0.0031*** ** | 3.18553 | **0.0063*** ** |
| GDP does not Granger Cause OP | 1.09946 | 0.3661 | 0.51414 | 0.8391 |
| OP does not Granger Cause OG | 4.30560 | **0.0042*** ** | 3.25534 | **0.0055*** ** |
| OG does not Granger Cause OP | 0.89095 | 0.4756 | 0.41515 | 0.9055 |
| OP does not Granger Cause NOG | 3.60823 | **0.0111** ** | 2.37904 | **0.0322** ** |
| NOG does not Granger Cause OP | 0.99813 | 0.4165 | 0.64015 | 0.7396 |
| OP does not Granger Cause CPI | 4.75130 | **0.0023*** ** | 2.54407 | **0.0230** ** |
| CPI does not Granger Cause OP | 1.53472 | 0.2049 | 1.03857 | 0.4229 |
| OP does not Granger Cause CBR | 4.66670 | **0.0026*** ** | 4.53978 | **0.0005*** ** |
| CBR does not Granger Cause OP | 1.00150 | 0.4147 | 0.53345 | 0.8247 |
| OP does not Granger Cause XR | 7.31928 | **8.E-05*** ** | 3.57784 | **0.0029*** ** |

| | | | | |
|---|---|---|---|---|
| XR does not Granger Cause OP | 0.89309 | 0.4744 | 0.49487 | 0.8531 |

*Note*: *, ** and *** implies that F-statistics is significant at 10%, 5% and 1% levels, respectively.

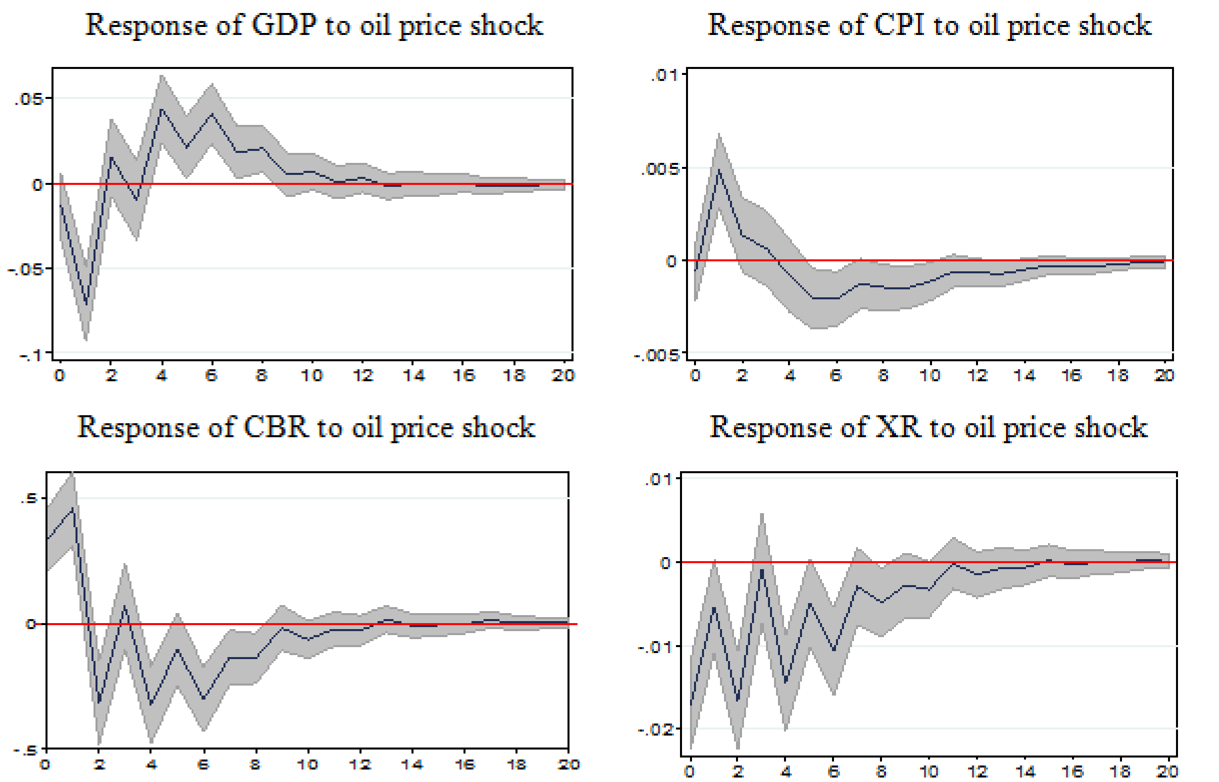
It is noteworthy that the test results exhibit no feedback effects from macro variables to the oil price variable, meaning that macroeconomic variables selected from Azerbaijan do not Granger-cause the global oil prices, which are determined exogenously. These outcomes are consistent with my expectations, because Azerbaijan is a small country and takes the oil prices as given. In other words, neither its output nor macroeconomic variables are capable of influencing world oil prices. Consequently, global oil prices have a statistically significant causal effect on all selected macro variables from Azerbaijan and the robustness tests confirm these inferences with lag length eight on the variables (Table 3). The next section provides further analysis to identify whether the relationship between oil price shocks and macroeconomic activity is negative or positive.

### 5.2. Impulse Response Functions of Linear Specifications

Here, I examine the impact of one-standard deviation oil price shock on other endogenous variables of the five and six-variable linear models in terms of orthogonalized IRFs and accumulated responses over the sample period from 2001q2 to 2018q4. The discussion of the significance of IRFs and accumulated responses is based on 68% confidence intervals (CI) and the prediction periods of the impulse responses are set to 20 steps.

Figure 3 shows IRFs of GDP, inflation, interest rate, and exchange rate after a one-standard deviation innovation in the oil price variable of the baseline five-variable VAR.

**Figure 3:** IRFs of five-variable linear model

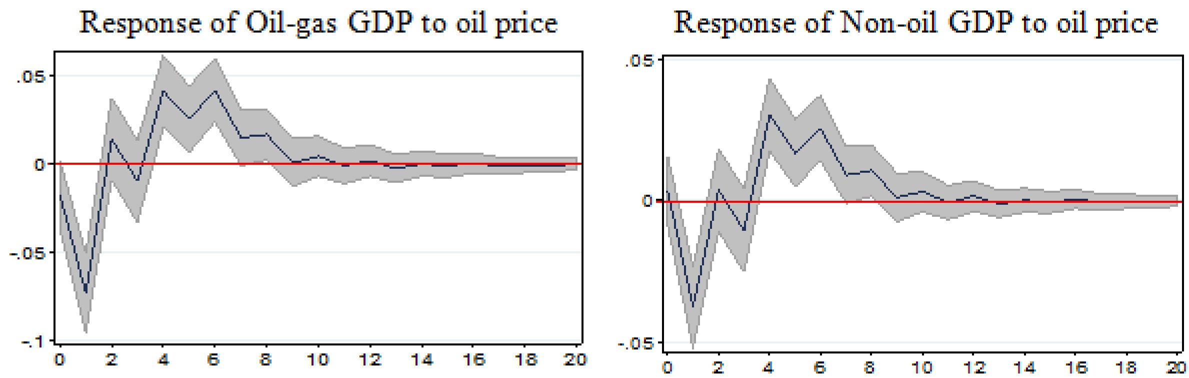



*Notes:* Grey-shaded areas indicate 68% confidence bands, the middle lines represent the impulse response function; ordering of the variables is as (i) OP, (ii) GDP, (iii) CPI, (iv) CBR, and (v) XR.

GDP growth is seen to decrease instantaneously in response to a one-standard-deviation oil price shock. However, under a one-standard error criterion (roughly 68% CI) this response coefficient is not significant (see Lütkepohl 2005, 119), while the second response coefficient is significant, where the shock decreases GDP growth about -7.1 percentage points (pp) in the first quarter after the shock. However, in the fourth quarter, the price shock increases GDP growth 4.4 pp where it reaches the most significant positive effect. The responses to the shock remain positive and significant till quarter eight before the effect shrinks down and gradually dies out almost entirely after about three years. Inflation increases roughly 0.5 pp one period after a one standard deviation oil price shock. The CBA raises the interest rate immediately, as well as one, three and five quarters after the shock, to suppress inflation, which leads to a negative response of inflation four to ten quarters after the oil price innovation. The decline in inflation then leads to a more accommodative monetary policy stance six to ten quarters after the shock. The manat depreciates instantaneously after the shock and reaches its most significant negative effect (-2 pp) until eight periods after the shock. The depreciation of the manat makes foreign goods more expensive by increasing import prices. More expensive raw, intermediary, and capital imports hamper the country's industrial and non-industrial sectors due to these sectors' significant reliance on foreign products.

Figure 4 shows IRFs after a one-standard deviation shock in the oil price variable for the baseline six-variable VAR where quarterly real GDP growth in the oil-gas sector and quarterly real GDP growth in the non-oil sector enter the system as separate variables[5].

**Figure 4:** IRFs of six-variable linear model




*Notes:* Grey-shaded areas indicate 68% confidence bands; the middle lines represent the IRFS; ordering of the variables is as (i) OP, (ii) OG, (iii) NOG, (iv) CPI, (v) CBR, and (vi) XR.

In general, quarterly GDP growth in both sectors responds in a similar fashion. After one quarter, we observe a significant decrease in both sectors and after two and four to nine quarters real GDP growth increases as a response to the oil price shock. It is noteworthy, however, that the magnitude of the responses differs considerably across sectors. The negative response of the oil-gas sector to oil price shock is approximately two times larger (-7.3 pp) than the negative response of the remaining economy (-3.7 pp), while the maximum positive effects are 4.2 pp (oil and gas sector) and 3.0 pp (non-oil sector), indicating that the total effect on real GDP growth is driven by the oil and gas sector.

Table 4 further demonstrates the corresponding cumulative responses of five and six-variable linear models after 100% innovation in oil prices. A 100% oil price shock leads to a loss of growth rates of total GDP roughly 15%, oil-gas sector of GDP 6%, while a gain of the growth rate of the remaining economy roughly 6% cumulatively over the twenty periods. However, due to CI, these responses are significant only until the third quarter, where growth rates in total GDP, the oil-gas sector, and the non-oil sector decrease 51%, 50%, and 31% cumulatively due to the 100% oil price shock. Like in Figure 4, the magnitudes of the accumulated responses of GDP growths in the oil-gas sector (-50%) and the non-oil sector of the economy (-31%) are notably different in table 4, once again confirming the fact that the total effect on real GDP growth is driven by the oil and gas sector.

**Table 4:** Cumulative responses of five and six-variable linear models

| Periods | Five-variable VAR Model | Six-variable VAR Model | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GDP | CPI | CBR | XR | OG | NOG | CPI | CBR | XR | |
| Quarter 1 | **-0.27**† | 0.01 | 1.31 | **-0.08**† | **-0.33**† | **-0.15**† | 0.02 | 1.36 | **-0.08**† |
| Quarter 3 | **-0.51**† | 0.001 | 1.79 | **-0.11**† | **-0.50**† | **-0.31**† | 0.01 | 1.69 | **-0.12**† |
| Quarter 8 | 0.03 | **-0.06**† | -2.49 | **-0.28**† | 0.14 | 0.16 | **-0.05**† | -3.32 | **-0.28**† |
| Quarter20 | -0.15 | **-0.08**† | -1.59 | **-0.26**† | -0.06 | 0.06 | **-0.07**† | -2.46 | **-0.27**† |

*Note:* CBR is given in first difference, the remaining variables are in first log-difference forms. † denotes the significance of the cumulative responses of the variables to a 100% oil price shock.

Oil price shocks also have significant cumulative effects on CPI, CBR and XR variables of both five- and six-variable models with different magnitudes. More precisely, a 100% oil price shock cumulatively decreases the CPI, CBR and XR variables by about 8%, 1.59%, and 26% in the five-variable model, and about 7%, 2.5%, and 27% respectively in the six-variable model. Due to CI, the accumulated responses of CPI to a 100% oil price shock in both models are significant after quarter eight. The responses of interest rates in both models are not significant at all, whereas the responses of exchange rates are significant along the whole prediction periods.

### 5.3. Variance Decompositions of Linear Specifications

Through variance decomposition, we can predict the proportion of the variables' variation when a shock is applied to the variable of oil prices and each of the other macro variables included in the system.

According to Table 5, oil price shocks play a significant role in the variability of all macro variables of the system. Notably, in the case of GDP, oil price shocks are the most significant source of the shock other than GDP itself accounting for about 19%, while oil price shocks comprise roughly 10% of the variation of the CPI. In the case of CBR, and XR variables, the oil price is the second largest source of the shock other than the variables themselves, accounting for roughly 23% and 22%, respectively.

**Table 5:** Variance decomposition of five and six-variable linear models

| **Five-variable VAR Model** | **Six-variable VAR Model** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Short and long-run variance of the macroeconomic variables due to oil price shocks | | | | | | | | | |
| Periods | GDP | CPI | CBR | XR | OG | NOG | CPI | CBR | XR |
| Quarter 1 | 0.01 | 0.00 | 0.10 | 0.15 | 0.01 | 0.00 | 0.01 | 0.10 | 0.15 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Quarter 5 | 0.16 | 0.07 | 0.21 | 0.21 | 0.16 | 0.13 | 0.07 | 0.21 | 0.21 |
| Quarter 10 | 0.19 | 0.10 | 0.23 | 0.22 | 0.12 | 0.16 | 0.10 | 0.23 | 0.21 |
| Quarter 15 | 0.19 | 0.10 | 0.23 | 0.22 | 0.18 | 0.16 | 0.10 | 0.22 | 0.20 |
| Quarter 20 | **0.19** | **0.10** | **0.23** | **0.22** | **0.18** | **0.16** | **0.10** | **0.22** | **0.20** |

*Note:* CBR is given in first difference, the remaining variables are in first log-difference forms.

In the six-variable model, the oil price shocks are substantial in the variance of OG and NOG variables, too. For the OG variable, the oil price is the most significant source of the shock other than the OG variable itself accounting for approximately 18%. In the case of the NOG variable, oil price takes the third place constituting approximately 16% of the variance. Moreover, the oil price is considerable in the fluctuations of the CPI, CBR and XR variables of the six-variable model too, accounting for about 10%, 22% and 20% of the variance, respectively.

An economic interpretation of the inferences obtained from four steps can be summarized based on the economic character of Azerbaijan, which is a so-called “subsidized economy,” or “supply based economy” in some studies (see, for instance, Bayramov and Abbas 2017; and Bayramov and Orujova 2017). The decline in GDP growth in the oil and gas sector one period after the shock can be explained by a reduction of oil revenues as a result of oil price slackening in the world oil market. The corresponding decline in GDP growth in the non-oil economy can be explained by its composition as it is mainly subsidized by government expenditures accumulated from oil incomes and taxes. The sharp oil revenue reduction makes the government incapable of subsidizing the non-oil sector and reduces the state budget expenditures for sustaining the non-oil sector in the initial periods. Therefore, declines (increases) in the oil and gas sector also prompt declines (increases) in the non-oil sector. Non-oil GDP growth is hindered directly by a reduction in oil-revenue-driven government spending and indirectly by depreciation of the exchange rate, which results in more expensive import goods. A tightening of monetary policy in response to the increase in inflation additionally harms the non-oil sector. After a couple of quarters, oil revenues increase in the wake of higher oil prices and GDP growth recovers in both sectors with the oil and gas sector driving the recovery in the remaining economy.

## 6. Empirical Results of Non-Linear Specifications

The previous section indicated that there is a significant relationship between oil price changes and the economic activity of Azerbaijan, and the impact of price shocks is linear. Nevertheless, much of the literature discussed confirms the possibility of asymmetric or non-linear impacts of oil prices. This section focuses on the analysis of two non-linear specifications of world oil prices and estimates the impact of asymmetric and net oil price shocks on the economic activity of Azerbaijan.

### 6.1. Results of Granger Causality Tests: Non-linear Cases

The Granger causality test demonstrates that both asymmetric and net oil price decreases Granger-cause all the macroeconomic variables included in the system (Table 6). More precisely, we can reject the null in favor of the alternative hypothesis that asymmetric and net oil price declines Granger-cause GDP, OG variables at the 1% and the NOG variable at the 5% significance level. Moreover, asymmetric and net decreases in oil prices Granger-cause the CPI and CBR at the 1% level and XR at the 5% significance level.

Further results of the test show that we cannot accept the alternative hypothesis that asymmetric and net oil price increases Granger-cause other macro variables of the system. However, the exchange rate happens to have a causal effect on asymmetric and net oil price increases at the 10% and 5% levels, respectively. As stated in an earlier section, these do not comply with the expectations of the research. I retested the Granger causality test by including eight lags on the variables to check the robustness of this relationship. Results indicate that XR Granger-causes the asymmetric oil price increase variable only at the 10% level; this causal effect of XR on the net oil price increase is not statistically significant. Ultimately, we can conclude that neither asymmetric nor net oil price increases Granger-cause the macro variables and the causal effect of the exchange rate on the oil price increase is not significant.

**Table 6:** Results of Granger Causality test: Asymmetric and Non-Linear Cases

| Null Hypothesis: | **Mork (1989)** | **Hamilton (1996)** | | |
|---|---|---|---|---|
| Tests with 4 lags | Rob. tests with 8 lags | Tests with 4 lags | Rob. tests with 8 lags | |
| **p-value** | **p-value** | | | |
| AOPD/NOPD does not Granger Cause GDP | **0.007*** ** | **0.051*** | **0.003*** ** | **0.015** ** |
| GDP does not Granger Cause AOPD/NOPD | 0.948 | 0.997 | 0.8306 | 0.981 |
| AOPD/NOPD does not Granger Cause OG | **0.008*** ** | **0.047** ** | **0.003*** ** | **0.016** ** |
| OG does not Granger Cause AOPD/NOPD | 0.954 | 0.997 | 0.8447 | 0.986 |
| AOPD/NOPD does not Granger Cause NOG | **0.016** ** | 0.133 | **0.006*** ** | **0.048** ** |
| NOG does not Granger Cause AOPD/NOPD | 0.976 | 0.989 | 0.912 | 0.978 |

| | | | | |
|---|---|---|---|---|
| AOPD/NOPD does not Granger Cause CPI | **0.003*** ** | **0.020** ** | **0.003*** ** | **0.019** ** |
| CPI does not Granger Cause AOPD/NOPD | 0.127 | 0.307 | **0.059* ** | 0.207 |
| AOPD/NOPD does not Granger Cause CBR | **0.018** ** | **0.006*** ** | **0.016** ** | **0.009*** ** |
| CBR does not Granger Cause AOPD/NOPD | 0.927 | 0.982 | 0.903 | 0.988 |
| AOPD/NOPD does not Granger Cause XR | **0.001*** ** | **0.039** ** | **0.019** ** | 0.166 |
| XR does not Granger Cause AOPD/NOPD | 0.971 | 0.993 | 0.862 | 0.975 |
| | | | | |
| AOPI/NOPI does not Granger Cause GDP | 0.403 | 0.483 | 0.361 | 0.577 |
| GDP does not Granger Cause AOPI/NOPI | 0.129 | 0.611 | 0.577 | 0.554 |
| AOPI/NOPI does not Granger Cause OG | 0.409 | 0.453 | 0.377 | 0.499 |
| OG does not Granger Cause AOPI/NOPI | 0.165 | 0.483 | 0.607 | 0.434 |
| AOPI/NOPI does not Granger Cause NOG | 0.553 | 0.802 | 0.438 | 0.643 |
| NOG does not Granger Cause AOPI/NOPI | 0.248 | 0.361 | 0.610 | 0.675 |
| AOPI/NOPI does not Granger Cause CPI | 0.419 | 0.557 | 0.342 | 0.701 |

| | | | | |
|---|---|---|---|---|
| CPI does not Granger Cause AOPI/NOPI | 0.126 | 0.101 | 0.142 | 0.249 |
| AOPI/NOPI does not Granger Cause CBR | 0.147 | 0.255 | 0.123 | 0.421 |
| CBR does not Granger Cause AOPI/NOPI | 0.133 | 0.327 | 0.521 | 0.483 |
| AOPI/NOPI does not Granger Cause XR | 0.112 | 0.359 | 0.286 | 0.616 |
| XR does not Granger Cause AOPI/NOPI | **0.059*** | **0.051*** | **0.023**** | 0.120 |

*Notes:* *, ** and *** implies that F-statistics is significant at 10%, 5% and 1% levels, respectively. AOPD and AOPI stand for asymmetric increase and decrease in oil prices, while NOPD and NOPI stand for net decease and increase in oil prices.

Thus, asymmetric and net increases in oil prices do not have a significant causal-effect on the variables; this notwithstanding, asymmetric and net decreases in oil prices are statistically significant in Granger-causing all macro variables from Azerbaijan.

### 6.2. Impulse Response Functions for Non-linear Specifications

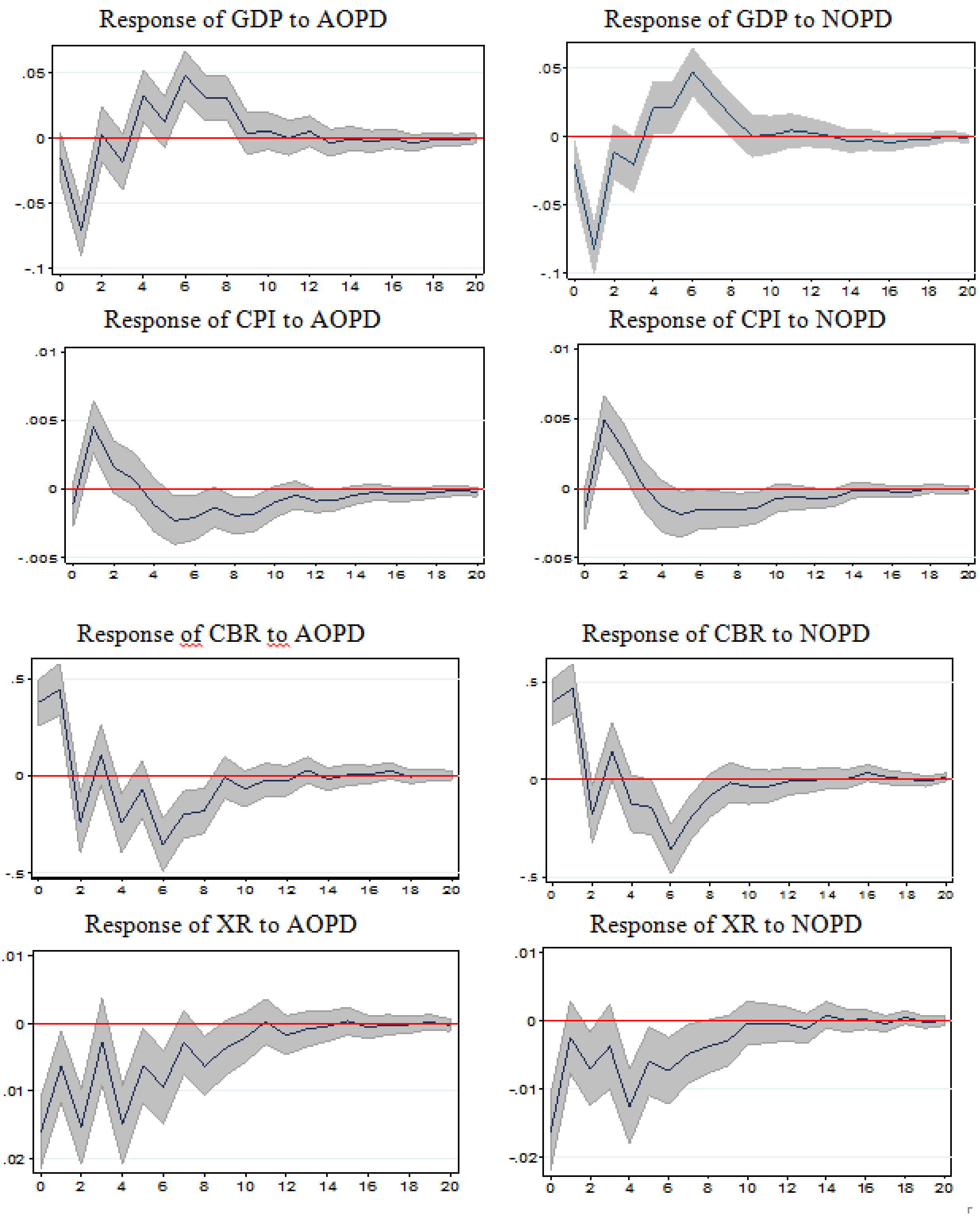
This section examines the impacts of oil prices on macroeconomic variables in terms of impulse response functions and accumulated responses for the asymmetric and non-linear specifications. Due to the limited scope of the study, I consider only the first five-variable model in the analysis.

Figure 5 depicts the Orthogonalized IRFs of GDP, inflation, interest rate and exchange rate after a negative one-standard-deviation innovation in both asymmetric and net oil price changes.

GDP growth retards instantaneously after a negative one-standard-deviation innovation in both asymmetric and net oil prices. The most significant adverse effects of both oil price shocks occur in the first quarter, after the initial negative shock, and retard the GDP growth significantly with slightly different magnitudes. The responses become positive and significant after four and eight quarters, where the shock reaches its largest positive effect in quarter six before fading out almost totally in about three years. Because of the public-spending-driven feature of the economy, the negative oil price shock happens to hamper GDP growth, as well as the subsidized non-oil sector, due to a substantial reduction in oil revenues in the initial three periods. Besides, the positive responses of GDP growth to negative price shock in subsequent periods could be associated with the sizable government expenditures driven from oil fund assets to aid in the recovery of economic growth.

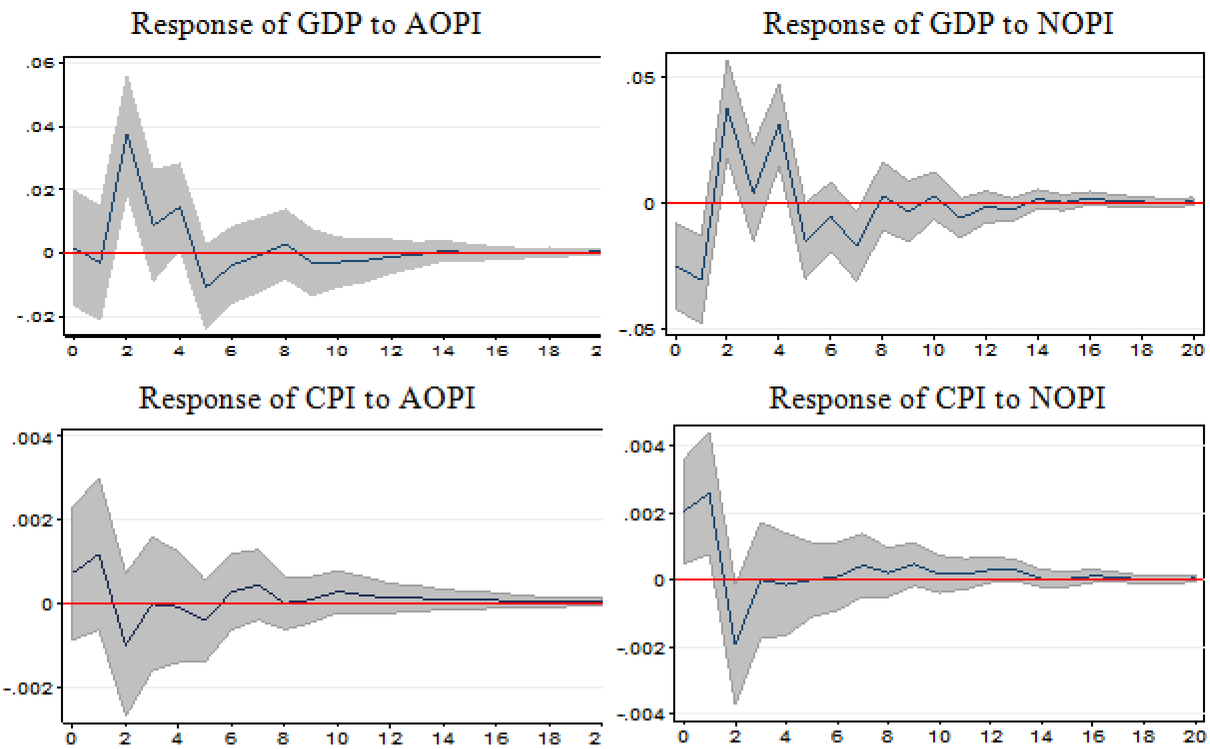
Inflation increases sharply after both negative oil price shocks in the first quarter, while in fact, the CBA responds to oil price declines with a tightening of monetary policy immediately and after one quarter. Following that, inflation declines and remains negative for four to nine quarters. The exchange rate depreciates right away by both negative price shocks, and the most considerable effects occur instantly after the initial shock. Both negative responses remain significantly different from zero over the whole forecast period until fading away almost entirely. The significant fall of the exchange rate leads to a substantial depreciation of the domestic currency (and, due to government policy – not considered as a variable in this research – a massive reduction in the government’s foreign exchange revenues). When oil revenue shrinks due to an oil price fall, the government struggles with a deficit of resources to clear the domestic exchange market and protect the exchange rate. The depreciation of the national currency results in higher import prices and more expensive foreign goods. Due to the country’s strong dependency on raw, intermediary, capital and consumable imports, the industrial production and non-tradable sector decrease, whereas inflation increases substantially.

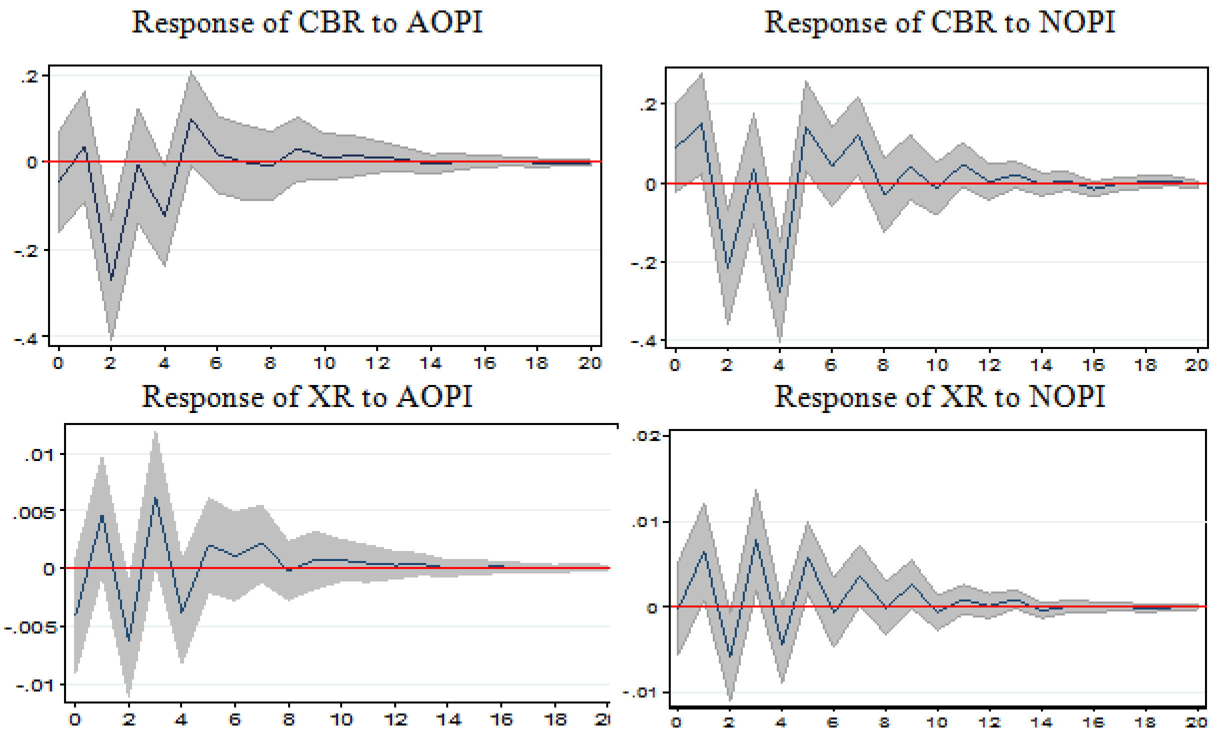
**Figure 5:** IRFs of variables to asymmetric and net oil price decreases




*Notes:* Grey-shaded areas indicate 68% asymptotic confidence bands, the middle lines represent the impulse response function; left hand-side of the figure displays responses of variables to AOPD, right hand-side to NOPD, respectively. Ordering of the variables is as (i) AOPD, (ii) AOPI, (iii) GDP, (iv) CPI, (v) CBR, and (vi) XR; (i) NOPD, (ii) NOPI, (iii) GDP, (iv) CPI, (v) CBR, and (vi) XR.

**Figure 6:** IRFs of variables to asymmetric and net oil price increases






*Notes:* Grey-shaded areas indicate 68% asymptotic confidence bands, the middle lines represent the impulse response function; the left-hand-side of the figure displays responses of variables to AOPI, right-hand-side to NOPI, respectively. Ordering of the variables is as (i) AOPD, (ii) AOPI, (iii) GDP, (iv) CPI, (v) CBR, and (vi) XR; (i) NOPD, (ii) NOPI, (iii) GDP, (iv) CPI, (v) CBR, and (vi) XR.

Figure 6 depicts the Orthogonalized IRFs of GDP, inflation, interest rate and exchange rate after a positive one-standard-deviation innovation in both asymmetric and net oil price changes.

A one-unit positive shock to each of the asymmetric and net oil price changes has different effects on GDP growth in the first quarter. In particular, the response of GDP growth to the asymmetric oil price increase only becomes significant after two and four quarters, and in quarter two GDP growth demonstrates its largest positive effect. On the contrary, the GDP growth rate retards immediately after the initial shock and reaches its largest negative effect in quarter one. The negative response of GDP growth to positive oil price shock can be explained by the immediate tightening of the interest rate in terms of suppressing the instantaneously increasing inflation till quarter two. We only observe a significant increase in inflation for one quarter after positive innovations (immediately after the shock) in net oil price specification, whereas responses after an increase in asymmetric oil price definition are insignificant over the whole prediction periods. Responses to positive price shock increase and GDP growth become positive and significant after two and four quarters. Correspondingly, inflation declines considerably in quarter two, while CBA cuts its interest rate following the decline in inflation and increase in GDP growth in quarters two and four. The exchange rate appreciates in one, and three to five quarters after a net oil price shock increase, while the response coefficients of exchange rate to asymmetric oil price increase happen to be insignificant over the whole prediction period. Exchange rate appreciation also limits the external competitiveness of the economy and, taken together with the increase in inflation, my results provide evidence that the Dutch Disease might apply to Azerbaijan.

As expected, the positive response of economic growth to oil price increases is compatible with the expectations of the research despite the contradiction with the Granger causality test inferences. The explanation for this contradiction is quite straightforward: rising oil prices increase oil reserves of the State Oil Fund (a sovereign wealth fund) automatically and boost oil-gas GDP growth directly. Consequently, non-oil GDP growth rises indirectly through government spending driven by oil fund transfers and hence, aggregate GDP growth increases.

The inflationary effect of positive oil price shocks in countries that suffer from Dutch syndrome could be explained through the “Spending Effect” which is proposed by Corden (1984). According to Corden, higher oil price windfalls lead to higher wages or profits in the booming sector (oil-gas sector) and provide positive income elasticity of demand for non-tradables (non-oil sector) due to indirect government spending (driven by taxes or other sources) or direct spending of company owners. Since the price of the tradable sector is determined in the world market exogenously, and the price of non-tradables is determined in the domestic market, the prices of non-tradables rise relative to the prices of tradables, leading to real appreciation. It absorbs resources from the booming sector into the non-tradable and causes inflation in these sectors (Corden 1984, 359-363).

Table 6 reports the corresponding cumulative responses of GDP, CPI, CBR and XR to 100% innovation in asymmetric and net oil changes. A negative shock to asymmetric and net oil prices has a negative cumulative effect on the GDP growth with different magnitudes. More precisely, a 100% negative shock to Mork's (1989) and Hamilton's (1996) oil price specifications cumulatively decreases the GDP growth by about 78% and 126%, respectively. Notwithstanding, because of CI the long-run response of GDP to AOPD is significant only up until quarter six, where GDP growth declined 64%, while long-run responses to NOPD are significant along the whole prediction periods. Further, a 100% shock to AOPD and NOPD cumulatively decreases XR about 61% and 22%, correspondingly, but unlike AOPD, the long-run responses of XR to NOPD are significant till quarter six where it decreases about 18% cumulatively. Thus, Hamilton's NOPD specification happens to perform a more extensive and more significant adverse effect on the GDP growth of Azerbaijan in the long-term relative to Mork's AOPD specification, while in the case of XR, the latter is stronger than the former. Moreover, a 100% negative shock to AOPD and NOPD has cumulative negative effects on inflation, accounting for about 18% and 8%, respectively. Responses to AOPD are significant from quarter five until the end of the forecast periods, while response coefficients to NOPD are only significant in quarter one. Besides, the cumulative responses of interest rate to a 100% shock in both AOPD and NOPD variables are different and significant until quarters four and six, respectively.

According to Table 6, a 100% shock to AOPI and NOPI have different cumulative effects on GDP, whereas the significant responses occur only within quarter one and four. The GDP growth rate increases roughly 115% and 107% in response to a 100% shock in AOPI and NOPI in quarter four, respectively. A 100% shock to both price definitions cumulatively increases inflation; however, response coefficients are not significant entirely due to CI. The responses of the interest rate to a 100% shock in AOPI and NOPI are significant until quarter three and only in quarter four, respectively, where it decreased cumulatively. Additionally, a 100% shock to AOPI and NOPI cumulatively increases XR about 37% and 55%, correspondingly. Nevertheless, the responses are only significant in the case of NOPI along the entire prediction periods, meaning that NOPI leads to an appreciation of the exchange rate in the long term.

**Table 6:** Cumulative responses of asymmetric and non-linear specifications

| Periods | **Asymmetric oil price decrease and increase** Mork (1989) | **Net oil price decrease and increase**Hamilton (1996) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| response shock | GDP | CPI | CBR | XR | response shock | GDP | CPI | CBR | XR | |
| Quarter 1 | AOPD | **-0.55†** | 0.01 | **2.86†** | **-0.16†** | NOPD | **-0.71†** | **0.03†** | **3.33†** | -0.05 |
| Quarter 4 | AOPD | **-1.05†** | -0.02 | **2.94†** | **-0.37†** | NOPD | **-1.49†** | 0.01 | **5.93†** | **-0.11†** |
| Quarter 6 | AOPD | **-0.64†** | **-0.08†** | 0.52 | **-0.48†** | NOPD | **-0.98†** | -0.03 | **2.83†** | **-0.18†** |
| Quarter 20 | AOPD | -0.78 | **-0.18†** | -0.14 | **-0.61†** | NOPD | **-1.26†** | -0.08 | 3.75 | -0.22 |
| Quarter 1 | AOPI | **0.11†** | 0.01 | **-0.79†** | 0.06 | NOPI | **-0.33†** | 0.03 | 0.76 | **0.12†** |
| Quarter 4 | AOPI | **1.15†** | -0.01 | **-7.26†** | 0.11 | NOPI | **1.07†** | -0.02 | **-7.34†** | **0.27†** |
| Quarter 6 | AOPI | 0.58 | -0.00 | **-3.34†** | 0.23 | NOPI | 0.37 | -0.01 | -2.48 | **0.36†** |
| Quarter 20 | AOPI | 0.30 | 0.06 | -0.85 | 0.37 | NOPI | -0.27 | 0.08 | 2.54 | **0.55†** |

*Note*: CBR is given in first difference remaining variables are in first log-difference forms. † denotes the significance of the cumulative responses of the variables to a 100% oil price shocks.

To summarize, impulse response analysis exhibited that both negative and positive oil price shocks have a significant effect on all macro variables of the system. However, negative shocks have a more significant recessionary, inflationary, monetary and currency impact on Azerbaijan's economy relative to the favorable effect of positive price shocks. Also, exchange rate appreciation and rise of inflation due to positive oil price shocks support the presence of Dutch Disease in Azerbaijan.

### 6.3. Variance Decomposition for Asymmetric and Non-linear Specifications

According to Table 7, specified asymmetric oil price decreases and net oil price decreases are the major source of variance in all macro variables included in the system, particularly in GDP, in relation to which they occupy the first place (other than the variable itself) contributing roughly 20% and 23%, respectively. Furthermore, both specified oil price variables also play a considerable role in the variability of inflation, interest rate, and exchange rate variables. More precisely, the asymmetric oil price decreases account for approximately 11%, 23% and 21% of variance in CPI, CBR and XR variables, individually, while net oil price decreases account for roughly 12%, 22% and 14% of variance in CPI, CBR and XR variables, respectively.

In the case of positive shocks, Table 7 demonstrates that specified asymmetric and net oil price increase variables play a minor role in the variance of all macroeconomic variables relative to asymmetric and net oil price decrease variables. More precisely, asymmetric oil price increases explain less than 5% of variance in other variables including GDP, whereas net oil price increases explain less than 10% of variance in other variables including GDP.

**Table 7:** Variance decomposition of asymmetric and non-linear specifications

| Periods | **Asymmetric oil price decrease and increase** Mork (1989) | **Net oil price decrease and increase** Hamilton (1996) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| variance shock | GDP | CPI | CBR | XR | variance shock | GDP | CPI | CBR | XR | |
| Quarter 1 | AOPD | 0.01 | 0.01 | 0.14 | 0.14 | NOPD | 0.02 | 0.01 | 0.16 | 0.12 |
| Quarter 5 | AOPD | 0.16 | 0.07 | 0.20 | 0.19 | NOPD | 0.20 | 0.10 | 0.19 | 0.13 |
| Quarter 10 | AOPD | 0.19 | 0.11 | 0.23 | 0.21 | NOPD | 0.22 | 0.12 | 0.22 | 0.14 |
| Quarter 15 | AOPD | 0.20 | 0.11 | 0.23 | 0.21 | NOPD | 0.22 | 0.12 | 0.22 | 0.14 |
| Quarter 20 | AOPD | **0.20** | **0.11** | **0.23** | **0.21** | NOPD | **0.23** | **0.12** | **0.22** | **0.14** |
| Quarter 1 | AOPI | 0.00 | 0.00 | 0.00 | 0.01 | NOPI | 0.03 | 0.03 | 0.01 | 0.00 |
| Quarter 5 | AOPI | 0.04 | 0.01 | 0.04 | 0.03 | NOPI | 0.09 | 0.04 | 0.07 | 0.04 |
| Quarter 10 | AOPI | 0.03 | 0.01 | 0.04 | 0.03 | NOPI | 0.08 | 0.04 | 0.07 | 0.05 |
| Quarter 15 | AOPI | 0.03 | 0.01 | 0.04 | 0.03 | NOPI | 0.08 | 0.04 | 0.07 | 0.05 |
| Quarter 20 | AOPI | **0.03** | **0.01** | **0.04** | **0.03** | **NOPI** | **0.08** | **0.04** | **0.07** | **0.05** |

*Note:* R is given in first difference remaining variables are in first log-difference forms.

Thus, variance decomposition confirms the preceding inferences showing that negative oil price shocks are more informative in explaining the variance in other macro variables of the system relative to positive oil price shocks. It is worth noting that both negative oil price definitions appeared to have more or less the same explanatory power over the sample period of the research, while Hamilton’s (1996) net oil price increase definition seems to be stronger in explaining most of the macroeconomic variables of the system relative to Mork’s (1989) asymmetric oil price increase specification.

## 7. Conclusion

Thanks to high resource windfalls in the last decades, Azerbaijan was able to achieve high economic growth. However, the oil price slump of 2014 showed that Azerbaijan’s economy is both heavily dependent on energy exports and operates based on large government expenditures driven by State Oil Fund assets. This paper sheds more light on Azerbaijan’s exposure to oil fluctuations. I analyze the impacts of oil price shocks on quarterly GDP growth, inflation, interest rate and exchange rate variables using vector autoregressive models for the period 2001q2-2018q4.

The key findings of the research are as follows: Firstly, there is a significant linear relationship between oil price shocks and the economic activity of Azerbaijan. Linear oil price shocks hamper aggregate GDP growth, and GDP growth in oil-gas and non-oil sectors in the first three quarters, while increasing them in the fourth and sixth quarters with growing responses. The decline in the oil-gas sector can be explained by a reduction of oil revenues due to the slackening oil prices in the world market. The corresponding decline in GDP growth in the non-oil economy can be explained by its composition, as it is driven by government expenditures subsidized mainly from oil income. The sharp reduction in oil revenues limits the government’s capacity to subsidize the remaining economy. Hence, downturns (upswings) in the oil and gas sector also prompt corresponding downturns (upswings) in the non-oil sector. After several quarters, oil revenues increase in the wake of higher oil prices and GDP growth recovers in both sectors, with the oil and gas sector driving the recovery in the remaining economy. Secondly, oil price shocks affect significantly the inflation, interest rate and exchange rate, leading to increased inflation, tightened monetary policy and depreciation of the exchange rate in the country. Depreciation of the manat leads to more expensive foreign goods. A tightening of monetary policy in response to the increase in inflation additionally harms the non-oil sector.

The results of non-linear specifications are as follows: Both, negative and positive oil price shocks have a significant impact on all variables included in the system, but the magnitudes are quite different. Negative oil price shocks have a significant adverse impact on economic activity with a larger magnitude than the positive impact of oil price shocks’ positive effect. This means that negative shocks have a more recessionary impact on the economy of Azerbaijan than the expansionary effect of positive oil price shocks. Finally, positive and negative oil price shocks lead to the appreciation and depreciation of the exchange rate and higher inflation. The appreciation of the manat, taken together with high inflation, indicates that the Dutch Disease syndrome is pertinent to Azerbaijan.

**References**

An, L., Jin, X., and Ren, X. (2014): "Are the Macroeconomic Effects of Oil Price Shock Symmetric? A Factor-Augmented Vector Autoregressive Approach," *Energy Economics* 45, 217-228.

Bayramov, V., and Orujova, L. (2017): "Volatility, Diversification and Oil Shock in Resource-Rich Turkic Countries: Avenues for Recovery," *Bilig – Türk Dunyası Sosyal Bilimler Dergisi* 83, 303-329.

Bayramov, V., and Abbas, G. (2017): "Oil Shock in the Caspian Basin: Diversification Policy and Subsidized Economies," *Resources Policy* 54, 149-156.

Burbidge, J., and Harrison, A. (1984): "Testing for the Effects of Oil-price Rises Using Vector Autoregressions," *International Economic Review* 459-484.

Bernanke, B. S., Gertler, M., Watson, M., Sims, C. A., and Friedman, B. M. (1997): "Systematic Monetary Policy and the Effects of Oil Price Shocks," *Brookings Papers on Economic Activity* 91-157.

Balke, N.S., Brown, S.P., and Yücel, M.K., (2002): "Oil Price Shocks and the US Economy: Where Does the Asymmetry Originate?" *The Energy Journal*, 27-52.

Brooks, C. (2008): "Introductory Econometrics for Finance," 2nd Edition, Cambridge University Press.

Berument, H., Ceylan, N. B., and Dogan, N. (2010): "The Impact of Oil Price Shocks on the Economic Growth of the Selected

MENA Countries," *The Energy Journal* 31(1), 149-176.

Bergmann, P. (2019): "Oil Price Shocks and GDP Growth: Do Energy Shares Amplify Causal Effects?" *Energy Economics* 80, 1010-1040.

Corden, W.M. (1984): "Booming Sector and Dutch Disease Economics: Survey and Consolidation," *Oxford Economic Papers 36*(3), 359-380.

Ciarreta, A., and Nasirov, S. (2012): "Development Trends in the Azerbaijan Oil and Gas Sector: Achievements and Challenges," *Energy Policy* 40, 282-292.

Dickey, D.A., and Fuller, W.A. (1979): "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association* 74(366a)*,* 427-431.

Darby, M.R. (1982): "The Price of Oil and World Inflation and Recession," *The American Economic Review* 72(4), 738-751.

Davis, S.J., and Haltiwanger, J. (2001): "Sectoral Job Creation and Destruction Responses to Oil Price Changes," *Journal of Monetary Economics* 48(3), 465-512.

Du, L., Yanan, H., and Wei, C. (2010): "The Relationship between Oil Price Shocks and China's Macro-economy: An Empirical Analysis," *Energy policy*, 38(8), 4142-4151.

Donayre, L., and Wilmot, N. (2016): "The Asymmetric Effects of Oil Price Shocks on the Canadian Economy," *International Journal of Energy Economics and Policy* 6(2), 167-182.

Emami, K., and Adibpour, M. (2012): "Oil Income Shocks and Economic Growth in Iran," *Economic Modelling* 29(5), 1774-1779.

Ferderer, J.P. (1996): "Oil Price Volatility and the Macroeconomy," *Journal of macroeconomics* 18(1), 1-26.

Farzanegan, M.R., and Markwardt, G. (2009): "The Effects of

Oil Price Shocks on the Iranian Economy," *Energy Economics* 31(1), 134-151.

Granger, C.W. (1969): "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica: Journal of the Econometric Society*, 424-438.

Gisser, M., and Goodwin, T.H. (1986): "Crude Oil and The Macroeconomy: Tests of Some Popular Notions," *Journal of Money, Credit and Banking* 18(1), 95-103.

Hamilton, J. D. (1983): "Oil and the Macroeconomy since World War II," *Journal of Political Economy* 91(2), 228-248.

Hamilton, J. D. (1994): "Time Series Analysis," Princeton University Press, NJ.

Hamilton, J. D. (1996): "This is What Happened to the Oil Price-macroeconomy Relationship," *Journal of Monetary Economics*, 38(2), 215-220.

Hamilton, J.D. (2003): "What is An Oil Shock?" *Journal of Econometrics* 113(2), 363-398.

Hamilton, J.D., and Herrera, A.M. (2004): "Comment: Oil Shocks and Aggregate Macroeconomic Behaviour: The Role of Monetary Policy," *Journal of Money, Credit and Banking*, 265-286.

Hamilton, J.D. (2011): "Nonlinearities and the Macroeconomic Effects of Oil Prices," *Macroeconomic Dynamics* 15(S3), 364-378.

Hooker, M.A. (1996): "What Happened to the Oil Price-macroeconomy Relationship?" *Journal of Monetary Economics* 38(2), 195-213.

Hooker, M.A. (2002): "Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications Versus Changes in Regime," *Journal of Money, Credit and Banking* 540-561.

Herrera A.M., Lagalo, L.G., and Wada, T. (2011): "Oil Price

Shocks and Industrial Production: Is the Relationship Linear?” *Macroeconomic Dynamics* (15), 472-497.

Herrera, A.M., Lagalo, L.G., and Wada, T. (2015): “Asymmetries in the Response of Economic Activity to Oil Price Increases and Decreases?” *Journal of International Money and Finance* 50, 108-133.

Iwayemi, A., and Fowowe, B. (2011): “Impact of Oil Price Shocks on Selected Macroeconomic Variables in Nigeria,” *Energy policy* 39(2), 603-612.

Jimenez-Rodriguez, R., and Sanchez, M. (2004): “Oil Price Shocks and Real GDP Growth: Empirical Evidence for some OECD Countries,” *European Central Bank Working Paper* 362, pp 04-61.

Jimenez-Rodriguez, R., and Sanchez, M. (2005): “Oil Price Shocks and Real GDP Growth: Empirical Evidence for Some OECD Countries,” *Applied Economics*, *37*(2), 201-228.

Kilian, L., and Vigfusson, R.J. (2009): “Are the Responses of the U.S. Economy Asymmetric in Energy Price Increases and Decreases?” Working Paper, University of Michigan.

Kilian, L., (2009). “Not all Oil Price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market,” *American Economic Review* 99(3), 1053-1069.

Kilian, L., and Vigfusson, R.J. (2011): “Are the Responses of the US Economy Asym-metric in Energy Price Increases and Decreases?” *Quantitative Economics 2*(3), 419-453.

Kilian, L., and Vigfusson, R.J. (2013): “Do Oil Prices Help Forecast US Real GDP? The Role of Nonlinearities and Asymmetries,” *Journal of Business and Economic Statistics* 31(1), 78-93.

Lütkepohl, H. (2005): “New Introduction to Multiple Time Series Analysis,” Springer Science & Business Media.

Lee, K., Ni, S., and Ratti, R.A. (1995): “Oil Shocks and the Macroeconomy: The Role of Price Variability,” *The Energy Journal*, 39-56.

Lee, B.R., Lee, K., and Ratti, R.A. (2001): “Monetary Policy, Oil Price Shocks, and the Japanese Economy,” *Japan and the World Economy* 13(3), 21-349.

Lorde, T., Jackman, M., and Thomas, C. (2009): “The Macroeconomic Effects of Oil Price Fluctuations on a Small Open Oil-producing Country: The Case of Trinidad and Tobago,” *Energy Policy 37*(7), 2708-2716.

Mork, K.A. (1989): “Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton’s Results,” *Journal of Political Economy* 97(3), 740-744.

Mork, K. A., Olsen, Ø., and Mysen, H. T. (1994): “Macroeconomic Responses to Oil Price Increases and Decreases in Seven OECD Countries,” *The Energy Journal*, 19-35.

Mork, K. A. (1994): “Business Cycles and the Oil Market,” *The Energy Journal*, 15-38.

Mory, J. F. (1993): “Oil Prices and Economic Activity: Is the Relationship Symmetric?” *The Energy Journal*, 151-161.

Mehrara, M., and Oskoui, K.N. (2007): “The Sources of Macroeconomic Fluctuations in Oil Exporting Countries: A Comparative Study,” *Economic Modelling 24*(3), 365-379.

Olomola, P.A., and Adejumo, A.V. (2006): “Oil Price Shock and Macroeconomic Activi-ties in Nigeria,” *International Research Journal of Finance and Economics 3*(1), 28-34.

Phillips, P.C., and Perron, P. (1988): “Testing for a Unit Root in Time Series Regression,” *Biometrika* 75(2), 335-346.

Rasche, R. H., and Tatom, J. A. (1977): “The Effects of the New Energy Regime on Economic Capacity, Production, and

Prices,” *Federal Reserve Bank of St. Louis Review* 59(4), 2-12.

Rasche, R.H., and Tatom, J.A. (1981) “Energy Price Shocks, Aggregate Supply and Monetary Policy: The Theory and International Evidence,” *Journal of Monetary Economics* 14(7), 9-93.

Rautava, J. (2004): “The Role of Oil Prices and the Real Exchange Rate in Russia’s Economy—A Cointegration Approach,” *Journal of Comparative Economics 32*(2), 315-327.

Rahman, S., and Serletis, A. (2010): “The Asymmetric Effects of Oil Price and Monetary Policy Shocks: A Nonlinear VAR Approach,” *Energy Economics* 32(6), 1460-1466.

Sims, C. A. (1980): “Macroeconomics and Reality,” *Econometrica: Journal of the Econometric Society*, 1-48.

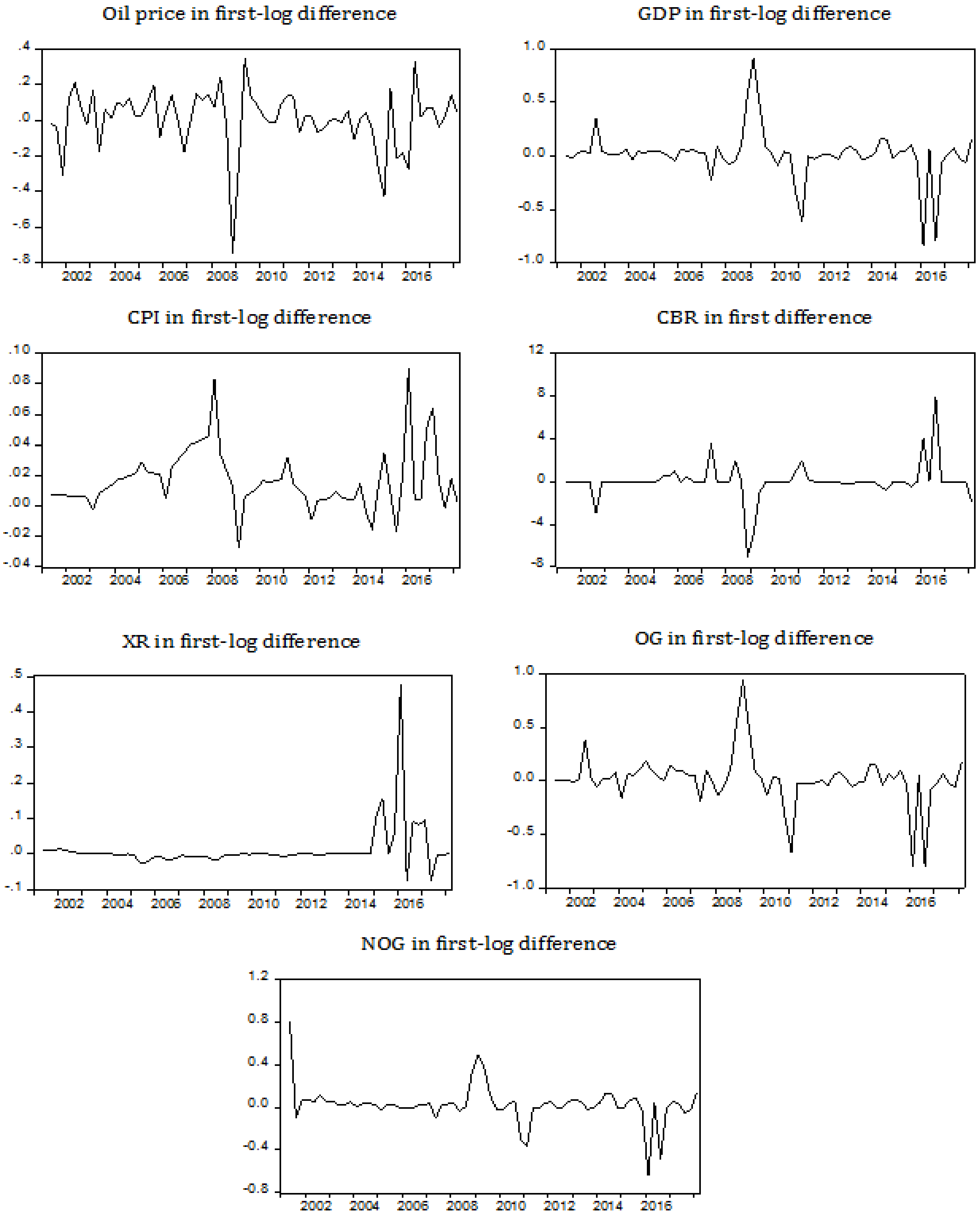
Sims, C. A. (1981): “An Autoregressive Index Model for The U.S. 1948-1975,” in J. Kmenta and J. B. Ramsey Editions, Large-Scale Macro-Econometric Models, North-Holland, Amsterdam, 283–327.

Tatom, J. (1988): “Are the Macroeconomic Effects of Oil Price Changes Symmetric?” In Karl Brunner and Allan H. Meitzer Editions, Stabilization Policies and Labor Markets*, Carnegie Rochester Conference Series in Public Policy* (28), 325-368. North-Holland.

Zulfigarov, F., and Neuenkirch, M. (2019): “Azerbaijan and its Oil Resources: Curse or Blessing?” *University of Trier, Research Papers in Economics,* (2019-11), 1-19

**Appendix**

**Figure A1:** Macroeconomic variables in Azerbaijan and World Oil Prices




*Notes*: All series are linearly de-trended. CBR is in first difference; remaining variables are in first-log difference. *Source:* U.S. Energy Information Administration (real OP), State Statistical Committee of the Republic of Azerbaijan (GDP, OG and NOG), International Monetary Fund (CPI, CBR and XR).

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[2] Developed by Clive W.J. Granger (1969), the Granger causality test is a method to estimate formally whether one variable is causal to another. However, it is not informative of whether the fluctuations in the given data have an immediate negative or positive impact on the other series and how many periods a shock has influence in the system (Brooks 2008, 289).

[3] IRF was generated as an extension to the VAR system to obtain complete information on the interaction of the variables that cannot be addressed by Granger causality tests. The IRF defines how and for how many subsequent periods, one exogenous shock or innovation on a variable's residuals affects the other variables, and until which period the shock has an influence on the variables in the system (Lütkepohl 2005, 51).

[4] FEVD is another tool for interpreting a VAR model. It identifies how much of the movements in a variable can be explained by its shocks versus exogenous innovations to the other variables (Brooks 2008, 300).

[5] To conserve space, I only report the results of the production indicators as the responses of the remaining variables (available on request) demonstrate the similar

patterns as in the Figure 6.