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# Implications of Oil Price Changes for the Economy: An Aggregate Analysis for Pakistan

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**Abstract:** *This study utilizes interim multipliers analysis based on a VAR-X model to investigate the impacts of changes in the world's crude oil prices on output growth rates, inflation rates, real exchange rates, and real interest rates in Pakistan. The study finds that following oil price inflation, the output growth rate initially increases but then declines in the medium to long run. The effects of oil price deflation on output growth are the opposite, though smaller in magnitude. Oil price inflation is also found to cause a moderate increase in the overall inflation rate, while oil price deflation reduces the inflation rate by a smaller margin. The resilience of the economy to oil price changes is attributed to the low share of oil in production costs, subsidized oil prices by Middle Eastern countries, remittance inflows from workers in the Gulf States, and the managed exchange rate regime. The study recommends the continuation of a conservative monetary policy, the development of inter-provincial political consensus on major hydro projects, and the ensuring of the credibility of fiscal measures aimed at the solarization of the economy, focusing more on long-term considerations rather than short-term budgetary compulsions.*

**Keywords:** Oil Price, Output, Inflation, Standard-VAR, Interim-Multiplier

**JEL Classification:** C32, E31, E43, Q31, Q43.

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# Implications of Oil Price Changes for the Economy: An Aggregate Analysis for Pakistan

## 1. Introduction

Despite the ongoing debate regarding the role of alternative renewable energy sources such as water, solar, and nuclear power, oil continues to play a critical role for many countries (Abdelsalam, 2020). Due to massive industrialization around the world, the demand for crude oil and its refined products has escalated rapidly. The economies of poorer and developing countries that import oil to keep their industries running are much more vulnerable to significant fluctuations in oil prices. Increases in oil prices also constrain government spending, as they often must absorb these increases by providing compensatory subsidies to consumers, which detracts from developmental expenditure.

An oil price shock is typically defined as a significant increase in oil prices that can lead to an economic downturn and rising inflation rates. The 1973 oil crisis resulted in a 4.7% decrease in GDP in the USA, 2.5% in Europe, and 7% in Japan, while the 1979 shock caused a 3% decline in global GDP (Salameh, 2015). An oil price shock may arise from a sudden surge in oil demand due to rapid global economic expansion or stagnation in production capacity (Salameh, 2015).

Since the first oil shock of 1973, international oil price variations have been a critical part of business cycle models across different countries. Exploring the relationship between energy prices and macroeconomic variables continues to be a fruitful research area for both academic and policy circles worldwide. Most research has concentrated on the effects of oil price fluctuations on GDP, with recent interest focusing on asymmetry in this relationship.

Undoubtedly, significant fluctuations in energy prices have also been a troubling factor for Pakistan's economy. The latest issue of the *Pakistan Economic Survey* (2022-23) indicates that during the past two fiscal years (2021-22 and 2022-23), Pakistan spent over 50% of its export earnings on the import of crude oil and petroleum products. This highlights the vulnerability of Pakistan's balance of payments and, consequently, inflation and the value of its currency, which necessitates borrowing and further exacerbates the deterioration in the balance of payments and exchange rate.

Pakistan has experienced episodes of stagflation over the past few decades. Khan and Ahmed (2011) indicate that a series of supply-side shocks, specifically global commodity price shocks, are at the root of the stagflation. Kiani (2011) also reports similar findings, noting that higher crude oil prices in the global market slow down the growth process. A threshold analysis of the relationship between Pakistan's output or real GDP and oil price increases conducted by Malik (2008) reveals a positive relationship between the two variables up to a certain threshold. Beyond this threshold, further increases in oil prices begin to harm the economy. Malik et al. (2017) also find that oil price hikes negatively impact Pakistan's real GDP and exchange rate while positively affecting inflation. Saleem et al. (2015) demonstrate a strong correlation between changes in oil prices and inflation in Pakistan, particularly when oil prices are on a continuous upward trend. Hanif et al. (2017) found that global oil price hikes cause inflation in Pakistan's administered prices and non-food prices. More recently, Andleeb and Ahmad (2025) have observed that Pakistan faced the highest inflation rates during the years 2008, 20011, 2019-20, and 2022-24, when inflation was triggered by rising oil and commodity prices in global markets.

Although numerous studies have analyzed the implications of oil price variations for Pakistan's economy, particularly regarding GDP growth and the inflation rate, their findings are based on models that may not be suitable for the context. The existing literature can be categorized into two strands. One approach commonly employed by recent studies treats oil prices similarly to other endogenous variables by relying on a standard VAR model (see, for example, Malik (2008) and Kayani (2011)). This approach is appropriate for a large country whose economic activity can influence world oil prices. However, the size of Pakistan's economy, especially its trade volume, is not large enough to significantly impact world oil prices, which are determined by factors external to Pakistan.

The second approach is to adopt the alternative extreme position by treating all but one focused variable as exogenous variables. This method was prevalent in earlier studies that relied on traditional regression analysis but has recently been revised through the application of the ARDL model of co-integration (for example, Nusair & Olson, 2021, and Li & Guo, 2022). The ARDL model is also not suitable in the present context because various economic variables within Pakistan, such as GDP, price levels, and interest rates, are not independent of one another; their values are determined endogenously with mutual interdependence.

In a nutshell, while econometric literature provides a variety of excellent models for analyzing economic data, one must choose the model that best suits the purpose at hand. In this context, we prefer the VAR-X model over other possible alternatives. Thus, this study reinvestigates the issue by considering a suitably specified VAR-X model, which is the standard VAR model augmented by exogenous variables. The specific model estimated in the study has several features, some of which are often overlooked in the previous literature. First, the model includes four endogenous variables: output, price level, real interest rate, and real exchange rate. The last two variables are included to take into account the responses in output growth and inflation rate to oil price changes, operating through the resulting changes in balance of payments and monetary policy, in addition to their direct responses.

Second, unlike most previous studies, the oil price is considered an exogenous variable, and its impacts on the economy are estimated through interim multipliers, which have somewhat different meanings and interpretations than the commonly estimated *Impulse Response Functions*. Specifically, interim multipliers have the advantage of tracing the dynamic structure of the relationships like impulse response functions but represent the impacts of exogenous changes rather than exogenous shocks.

Finally, the model accounts for asymmetry between the effects of oil price increases and decreases on the variables of interest. Asymmetry in relationships is likely to occur due to the expected differences in the levels of upward and downward flexibility in prices and outputs.

The specific research questions that this study attempts to address are:

1 In what direction and to what extent do changes in oil prices affect key economic indicators of Pakistan's economy, namely output growth, inflation, real interest rates, and the real exchange rate?

2 What is the time profile of these effects? and

3 Are the effects of oil price changes symmetric concerning positive and negative changes in oil prices? To answer some of these questions, the study tests two neutral hypotheses:

   a) Changes in oil prices have no effect on the economic indicators of Pakistan; and

b) The effects of positive and negative changes in oil prices are symmetric.The remaining research questions can be addressed by looking at the sings and patterns of the multipliers and are not formally tested.

The rest of the paper is organized as follows: Section 2 presents the theoretical background on the subject based on past literature. Section 3 outlines the methodology, while Section 4 describes the data and its sources. Section 5 presents the results and discusses those results. Section 6 concludes the study, and finally, Section 7 addresses the limitations of the study and suggests directions for future research.

## 2. Theoretical Background

The effects of oil price variations on macroeconomic activity have been extensively studied since the oil price shocks of the 1970s. For instance, Hamilton (1983) attributed seven out of eight recessions in the USA to oil price shocks, while Yucel and Brown (2001) concluded that eight out of nine economic recessions following World War II were preceded by rising oil prices.

Oil prices can affect economic activities through both demand and supply side channels. According to Lescaroux and Mignon (2009), when oil prices rise, consumers must reduce spending on non-essential items as their discretionary income falls behind inflation. Galesi and Lombardi (2009) argued that since products containing oil constitute a significant portion of the consumer price index, a direct consequence of high oil prices is an increase in headline inflation. Energy prices also affect other durable goods like home appliances. Additionally, significant fluctuations in oil prices create uncertainty for economic agents regarding the future consequences of their current decisions, leading to a temporary decline in spending on items such as cars, home appliances, and investment goods. From a demand-side perspective, remittances are considered a crucial source for building foreign reserves, addressing balance of payments issues, servicing debt, alleviating poverty, and reducing unemployment (Shah & Rehman, 2022). Increased oil revenue in oil-exporting nations results in higher remittance outflows to other (mostly developing) countries, boosting household income and consumption. This rise in consumption tends to elevate aggregate demand, which in turn produces increased output. According to Barajas et al. (2009) and Rehman (2014), remittances can impact economic growth in three fundamental ways: first, by directly contributing to capital accumulation; second, by promoting total factor productivity growth; and third, by affecting labor inputs through labor force contributions. Furthermore, the inflow of remittances helps stabilize the exchange rate in the host economy (Ur Rehman & Hysa, 2021). Abbas (2020) notes that during economic downturns, remittances are generally counter-cyclical, serving as a stable source of foreign exchange and aiding in financing imports.

This stabilizing effect is particularly important for Pakistan, where remittances constitute a significant portion of the country's foreign exchange reserves. More than 70% of all remittance inflows to Pakistan come from Gulf countries that export oil (Abbas, 2020). According to BE&OE (2019), estimates suggest that about 10.48 million Pakistanis are employed overseas, with 96.5 percent residing in GCC nations. Thus, it is crucial to consider the connection between changes in crude oil prices and GCC remittances.

On the supply side, an increase in oil prices raises production costs and lowers firms' profitability (Killian, 2008; Lescaroux and Mignon, 2009). Furthermore, because rising oil prices depress profit margins for producers, they resort to wage cuts and layoffs to restore equilibrium, thereby leading to a reduction in output. Bernanke (1983) argues that uncertainty about energy prices may cause firms to postpone investment decisions, which results in lower output.

Jiménez-Rodriguez and Sánchez (2005) argue that the demand-side shocks from an oil price hike also have implications for the supply side. If income lags behind inflation, consumers reduce savings to finance increased spending on fuel and food. This leads to a decrease in investment spending and, consequently, a decrease in output.

Regarding the supply-side effects of oil price changes, subsidies remain a major mechanism through which governments attempt to mitigate the impacts of these changes on production costs and output. In developing countries, not all of the rise in crude oil prices is passed on to consumers; rather, governments absorb part of the price hike by providing subsidies (Cantah & Asmah, 2015). Countries like Pakistan offer subsidies on food and fuel for political reasons, causing consumers to avoid facing the true market prices of commodities. In the case of Pakistan, subsidies serve as a mediator by providing households with immediate relief during oil price increases. Furthermore, subsidies help maintain economic stability and alleviate inflationary pressures by reducing the price of energy items. Khalid (2022) and Arafeen et al. (2018) indicate that in

Pakistan, the prices of gasoline and diesel, which are vital for industrial and transportation operations, have been stabilized through the implementation of fuel subsidies.

Exchange rate fluctuations are yet another factor affecting domestic output. As the terms of trade change due to shifts in oil prices, the country's exchange rate responds accordingly. When considering the effects of oil price changes and exchange rate fluctuations, Cantah & Asmah (2015) argue that inflationary pressures caused by higher oil prices through the exchange rate lead to increased production costs, which subsequently reduce profit margins, ultimately resulting in lower levels of employment, investment, and output. In Pakistan's case, oil prices remain a key driver of exchange rate fluctuations. Khurshid et al. (2023) have demonstrated that increased oil prices lead to currency depreciation, thereby exacerbating the impact of oil price changes on inflation.

Several studies have utilized non-linear transmission mechanisms and found asymmetries in the output response, along with other variables, to oil price changes (e.g., Cunado & De Gracia, 2005; Jiménez-Rodriguez and Sánchez, 2005; Pelin & GÜNEY, 2013; Zhao et al., 2016; Nusair & Olson, 2021).

The studies on large or developed economies (such as Jiménez-Rodriguez and Sánchez, 2005 for OECD and Zhao et al., 2016 for China) include oil prices in the category of endogenous variables within the standard VAR framework, a practice that is unsuitable for an oil-importing small economy like Pakistan. However, several studies, including Cunado & De Gracia (2005), Malik (2008), Pelin & GÜNEY (2013), Yasmeen et al. (2019), and Nusair & Olson (2021), regard oil prices as exogenous variables but limit their analyses to static effects, causality tests, or direct effects, neglecting the influence of other potentially endogenous variables. These limitations in the existing literature are some of the issues that the present study seeks to address.

## 3. Methodology

With the above background, we proceed with a VAR model consisting of four endogenous variables: output, price level, real interest rate, and real exchange rate. The oil price is treated as an exogenous variable and is divided into two components, namely the period-to-period accumulated price increases and accumulated price decreases, which represent the episodes of oil price inflation and oil price deflation, respectively. For the technical details, we employ the following notations:

$Q_t$ = Output (GDP at constant prices),

$P_t$ = Price level (GDP deflator),

$R_t$ = Real interest rate (weighted average of interest rates on bank advances minus inflation rate based on GDP deflator),

$E_t$ = Real exchange rate (nominal exchange rate multiplied by foreign price level divided by domestic price level,

$O_t$ = Oil price,

$O_t^+$ = Accumulated period-to-period oil price increases,

$O_t^-$ = Accumulated period-to-period oil price decreases.

The two series of oil price, expressed in natural logs, can be obtained from the original series of observed oil prices as follows:

$$\ln O_{t-i}^{+} = \sum_{i=1}^{t} max(\Delta \ln O_i, 0) \tag{1}$$

$$\ln O_{t-i}^{-} = -\sum_{i=1}^{t} min(\Delta \ln O_i, 0) \tag{2}$$

where

$$\ln O_{t-i}^{+} + \ln O_{t-i}^{-} + \ln O_0 = \ln O_t \tag{3}$$

The VAR model specification requires stability in the time paths of all variables. Since all variables are integrated of order one, we specify the VAR model with all variables in first difference form. For output, price level, real exchange rate, and oil price, we consider first differences of logs, while for the real interest rate, we consider first differences without logs.

Since the model will be estimated on quarterly data, we control for seasonal variation by including seasonal dummies, using the first quarter as the base/reference quarter. The proposed VAR model of order p, that is

VAR(p), with the exogenous oil price variables appearing with lag order q can be expressed in full expanded form as follows.

$$\begin{bmatrix} \Delta\ln Q_t \\ \Delta\ln P_t \\ \Delta R_t \\ \Delta\ln E_t \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{10} \\ \alpha_{10} \\ \alpha_{10} \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \alpha_{11}(i) & \alpha_{12}(i) & \alpha_{13}(i) & \alpha_{14}(i) \\ \alpha_{21}(i) & \alpha_{22}(i) & \alpha_{23}(i) & \alpha_{24}(i) \\ \alpha_{31}(i) & \alpha_{32}(i) & \alpha_{33}(i) & \alpha_{34}(i) \\ \alpha_{41}(i) & \alpha_{42}(i) & \alpha_{43}(i) & \alpha_{44}(i) \end{bmatrix} \begin{bmatrix} \Delta\ln Q_{t-i} \\ \Delta\ln P_{t-i} \\ \Delta R_{t-i} \\ \Delta\ln E_{t-i} \end{bmatrix}$$
$$+ \sum_{i=0}^{q} \begin{bmatrix} \beta_{11}(i) & \beta_{12}(i) \\ \beta_{21}(i) & \beta_{22}(i) \\ \beta_{31}(i) & \beta_{32}(i) \\ \beta_{41}(i) & \beta_{42}(i) \end{bmatrix} \begin{bmatrix} \Delta\ln O^{+}_{t-i} \\ \Delta\ln O^{-}_{t-i} \end{bmatrix} + \begin{bmatrix} \gamma_{12} & \gamma_{13} & \gamma_{14} \\ \gamma_{22} & \gamma_{23} & \gamma_{24} \\ \gamma_{32} & \gamma_{33} & \gamma_{34} \\ \gamma_{42} & \gamma_{43} & \gamma_{44} \end{bmatrix} \begin{bmatrix} D_{2t} \\ D_{3t} \\ D_{4t} \end{bmatrix} +$$
$$\begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \quad (4)$$

Or, combining the last two terms involving seasonal dummies and random errors, the above system can be written in compact form as:

$$Y_t = A_0 + \sum_{i=1}^{p} A_i\, Y_{t-i} + \sum_{i=0}^{q} B_i\, X_{t-i} + u_t \quad (5)$$

Since the oil price does not appear on the left-hand side of the model, we cannot compute random shocks in oil price unless these shocks are estimated through some auxiliary model for the oil price itself. Therefore, to analyze the effects of changes in the oil price, we rely on the multipliers of endogenous variables with respect to exogenous variables, for which the VAR model is first converted into Vector Moving Average (VMA) form. This is not a straightforward procedure because it involves solving a set of difference equations of order p, where p can be any positive integer. Fortunately, Tsay (2010) proposes a solution by artificially augmenting the model to resemble a VAR(1) model while containing the original VAR(p) as a component. The augmented VAR(1) model is given by:

$$\begin{bmatrix} Y_t \\ Y_{t-1} \\ Y_{t-2} \\ \cdot \\ \cdot \\ Y_{t-(p-1)} \end{bmatrix} = \begin{bmatrix} A_0 \\ 0 \\ 0 \\ \cdot \\ \cdot \\ 0 \end{bmatrix} + \begin{bmatrix} A_1 & A_2 & \cdot\ \cdot & A_p \\ I & 0 & \cdot\ \cdot & 0 \\ 0 & I & \cdot\ \cdot & 0 \\ \cdot & \cdot & \cdot\ \cdot & \cdot \\ \cdot & \cdot & \cdot\ \cdot & \cdot \\ 0 & 0 & \cdot\ \cdot & 0 \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ Y_{t-2} \\ \cdot \\ \cdot \\ \cdot \\ Y_{t-p} \end{bmatrix} + \begin{bmatrix} B_0 & B_1 & \cdot\ \cdot & B_q \\ 0 & 0 & \cdot\ \cdot & 0 \\ 0 & 0 & \cdot\ \cdot & 0 \\ \cdot & \cdot & \cdot\ \cdot & \cdot \\ \cdot & \cdot & \cdot\ \cdot & \cdot \\ 0 & 0 & \cdot\ \cdot & 0 \end{bmatrix} \begin{bmatrix} X_t \\ X_{t-1} \\ \cdot \\ \cdot \\ \cdot \\ X_{t-q} \end{bmatrix} + \begin{bmatrix} u_t \\ 0 \\ 0 \\ \cdot \\ \cdot \\ 0 \end{bmatrix} \quad (6)$$

Or, in compact form:

$$Z_t = C + A\, Z_{t-1} + B\, W_t + v_t \tag{7}$$

This augmented VAR(1) model can be easily convert into an augmented VMA model:

$$Z_t = (I - A)^{-1} C + B \sum_{i=0}^{\infty} A^i\, W_{t-i} + \sum_{i=0}^{\infty} A^i\, v_{t-i} \tag{8}$$

From this model we can easily extract VMA representation of the original VAR model, which looks like the following.

$$Y_t = \Pi + \sum_{i=0}^{\infty} \Pi(\mathrm{i})\, X_{t-i} + \sum_{i=0}^{\infty} \Gamma(\mathrm{i})\, u_{t-i}, \qquad \Gamma(0) = 1 \tag{9}$$

To analyze the effects of oil price changes on the economy, we can identify three types of multipliers: *Dynamic Multipliers*, *Interim Multipliers,* and *Total Multipliers* (see Lütkepohl, 2005). The *Dynamic Multipliers* are similar to *Impulse Response Functions,* but they track the effect of a one-time change in an exogenous variable, rather than an exogenous shock, on the variable of interest with successive lags of zero, one, two, and so on. However, unlike *Impulse Response Functions*, *Dynamic Multipliers* are not commonly used because changes in exogenous variables don't behave like shocks that tend to revert to zero. For example, oil price changes occur as swings rather than shocks. Thus, it is more reasonable to estimate the accumulated effects of changes in an exogenous variable over means they have on the current value of the variable of interest. These accumulated effects *are captured*, which are widely by Interim Multipliersd. Finally, the *Total Multiplier* measures the effect of changes in an exogenous variable on the variable of interest, accumulated over time.infinite period. The Total Multiplier Multiplier is also not straightforward, as it would be trivial to know the accumulated effect of changes in oil price from the indefinite past on the current inflation rate.

It follows from above that that an *Interim Multiplier* is the accumulated value of *Dynamic Multipliers* over the lag lengths zero to any number say 10, while *Total Multipliers* is the accumulated value of *Dynamic Multipliers* over the infinite lag length. With a stable system wherein all variables are stationary, the dynamic multipliers approach towards zero with increase in lag length, while the *Interim Multipliers* approach to constant values equal to the corresponding *Total Multipliers*.

At this point it is important to note that the estimates of *Impulse Response Functions* rely on the parameters estimates of the Structural VAR model retrieved from the parameter estimates of a VAR model by imposing certain identification restrictions, which are often arbitrary and subject to criticism. The estimation of multipliers, on the other hand, does not require the knowledge of structural parameters. In fact, the multiplier analysis remains the same whether we work with VAR model or Structural VAR model. (see Enders, 2012) and (Lütkepohl, 2013) for the mathematical details on this subject).

The three types of multipliers are derived from equation (9) and are as follows:

***Dynamic Multiplier*** of variable $Y_m$ with respect to an exogenous variable $X_k$ at lag i:

$$\frac{\partial Y_{mt}}{\partial X_{kt-i}} = \Pi_{mk}(i) \tag{12}$$

***Interim Multiplier*** of variable $Y_m$ with respect to an exogenous variable $X_k$ up to lag j:

$$\sum_{i=0}^{j} \frac{\partial Y_{mt}}{\partial X_{kt-i}} = \sum_{i=0}^{j} \Pi_{mk}(i) \tag{13}$$

***Total Multiplier*** of variable $Y_m$ with respect to an exogenous variable$X_k$:

$$\sum_{i=0}^{\infty} \frac{\partial Y_{mt}}{\partial X_{kt-i}} = \sum_{i=0}^{\infty} \Pi_{mk}(i) \tag{14}$$

The multiplier analysis is conducted to estimate and compare the effects of positive and negative changes in the oil price. Further non-linearity in the model can be introduced by allowing any subset of the parameters to vary over time.[1] Since the model already contains too many

[1] One of the referees has suggested to allow the impacts of oil price changes to change over time and to test if oil price effects differ after Pakistan's shift to a managed exchange rate in 2000.

parameters (34 in each equation), such extensions in the model are not feasible.

## 4. Data

The study employs quarterly data from the first quarter of 1990 to the fourth quarter of 2021. This period is chosen to ensure that reliable quarterly data on all the required variables are available on a consistent basis. The data for crude oil prices (dollars per barrel) are obtained from the *Energy Information Administration* (*EIA*), the US Department of Energy[2]. The real GDP data are sourced from the State Bank of Pakistan and Arby (2008).[3] Likewise, the GDP deflator series, as a measure of price level, is derived from the series of GDP at current and constant prices (that is, nominal and real GDP). The nominal interest rate is represented by the weighted average rates of return on lending, with data taken from various issues of the *Monthly Statistical Bulletin* of the State Bank of Pakistan (SBP) and the *Handbook of Statistics*. The real interest rate is calculated by subtracting the inflation rate based on GDP deflators from the nominal interest rate. The real exchange rate data are sourced from the *International Financial Statistics* (*IFS*) of the IMF.

## 5. Results and Discussion

To proceed with the empirical work, we begin with the Unit Root tests. The results of the ADF test, presented in Table 1, indicate that all variables are integrated of the first order. The KPSS test results, also shown in the same table, support the ADF test findings, except that the real interest rate is stationary in levels. Since the VAR model must be estimated with stationary data, we carry all variables, including the interest rate for consistency, in first-difference form. As output, price index, real exchange rate, and crude oil price are measured in natural logs, their first differences represent growth rates.

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[2] See http://www.eia.doe.gov/

[3] State Bank of Pakistan (sbp.org.pk)

**Table 1: The Results of Unit Root Tests**

| Variables | ADF Test Statistics (t) | | KPSS Test Statistic (LM) | | Order of Integration |
|---|---|---|---|---|---|
| | Level | First Difference | Level | First Difference | |
| $\ln Q_t$ | -1.00 | -5.02* | 1.34* | 0.16 | I(1) |
| $\ln P_t$ | 0.04 | -15.96* | 1.33* | 0.09 | I(1) |
| $R_t$ | -3.18 | -8.76* | 0.26 | 0.14 | I(1) |
| $\ln E_t$ | -1.76 | -14.84* | 0.62* | 0.08 | I(1) |
| $\ln O_{t-i}^{+}$ | 0.67 | -10.49* | 1.38* | 0.11 | I(1) |
| $\ln O_{t-i}^{-}$ | 0.65 | -9.35* | 1.34* | 0.14 | I(1) |

Note: The statistics significant at 5% level, indicated by *, show the rejection of null hypothesis, which is the presence of unit root in case of ADF test and absence of unit root in case of KPSS test.
*Source:* Authors' calculations.

The VAR model is first estimated with eight lags for both the endogenous and exogenous variables. Next, lag length criteria and lag exclusion tests are applied to the endogenous variables to eliminate those lagged variables that are highly insignificant in joint tests. The results of this stepwise backward elimination procedure are presented in the second column of Table 2. Once the lag structure of the endogenous variables is specified, the next step is to apply Wald tests to the lagged exogenous variables, using the same stepwise backward elimination procedure. The results of these tests are displayed in the third column of Table 2. The table indicates that we select lags 1 to 5 for the endogenous variables and lags 2, 6, 7, and 8 for the oil price (exogenous) variables.

These results indicate that all retained lags are jointly significant across the four equations, despite the fact that the corresponding coefficients may not all be individually significant. For instance, the retention of lag one for the endogenous variables suggests that 16 regression coefficients of one quarter lagged output, price, real interest rate, and real exchange rate variables in the output, price, interest rate, and exchange rate equations are jointly significant, even though, as shown in Table A1 in the Appendix, only seven of these coefficients are individually significant. The same principle applies to the lags of exogenous (oil price) variables. This finding confirms that oil prices have significant effects on Pakistan's economic indicators, leading to the rejection of the study's first hypothesis.

**Table 2: Results of Lag Selection Process**

| Test Round | Lags Dropped in Successive Rounds | |
|---|---|---|
| | Endogenous variables | Oil price variables |
| Round 1 | 6 | 5 |
| Round 2 | 8 | 0 |
| Round 3 | 7 | 4 |
| Round 4 | | 3 |
| Round 5 | | 1 |
| Lags retained | 1 – 5 | 2, 6, 7, 8 |

*Source:* Authors' calculations.

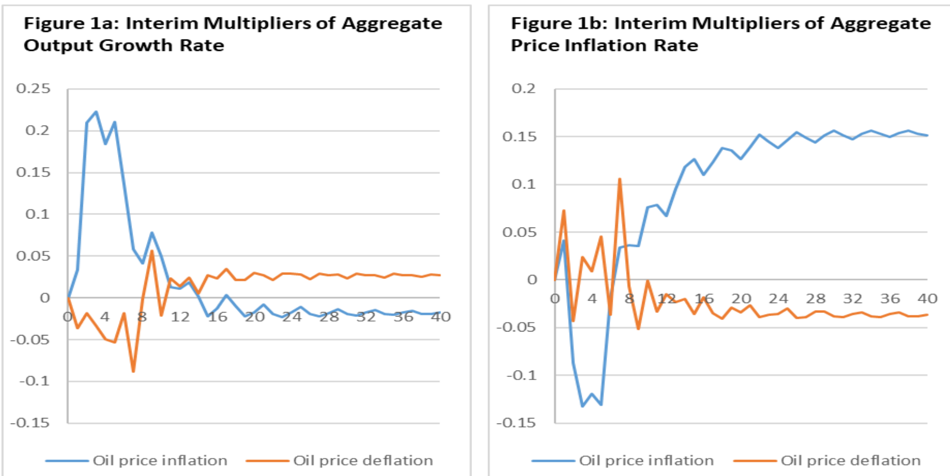
Finally, to explore symmetry, we apply Wald tests to the null hypothesis that each parameter related to the oil price inflation variable equals the negative of the corresponding parameter related to oil price deflation. The Wald test statistic is found to be highly significant, with a probability value close to zero up to three decimal places, indicating that the effects of oil prices are asymmetric. The parameter estimates of the final selected VAR model are presented in Appendix Table A1.

Moving now to the main part of the analysis, Figure 1, which contains four panels, shows the quarter-to-quarter cumulative impacts of changes in the growth rate of oil prices on output growth rate, inflation rate, changes in real interest rates, and the growth rate of the real exchange rate. Panel 1a indicates that in response to an increase in oil price inflation, the growth rate of GDP temporarily rises for the first few quarters, but in the medium to long run, oil price inflation leaves a negative effect on output growth rate. However, the depressing effect of oil price inflation on output growth is small. This result is contrary to our expectations. If we examine data from periods of major oil price shocks, we do not observe any substantial change in GDP growth rates. Furthermore, our analysis does not distinguish between small and large changes in oil prices, and historically, during most years, oil prices have increased alongside reasonably good economic growth.

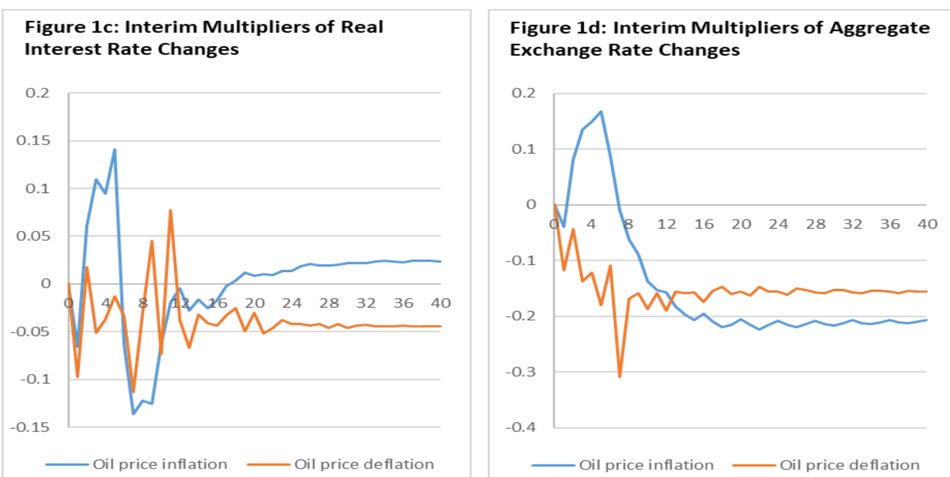
In any case, we can offer a few plausible explanations for the positive effect of oil price inflation on the GDP growth rate within short time lags and relatively small adverse effects over longer time periods. First, when the oil price inflation rate increases, the employment prospects and incomes of a large number of Pakistanis living in oil-producing Middle Eastern countries improve, enabling them to send greater amounts of money home in remittances. This increased inflow of funds results in heightened spending, particularly on housing, vehicles, and other durable goods. In turn, this boosts production activity in the construction, automobile, and durable goods industries.

Another explanation is that Pakistan has greatly benefited from oil imports from 'friendly' countries on deferred payments and occasionally at subsidized prices. As a result, when the rest of the world faced adverse consequences from oil price inflation, Pakistan could negotiate somewhat better deals due to its special relationships with oil-exporting Middle Eastern countries.

**Figure 1: Interim Multipliers Based on VAR Model for the Aggregate Economy**




*Source:* Authors' calculations.




*Source:* Authors' calculations.

Another explanation could be that, except for the most recent years, prices of oil-based energy products, particularly electricity prices in Pakistan, have been controlled and subsidized. The heavy reliance of the power sector on oil as an input and the consumption of energy-intensive products by consumers are relatively recent phenomena. Our data period also includes years when oil was not as significant in power generation and household budgets as it is today. Our results align with those of Hayat & Nadir (2023), who find that an increase in oil prices positively affects Pakistan's GDP output in both the short and long run. Additionally, Triantoro et al. (2023) have shown similar findings that rising oil prices positively impact Pakistan's output through various channels.

When considering oil price deflation, we observe that the interim multipliers do not indicate symmetry. While symmetry exists in that the effects of oil price deflation are generally opposite to those of oil price inflation, the magnitudes of the short-run multipliers for oil price deflation are smaller than those for oil price inflation. However, in the medium to long run, oil price inflation and deflation exhibit nearly symmetric effects.

Panel 1b of the figure illustrates that in the short run, oil price inflation and deflation produce mixed effects on the inflation rate, oscillating between positive and negative values. Nonetheless, the adverse effect of oil price inflation on the overall inflation rate prevails, likely due to the aforementioned reasons for the favorable short-run impact of oil price inflation on the output growth rate.

In the medium to long run, the effects of oil price changes on the overall inflation rate are symmetric in terms of sign, but they are right-skewed in terms of magnitude. As expected, in the medium to long run, the inflation rate is positively impacted by oil price inflation and negatively impacted by oil price deflation. However, the estimated value of the interim multiplier is around 0.15 for oil price inflation and approximately -0.04 for oil price deflation. This implies that, for example, a 10 percentage point increase in the oil price inflation rate leads to a 1.5 percentage point rise in the overall inflation rate, while an oil price deflation of the same magnitude results in a decrease of only 0.4 percentage points in the overall inflation rate.

A possible reason for this asymmetry is that the presence of monopolistic elements and other distortions in the markets leads firms to exert their best efforts to transfer the additional costs of oil price inflation to consumers. However, they manage to transfer only a portion of the reductions in costs when oil prices decline, absorbing most of the benefits into their profits. This occurs because while the demand for oil is inelastic to oil price inflation due to habit persistence and adjustment costs, it is relatively more elastic to oil price deflation.

The effects of oil price inflation on the real rate of interest, shown in panel 1c of the figure, are mostly positive in the short run and negative in the medium run. This pattern somewhat aligns with the response of the overall inflation rate to oil price inflation. However, in the long run, oil price inflation is found to have a positive effect on the real interest rate. This indicates that, in the long run, oil price inflation results in a greater increase in the nominal interest rate compared to the overall inflation rate. For instance, a 10 percentage point increase in oil price inflation leads to a 0.2 percentage point increase in the real rate of interest, which implies about a 1.7 percentage point increase in the nominal interest rate, given that the overall inflation rate rises by 1.5 percentage points. A possible reason for this could be that to counter the adverse balance of payments effects of oil price inflation in the long run, the monetary authority raises interest rates by a sufficient margin to attract inflows of foreign capital.

The interim multipliers for oil price deflation do not display a systematic pattern during the short to medium term, whereas, in the long term, oil price deflation results in a greater decrease in the real interest rate; specifically, 0.4 percentage points in response to a 10 percentage point increase in the rate of oil price deflation. This effect is symmetric to that of oil price inflation in terms of sign but is twice as much the latter in absolute magnitude. Therefore, as the balance of payments situation improves following oil price deflation, the resulting increase in liquidity leads to a reduction in interest rates.

In response to the increase in oil price inflation, the real exchange rate temporarily depreciates in the early quarters (see panel 1d), most likely because the nominal exchange rate does not respond to oil price inflation in the short run, while the domestic inflation rate decreases. In the long run, however, the real exchange rate is found to appreciate as a consequence of the ultimate inflationary effect of oil price inflation. A 10 percentage point increase in the oil price inflation rate results in a depreciation of the real exchange rate by around one percentage point in the short run, and later, with a cumulative lag effect, it appreciates by a little more than 1.5 percentage points in the long run.

An interesting result is that in the long run, oil price inflation and deflation have highly asymmetric effects on the real exchange rate. Notably, both oil price inflation and deflation lead to real currency appreciation, though the effect of the former is about twice as large as that of the latter in absolute terms. This asymmetry can be explained by the dual effects of oil prices on the real exchange rate. An increase in the oil price inflation rate causes the overall inflation rate to rise by a greater margin than the increase in the rate of nominal depreciation, probably due to managed float, resulting in net real appreciation of the rupee. On the other hand, an increase in the rate of oil price deflation leads to a small decrease in the overall inflation rate, likely due to the downward price rigidities noted above, compared to the rate of nominal appreciation, thus resulting in a slight appreciation of the rupee.

Appendix Table A1 presents the coefficients of seasonal dummies used in our analysis to isolate the estimated multiplier from seasonal variations in the data. The table shows that, compared to the first quarter of the calendar year, the second and fourth quarters exhibit significant changes across all the variables. The positive coefficients in the output equation align with the major cropping seasons, as the largest crop, wheat, is harvested in quarter 2, while cotton, rice, and sugarcane are harvested in quarter 4, generating economic activities both directly and indirectly. The coefficients in the price equation are negative, indicating the anti-inflationary effects of the arrival of new crops.

The real interest rate is notably higher in the second and fourth quarters compared to the first quarter. Since the State Bank of Pakistan announces its monetary policy approximately every two months and this policy stance reflects recent inflationary trends, it is reasonable to anticipate a significant increase in the interest rate during the second and fourth quarters, following the periods of lower inflation rates in the first and third quarters. Finally, the table demonstrates that the rate of real exchange rate depreciation is greater in the second and fourth quarters relative to the first quarter.

Before concluding the discussion, it is worth noting that the model was expanded for disaggregated analysis. However, this effort proved unproductive because the differences in sectoral classification between Pakistan and the USA led to poor data quality for analysis.

## 6. Conclusion

This study utilizes standard VAR methodology to examine the impacts of changes in the world's crude oil price on output growth rates, overall inflation rates, changes in the real interest rate, and growth rates of real exchange rates in Pakistan, using quarterly data from 1990Q1 to 2021Q4. The interim multiplier analysis reveals that inflationary and deflationary oil price shocks have asymmetric effects on the economy. Following an increase in the oil price, the inflation rate causes the output growth rate to initially rise, but it declines in the medium to long run, although the depressing effect of oil price inflation is small. Several possible reasons for this result include the impacts of increased remittance inflows from oil-producing Middle Eastern countries, oil imports at subsidized prices or on deferred payment from allied nations, and price subsidies on petroleum products and electricity to stabilize their prices, except during the most recent wave of oil price inflation. The effects of oil price deflation on the output growth rate follow the opposite pattern as expected, but the magnitudes of multipliers for oil price deflation are somewhat smaller than those for oil price inflation.

The study observes that, in the medium to long run, the overall inflation rate is positively influenced by oil price inflation and negatively impacted by oil price deflation. However, the size of the multipliers for oil price inflation is nearly four times larger than those for oil price deflation. This result indicates the presence of monopolistic elements in markets, habit persistence, and adjustment costs, which make prices relatively less flexible in the downward direction.

This behavior of price flexibility also produces an asymmetric response of the real exchange rate to changes in oil prices, such that in the long run, both oil price inflation and deflation result in a real appreciation of the currency. It is further found that the real interest rate tends to rise due to oil price inflation, possibly because of the adverse impacts of oil price inflation on the balance of payments. Conversely, when oil prices decrease, the real interest rate declines by a greater margin.

Pakistan's economy appears reasonably robust, as it has not been significantly affected by changes in oil prices. The observation that the most recent wave of oil price shocks is accompanied by stagflation can be properly analyzed after a few more years have passed to yield sufficient data regarding the stagflation period. It seems that the economic conditions prevailing during this time are correlated (positively or negatively) with various factors outside of the oil price hikes, including debt accumulation prior to the price increases, political crises, and the Covid-19 pandemic.

The process of deregulating the energy sector in Pakistan is expected to continue in the near future, which will make its economy more exposed to external shocks. Furthermore, even if the Saudi Arabian oil facility on deferred payments continues, it will only equate to rolling over previous obligations with minimal or no net relief. This indicates that Pakistan must tighten its belt in the coming years due to the continuation of the conservative monetary policy currently in place. Expanding renewable energy production, particularly hydro and especially solar energy, is vital to reducing reliance on oil imports. This will only be achievable if the state of Pakistan can develop an inter-provincial political consensus on major hydro projects, and if fiscal policy measures for solar energy in the industrial, services, and household sectors are made credible and focused on long-term considerations rather than short-term budgetary constraints.

This study has a few limitations. First, we have used the GDP deflator rather than the CPI as a measure of the price level on the grounds that the GDP deflator reflects the price level of all goods produced, including consumer goods and investment goods. However, the GDP deflator is also a poor indicator of the price level faced by a country because it includes prices of exported goods, which are not consumed domestically, and excludes the prices of imported goods, which are consumed within the country. Second, we have used the real exchange rate of Pakistan with the US dollar, whereas a more comprehensive measure, namely the multilateral (effective) exchange rate index, could have been utilized.

Third, if sufficient data can be accessed, the study could be enhanced by testing for the possible presence of structural breaks and re-estimating the model based on the results of these tests. Fourth, the estimates of multipliers are presented without confidence intervals because the presence of complex non-linearity made it difficult to compute standard errors. It is hoped that this limitation will be addressed in a future study. Finally, for better insight, a similar analysis can be conducted for various broad sectors of the economy, and the authors are in the process of gathering the necessary data for this purpose.

## Appendix Table A1: Results of VAR Model for the Aggregate Economy of Pakistan

| variables | Output equation | | Price equation | | Interest rate equation | | Exchange rate equation | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | t-statistic | Coefficient | t-statistic | Coefficient | t-statistic | Coefficient | t-statistic |
| $\Delta \ln Q_{t-1}$ | 0.300 | 1.73* | -0.805 | -3.93*** | 0.836 | 4.05*** | 0.932 | 3.87*** |
| $\Delta \ln Q_{t-2}$ | -0.004 | -0.03 | -0.143 | -0.86 | 0.162 | 0.97 | 0.323 | 1.65* |
| $\Delta \ln Q_{t-3}$ | 0.141 | 0.98 | -0.416 | -2.45** | 0.432 | 2.53** | 0.494 | 2.48** |
| $\Delta \ln Q_{t-4}$ | 0.445 | 2.82*** | 0.152 | 0.82 | -0.058 | -0.31 | -0.048 | -0.22 |
| $\Delta \ln Q_{t-5}$ | -0.323 | -1.64 | 0.549 | 2.36** | -0.564 | -2.4** | -0.406 | -1.48 |
| $\Delta \ln P_{t-1}$ | -1.043 | -1.52 | 0.468 | 0.58 | -0.358 | -0.44 | 0.032 | 0.03 |
| $\Delta \ln P_{t-2}$ | 0.028 | 0.13 | -0.032 | -0.13 | 0.128 | 0.51 | 0.252 | 0.86 |
| $\Delta \ln P_{t-3}$ | 0.492 | 2.26** | -0.434 | -1.69* | 0.471 | 1.82* | 0.603 | 2** |
| $\Delta \ln P_{t-4}$ | 0.237 | 1.13 | 0.337 | 1.36 | 0.632 | 2.53** | -0.222 | -0.76 |
| $\Delta \ln P_{t-5}$ | 0.816 | 1.2 | -0.606 | -0.75 | 0.509 | 0.63 | 0.379 | 0.4 |
| $\Delta R_{t-1}$ | -1.411 | -2.2** | 1.382 | 1.83* | -1.295 | -1.7* | -1.042 | -1.17 |
| $\Delta R_{t-2}$ | -0.063 | -0.67 | -0.013 | -0.12 | 0.024 | 0.21 | 0.105 | 0.81 |
| $\Delta R_{t-3}$ | -0.023 | -0.25 | 0.027 | 0.25 | -0.030 | -0.28 | 0.066 | 0.51 |
| $\Delta R_{t-4}$ | -0.009 | -0.1 | 0.020 | 0.18 | -0.024 | -0.22 | 0.014 | 0.11 |
| $\Delta R_{t-5}$ | -0.086 | -0.98 | 0.153 | 1.49 | -0.165 | -1.6 | -0.145 | -1.2 |
| $\Delta \ln E_{t-1}$ | -0.037 | -0.27 | -0.048 | -0.29 | 0.035 | 0.21 | 0.063 | 0.33 |
| $\Delta \ln E_{t-2}$ | -0.128 | -0.91 | 0.205 | 1.24 | -0.171 | -1.02 | -0.100 | -0.51 |
| $\Delta \ln E_{t-3}$ | 0.466 | 3.29*** | -0.316 | -1.9* | 0.297 | 1.76* | 0.323 | 1.65 |
| $\Delta \ln E_{t-4}$ | -0.071 | -0.51 | 0.087 | 0.53 | -0.063 | -0.38 | -0.008 | -0.04 |
| $\Delta \ln E_{t-5}$ | -0.046 | -0.34 | -0.049 | -0.3 | 0.035 | 0.21 | 0.090 | 0.47 |
| Intercept | -0.085 | -2.94*** | 0.101 | 2.95*** | -0.093 | -2.71*** | -0.094 | -2.34** |
| $\Delta \ln O^{+}_{t-1}$ | 0.034 | 0.59 | 0.041 | 0.61 | -0.066 | -0.98 | -0.039 | -0.49 |
| $\Delta \ln O^{-}_{t-1}$ | 0.036 | 0.67 | -0.073 | -1.16 | 0.097 | 1.54 | 0.118 | 1.6 |
| $\Delta \ln O^{+}_{t-2}$ | 0.114 | 2.07** | -0.031 | -0.48 | 0.029 | 0.45 | 0.021 | 0.28 |
| $\Delta \ln O^{-}_{t-2}$ | 0.037 | 0.68 | 0.051 | 0.78 | -0.049 | -0.76 | -0.012 | -0.16 |
| $\Delta \ln O^{+}_{t-6}$ | -0.100 | -1.5 | 0.087 | 1.11 | -0.072 | -0.91 | -0.075 | -0.81 |
| $\Delta \ln O^{-}_{t-6}$ | -0.062 | -1.28 | 0.048 | 0.85 | -0.049 | -0.86 | -0.043 | -0.64 |
| $\Delta \ln O^{+}_{t-7}$ | -0.044 | -0.71 | 0.032 | 0.44 | -0.012 | -0.16 | -0.121 | -1.41 |
| $\Delta \ln O^{-}_{t-7}$ | 0.100 | 1.84* | -0.142 | -2.2** | 0.138 | 2.14** | 0.188 | 2.49** |
| $\Delta \ln O^{+}_{t-8}$ | -0.015 | -0.24 | -0.010 | -0.14 | 0.011 | 0.15 | -0.031 | -0.36 |
| $\Delta \ln O^{-}_{t-8}$ | -0.101 | -1.85* | 0.094 | 1.45 | -0.076 | -1.17 | -0.112 | -1.48 |
| D2 | 0.191 | 4.16*** | -0.162 | -2.99*** | 0.136 | 2.5** | 0.190 | 2.98*** |
| D3 | 0.026 | 0.9 | -0.028 | -0.85 | 0.026 | 0.79 | 0.016 | 0.4 |
| D4 | 0.110 | 2.33** | -0.123 | -2.21** | 0.107 | 1.91* | 0.129 | 1.98** |
| $R^2$ | 0.927 | | 0.511 | | 0.658 | | 0.477 | |

Note: The statistics significant at 10%, 5% and 1% levels are indicated by *, ** and *** respectively.

*Source:* Authors' calculations.

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