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Does the source of the oil price shock matter for inflation in Pakistan: Implications for monetary policy

Naafey Sardar* and Zulfiqar Hyder**

Abstract

Using local projections method on sample period 2002-2021, this paper analyzes the response of inflation in Pakistan to global oil price shocks, as identified in Kilian (2009). We find significant differences in the impact of oil prices driven by supply and demand factors on administered fuel prices, and other inflation measures. Oil demand shocks in Pakistan are more inflationary than oil supply shocks due to the presence of the administered domestic petroleum price mechanism. Evidence suggests that policy-makers were able to correctly identify the nature of the oil shock on most occasions, and adjust the administered fuel prices accordingly. Our results have important implications for monetary policy in Pakistan, as we find that purging of oil supply and demand shock matters for monetary policy formulation in case of a transitory supply shock.

JEL Classification: E32, Q41.
Key Words: Oil price shocks; Inflation; FPAS.

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Non-technical Summary

Using data on Pakistan's economy from 2002 to 2021, this paper examines whether the source of the oil price shock matters for the response of inflation, and highlights the implications of our findings for monetary policy. Consistent with existing literature, we find that a one-standard deviation increase in the price of oil leads to higher inflation. This methodology, however, does not distinguish between oil price changes driven by supply or demand factors. To address this, structural oil price shocks are identified as in Kilian (2009), and the impact on various measures of inflation is studied. Further, we highlight the implications of our results for monetary policy in Pakistan using FPAS. To conclude, we find that oil demand shocks, unlike oil supply shocks, have a stronger impact on inflation.

Our results are in line with the existing literature stressing the need for central banks to not respond to transitory supply shocks. The underlying reason for this is entrenched in monetary policy having an adverse impact on economic activity over the duration of the monetary transmission mechanism in case of over-tightening. Moreover, central banks should respond to supply shocks that are protracted in nature appropriately in a bid to manage the second-round impact of such shocks. This helps to contain the wage-price spiral, and allows the central bank to build its credibility. An inappropriate response in the face of an oil price shock would exacerbate the inflation outcome, and also result in the economy paying a higher price, in terms of output loss, higher inflation and central bank credibility.

Therefore, it is essential for policy makers to continuously monitor international oil prices, and make an assessment about the source and duration of the oil price shock, while calibrating its monetary policy response.

1. Introduction

International food and energy prices rose significantly amidst the recent Russian-Ukraine war. For commodity importing economies like Pakistan, central bank's monetary policy formulation poses di-cult challenges to deal with an aggregate supply shock. Specifically, these central banks face a trade-off between economic growth and inflation, while setting monetary policy to deal with a supply shock which tends to move output and inflation in the opposite direction. With a negative aggregate supply shock, output tends to decrease while resulting in higher inflation. Responding to a negative supply shock through strong monetary tightening risks considerable slowdown in the economy. In contrast, responding to these shocks too little too late risks a wage-price spiral and de-anchoring of inflation expectations which adversely affects central bank credibility.

Within this context, using data on Pakistan's economy from 2002 to 2021, this paper examines whether the source and duration of the oil price shock matters for the response of inflation. Further, we also highlight the implications of our findings for monetary policy. First, we begin by presenting stylized facts on how domestic petroleum prices (paid by consumers at the filing station) are determined in Pakistan. Key factors considered by policymakers while deciding the pass-through of global crude oil to domestic petroleum prices include the source of the oil price shock, its duration, fiscal space, and state of the business cycle. Another related consideration in this regard is whether the country is taking part in an IMF programme or not. We then document the impact of oil price changes on inflation in Pakistan. Consistent with existing literature, we also find that a one-standard deviation increase in the price of oil leads to higher inflation. This methodology, however, does not distinguish between oil price changes driven by supply or demand factors. To address this, structural oil price shocks are identified as in Kilian (2009), and the impact on various measures of inflation is studied.

The impulse response functions of domestic fuel prices suggests that policymakers in Pakistan perceive oil price increases driven by changes in global demand as something long-lasting, which prompts them to adjust domestic fuel prices upwards. This increase in domestic energy prices seeps into other inflation measures, and also generates an increase in non-energy (core) prices as well. In the case of oil supply shocks, this argument does not hold as evident from the response of policymakers, who before increasing domestic fuel prices ascertain the duration of the oil supply shock. The domestic administered oil prices are only adjusted as if the policy-makers believe that the oil supply shocks are protracted in nature, rather than transitory. Overall, we find that oil supply shocks produce a muted response of headline and core inflation, which is not significant in a statistical sense. This is due to few occurrences of protracted oil supply shocks in the sample data, barring the ongoing episode.

Our results have important implications for monetary policy in Pakistan, as it highlights the need for the central bank to account for the source and duration of the oil price shock, and only respond to those that are inflationary in nature. Particularly, purging of oil supply and demand shock matters for monetary policy formulation in case of the transitory shock because of lower output cost in contrast to a protracted aggregate supply shock which requires to tighten the policy for anchoring inflation expectations and shoring central bank credibility.

The paper is structured as follows. We present stylized facts on how petroleum prices are set in Pakistan in Section 2. Section 3 sheds light on the methodology used to identify oil price shocks, and estimate the response of inflation. Section 4 presents the data. A discussion on the empirical results is included in Section 5. Section 6 highlights the implications of our results for monetary policy in Pakistan, and presents an augmented-FPAS version of Ahmed and Pasha (2015). Section 7 concludes.

2. Stylized facts: How domestic fuel prices are set in Pakistan?

Before analyzing whether the source of the oil price shock matters for Pakistan, it is important to understand the transmission mechanism though which oil price increases impact domestic fuel prices and inflation. In most oil-importing economies like Pakistan, India, Indonesia, Philippines, and Turkey, etc., the fuel price paid by consumers at the filling-stations is administered. The high degree of price regulation allows the government in these countries impose taxes on fuel, and use those as a source of revenue to meet their respective fiscal target. As a result, the government has significant discretion when it comes to setting domestic fuel prices. However, in countries with significant political uncertainty, like Pakistan, the government might not act as the best social planner when it comes to determining domestic fuel prices.

To understand how various political considerations affect the government's ability to set fuel prices, it is essential to first understand the pricing framework in Pakistan. The price is divided into six components: ex-refinery price, in-land freight equalization margin (IFEM), distributor margin, dealer commission, fuel levy, and sales tax. Ex-refinery price is the amount at which oil refiners sell their product to oil marketing companies (OMCs), and this component is dependent on the price of imported crude oil. IFEM is the transportation cost of fuel throughout the country. Distributor margin and dealer commission refer to the per liter earning of OMCs and dealers (filling-stations) respectively. The fuel levy and sales tax are determined by the government. Both tax components are a certain percentage of either the ex-refinery price, or a combination of the sum of various components.

The Economic Coordination Committee (ECC), on recommendation of the Oil and Gas Regulatory Authority (OGRA), has the final say in deciding the pass through of global oil to domestic prices. Following an adverse (positive) oil price shock, the ECC decides on the pass through by adjusting various components in the administered fuel price. If global crude oil prices increase, the ECC could decide in favor of a complete pass through to domestic consumers. This can be done by adjusting the ex-refinery price upwards which depends on global crude oil prices, and leaving the percentage of each component unchanged. This will then result in an increase in revenue due to the proportional nature of taxes implemented on fuel prices, and allow the government to meet its fiscal target since fuel taxes are a significant chunk of its revenue.[1] The government could also decide against a complete pass through following an adverse oil price shock. In this case, the policy-maker will have to adjust the ex-refinery price upwards since that is a function on global crude oil prices. However, it could revise the tax and non-tax components of the price downwards such that the final fuel price

[1] Source: Table 19, Non Tax Revenue Receipts, Budget in Brief 2021-22.
For example, during FY 2020-21 revised estimates suggest that fuel levy worth PKR 500,000 million was to be collected, while total non-tax revenue stood at PKR 1,704,443 million. This suggests that approximately 29.3% of the non-tax revenue came from the fuel levy alone.

stays constant, or doesn't change by much. This would mean that the government would have to give up on its revenue, thus worsening its fiscal balance.

The pricing framework mentioned above implies that the government's decision in setting domestic fuel prices also hinges on its ability to absorb losses by either giving up on its revenue, or providing direct subsidy to consumers.[2] One important consideration in this regard is whether Pakistan is under an IMF programme or not. The IMF programme, either in the form of an Extended Fund Facility (EFF) or a Stand-By Arrangement (SBA), aims to help countries address their balance of payment crisis. Usually, one of the stipulations of the IMF programme include maintaining a contractionary fiscal stance. This stance would translate into the government not being able to reduce the tax component of fuel price following an oil price shock, as doing so would reduce its revenue, which would be in violation of the IMF programme conditions. As a result, one would expect a larger pass through of global oil prices to domestic fuel prices whenever Pakistan is in an IMF programme.

To validate this, we plot the ratio of domestic fuel prices to global crude oil prices (converted into PKR) in Figure 1[3], and highlight periods when Pakistan was in an IMF programme. This ratio will always be larger than one, because refinery, transportation costs, and other margins mean that the price of the product consumers pay for at the filling stations is greater than the price of unrefined crude oil (expressed in PKR). We observe that the ratio between prices is significantly higher during the IMF regime as opposed to the non-IMF regime. A higher ratio suggests that price components like fuel levy and sales tax are higher during the IMF regime than levels set by the government under a non-IMF regime.[4] Table 1 shows that the ratio of domestic to global prices is almost 22% larger under an IMF programme across our entire sample period.

In addition to the fiscal priority, other considerations that could influence the pass through decision is the observed inflation rate. For example, if observed inflation is higher than expected inflation, the ECC might reduce the burden on domestic consumers by reducing the sales tax and fuel levy rates, while adjusting the ex-refinery price upwards such that the price of the final product is constant. Under the same scenario, if oil prices decrease, the ECC could allow for a complete pass through, and reduce domestic fuel prices.

Moreover, if observed inflation is lower than target inflation, the ECC could allow for a complete pass through of higher global oil prices to domestic fuel prices. Under the same scenario, if oil prices decrease considerably, the government could decide against passing on the complete benefit to consumers. The government could potentially use this as an opportunity to increase its revenue by raising the sales tax and fuel levy rates, while adjusting the ex-refinery price downwards (which is a function of global crude oil prices) such that the price of the final product declines. To summarize, key factors that influence the government's domestic fuel price setting behavior include operating under an IMF programme, and the prevailing inflation rate. As a result, it is essential to control for these mechanisms while we try to understand the dynamic relationship between oil prices and inflation in Pakistan.

[2] For example, following an increase in the price of oil between February 16, 2022, and March 1, 2022, the government gave up on its non-tax revenue by reducing the petroleum levy so that it could keep fuel prices constant. More recently, the government decided in favor of providing a subsidy of PKR 47/liter according to gasoline prices notified on May 16, 2022, with the intention of keeping domestic fuel prices unchanged.
Source: OGRA E-10 Notified Gasoline Prices

[3] Figures and Tables are given at the end of the main text.

[4] This assumes that price components like the distributor margin and dealer commission are not dependent on Pakistan operating under an IMF programme or not.

3. Empirical methodology

3.1 Decomposing shocks to the real price of oil

Kilian (2009) decomposes global oil price changes into respective demand and supply components by estimating a tri-variate VAR model consisting of month-by-month percentage change in global crude oil production, the index of real economic activity, and the log of real oil price. In Pakistan, the government has significant discretion when it comes to controlling the price of domestic fuel. For example, there could be an increase in fuel prices due to an unanticipated increase in the petroleum levy, or reduction in prices near elections to influence the public to vote in favor of the ruling party. Therefore, in addition to variables used in Kilian (2009) to identify oil price shocks, we add the log of the real price of domestic fuel as a fourth variable. The shock for this equation corresponds to unexpected changes in domestic fuel prices driven by factors other than the price of global crude oil.

Data on global crude oil production has been retrieved from the U.S. Energy Information Administration (EIA). The index of real economic activity constructed by Kilian (2009), and then modified by Kilian and Zhou (2018) has been downloaded from the Federal Reserve Bank of Dallas' website. For our purpose, we use the CPI-deflated Dubai Fateh crude oil price as the measure of real oil price. This series was downloaded from the Federal Reserve Economic Database (FRED). We utilize CPI-deflated domestic petroleum price as the measure of fuel price. The following VAR model is estimated to recover the structural oil shocks:

$$z_t = A_0^{-1}\alpha + \sum_{i=1}^{24} A_0^{-1} A_i z_{t-i} + A_0^{-1}\varepsilon_t \quad Eq. (1)$$

Where , is the change in global oil production, is the index of real economic activity, is the log of the real price of oil, and is the log of the real price of domestic fuel products.

$$e_t = A_0^{-1}\varepsilon_t = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{s} \\ \varepsilon_t^{ad} \\ \varepsilon_t^{pd} \\ \varepsilon_t^{fuel} \end{bmatrix} \quad Eq. (2)$$

For the purpose of identifying oil shocks, the Cholesky decomposition is applied to the reduced form residuals matrix. The oil supply (ε_t^{s}), aggregate-demand (ε_t^{ad}), oil specific-demand (ε_t^{pd}), and residual shocks (ε_t^{fuel}) correspond to residuals for the global crude oil production, index of real economic activity, real oil price, and real fuel price equations, respectively. The oil supply shock is defined as an increase in the price of oil driven by unanticipated changes in global production. An example of such a shock would be disruptions to supply following the Iran-Iraq War of 1980. The aggregate demand shock indicates an increase in the price of oil due to unanticipated increase in demand for global commodities. An example of such an event would be the surge in crude oil prices during the early 2000's, following an increased preference of consumers in Asian countries like India and China for energy-consuming durable goods like automobiles. Whereas, the oil-specific demand shock, refers to a change in the price of oil driven by an increase in demand for oil due to expectations of shortfall in future oil supplies. For example, this shock can be thought of capturing an increase in the price driven by an increase in demand for oil due to skepticism about future supplies as conflict breaks out in the Middle East. The residual shock captures unexpected changes in domestic fuel prices driven by factors other than movements in global crude oil production, economic activity, and price of crude oil. An example of such a shock would be an increase in fuel prices due to an unanticipated increase in the petroleum levy, or reduction in prices near elections to influence the public to vote in favor of the ruling party. Figure 2 suggests that most of the global oil price fluctuations from January 2002 onward were driven primarily by the aggregate and oil-specific demand shocks.

Our decomposition suggests that the methodology proposed in Kilian (2009) does a decent job of identifying supply and demand driven movements in the global crude oil market. For simplicity, we add up the aggregate demand and oil-specific demand shocks, and classify both as the *oil demand shock*. We also present the historical decomposition of domestic fuel prices in Figure 3. Results indicate that most of the fluctuations in the domestic fuel market can be explained by aggregate demand, oil-specific demand, and residual shocks.

3.2 Modeling the effects of structural oil price shocks on inflation

We use local projections to calculate the impulse response functions of inflation following oil supply and demand shocks. Local projections allow us to directly estimate the impulse response functions using a single equation, and is particularly suited to assess the dynamic response of inflation to an oil price shock that has been identified outside a system, with a need to incorporate control variables. Following Jorda (2005), Ramey and Zubairy (2018), Pizzuto (2020), Sardar and Atems (2021), and Sardar and Sharma (2022), our equation takes the form:

$$\pi_t = \alpha_h + \beta_h \varepsilon_{oil,t} + \lambda_h X_t + \gamma_t \quad Eq.(3)$$

Where x_t is the variable of interest, $\varepsilon_{oil,t}$ is the structural oil shock in month t, α_h is the intercept, β_h represents the response of inflation to an oil price shock during month h, X_t is the vector of control variables, λ_h is the vector of coefficients for the control variables, and $\gamma_t$is the error-term. We follow Hyder and Hussain (2019), and use the following control variables: i) current and past changes in industrial production, ii) current and past changes in the policy rate, and iii) current and past changes in the real effective exchange rate. In addition, we also include the current and past IMF-programme dummies, along with past structural oil shocks. Inclusion of both these variables in our specification ensures that the impact of past inflation, and Pakistan's presence in the IMF programme does not influence the pass through of oil shocks to domestic inflation as discussed in Section 2, and thus is not captured in the coefficient, β_h.

The cumulative effect of an oil price shock on inflation is calculated by sequentially estimating Eq. (3) for each forecast horizon h, and then summing those up. Thus, the cumulative impulse response function for forecast horizon h is expressed as $\sum_{i=0}^{h} \beta_i$. The successive leading of the dependent variable, π_t, induces serial correlation in the error-term. To address this, we calculate the Newey West standard errors of the cumulative sum of our estimated coefficients. The exercise is carried out by first estimating a system of equations that are used to recover the cumulative impulse response functions. This is followed by applying the Newey West correction to the variance-covariance matrix. Finally, we use the delta method to extract standard errors of the nonlinear function of our parameters, $\sum_{i=0}^{h} \beta_i$.

4. Data

For our analysis, we utilize data on Pakistan's economy from January 2002 to August 2019. We begin our analysis in January 2002 since this is the starting point for the State Bank of Pakistan's Quarterly Projection Model (QPM), which generates medium-term projections for inflation and other macro variables. Our headline CPI measure is constructed using 2007-08 as the base year, and this series is available from January 2002 to August 2019. Data on dependent variables, namely, headline inflation, core inflation, and domestic price for fuel (petrol super) have been downloaded from SBP's website. The control variables like industrial production, policy rate, and real effective exchange rate have been provided to us by the SBP's Monetary Policy Department. All variables have been seasonally adjusted, and converted into period-by-period percentage changes to deal with non-stationarity. Furthermore, global crude oil supply and demand shocks have been derived following Kilian (2009), and a discussion on the recovery of these shocks is included in the preceding section.

5. Empirical results

5.1 Dynamic response of inflation to oil price changes

We begin by documenting the impact of a global oil price increase on various inflation measures in Pakistan. We find that a one-standard deviation real oil price increase, that corresponds to a monthly growth rate of 8.70 pp., generates a cumulative increase of 2.94 pp., 1.33 pp., and 1.22 pp. in domestic fuel, headline, and core inflation respectively after one year. The cumulative impulse response functions are statistically significant at each forecast horizon. One feature implicit in the use of this measure of oil price is that it ignores whether the change is driven by supply or demand factors. An abundance of the literature, starting with Kilian (2009), has suggested that oil supply and demand shocks have different effects on the economy.[5] Hence, the cumulative impulse response functions in Figure 4, can be interpreted as being the average response of inflation to oil supply and demand shocks. It is worth pointing out that these results do not represent an original contribution, as an abundance of studies have analyzed the relationship between oil prices and inflation in Pakistan. These results however provide a benchmark for comparison results in the succeeding section where we explicitly differentiate between supply- and demand-driven oil price changes.

5.2 Impact of oil price shocks on the pump price of petrol

We present the impulse response functions of real oil price, and real fuel (petrol) price to the four identified oil price shocks in Figure 5. Oil supply shocks, which capture unanticipated changes in global crude oil production, generate an increase in the price of crude oil that is statistically significant after 10 months. However, we observe that such a shock is not followed by higher domestic fuel prices. This could suggest that policy-makers view supply shocks as transitory, and thus decide to not increase administered fuel prices.

Aggregate demand shocks generate a moderate increase in global crude oil prices, which is then also followed by a cumulative increase in domestic fuel prices. The impulse response function of domestic fuel price is statistically significant after five months, since zero lies outside the confidence bands. On the other hand, the response of crude oil prices to the oil-specific demand shock is stronger in comparison to the oil supply and aggregate demand shocks. We observe that such a shock generates a cumulative increase of around 5% in the real price of oil after a year, which is statistically significant. This is then followed by a cumulative increase of approximately 3% in domestic fuel prices. The residual shock, which captures unexpected changes in domestic fuel prices driven by factors other than the price of crude oil, leads to a temporary increase in domestic fuel prices that lasts for a few months. The cumulative response after a year is close to zero. Our results in this section highlight that policy-makers price setting behavior is influenced primarily by the aggregate demand and oil specific demand shocks.

[5] For more on whether the source of the oil price shock matters, see Kilian and Park (2009), Alsalman and Karaki (2018), Melek (2018), and Sardar and Sharma (2022).

5.3 Responsiveness of domestic fuel prices to crude oil prices

To check whether the response of domestic prices to global crude oil prices depends on the source of the shock, we also present the elasticities in Table 2. Due to the lagged response of government in setting domestic prices following changes in global oil prices, the elasticity is calculated using the following formula:

$$\varepsilon_t^{fuel,oil} = \frac{\%\Delta\ Domestic\ \ petroluem\ \ prices_t}{\%\Delta\ Global\ oil\ prices_{t-1}}$$

This is followed by classifying elasticities into two regimes, i.e., episodes where oil demand shocks are the primary drivers of oil prices, and events where these prices are influenced predominantly by supply shocks. As shown in Table 2, approximately 83% of the sample comprises of observations where the oil demand shocks are dominant. This is in line with Kilian (2009), and Sardar and Sharma (2022) who find that the oil price fluctuations in recent years have been driven by demand factors, with the importance of supply factors declining considerably in recent years. Results in Table 2 suggest that there were at least 72 months, where the price-setting authorities did not adjust domestic fuel prices following a change in the global crude oil price. Specifically, of the 72 months, there are 29 episodes where the prices were not adjusted downwards following an oil price decrease (*favorable shock*). Such a kind of policy measure would primarily be taken when the government is trying to improve the fiscal balance. Recalling the price components of fuel discussed in Section 2, low global oil prices will translate into a lower ex-refinery price. For the final price of fuel to remain constant, the government will have to increase the sales tax and petroleum levy rates. Thus, allowing the government to generate revenue, and improve its fiscal balance. There are also multiple instances where the government decided against increasing domestic prices even as global oil prices rose (*adverse shock*). In such cases, following an increase in the ex-refinery price, the government would have to reduce the sales tax or petroleum levy rates, so that the final price remains unchanged. There are 43 months in which the government took these kinds of measures.

Furthermore, there are 39 episodes of negative elasticity, suggesting that global oil prices and domestic fuel prices moved in the opposite direction. For 15 months, this was done following an oil price decrease, and 24 times it was done following an oil price increase. That being said, we find that global oil prices and domestic fuel prices move in the same direction across a larger part of our sample, as illustrated by the positive elasticities. Furthermore, we find clear evidence that the government's price-setting behavior depends on the source of the oil price shock. When oil supply shocks are the main drivers of global prices, a 1% in the price of oil leads to an increase of 0.7% in domestic fuel prices. On the other hand, when oil demand shocks are dominant, a 1% increase in the price of crude oil leads to a 1.2% increase in domestic fuel prices.

5.4 Dynamic response of inflation to oil supply and demand shocks

The previous section illustrated that the source of the oil shock matters for the policy-makers' price-setting behavior. We now analyze the dynamic response of inflation to the identified oil price shocks. The estimated response of headline inflation to oil price shocks using monthly data from 2002 to 2019 is presented in Figure 6. All shocks have been normalized such that these represent a one-standard deviation unanticipated increase in the real price of oil due to supply or demand factors. The solid lines represent the cumulative impulse responses of our measure of inflation to a one-standard deviation oil price shock. Whereas the corresponding red and blue dashed lines indicate the one- and two-standard deviation error bands, respectively. We find that a one-standard deviation oil supply shock generates a cumulative increase of 0.02 pp. in headline inflation after a year. Furthermore, a shock of same size leads to an increase of 0.18 pp. in core inflation. Since zero lies inside the confidence bands, the dynamic responses of both measures of inflation to oil supply shocks are not statistically significant. This suggests that oil price increases driven by unanticipated changes in oil production do not have any large or significant impacts on inflation in Pakistan.

Furthermore, a one-standard deviation oil demand shock drives up headline inflation by 1.33 pp. after one year. Furthermore, we observe strong second-round effects of oil demand shocks, as core inflation increases by 0.93 pp. over the course of year. These cumulative impulse responses are statistically significant.

Our results point to the importance of understanding the source of the oil price movement since the resulting responses of domestic fuel prices, and inflation are likely to differ depending on whether the oil price shock is supply- or demand-driven. The impulse response functions of domestic fuel prices suggests that OGRA potentially perceives oil price increases driven by changes in global demand as long-lasting. This then leads to strong first- and second-round effects. The first-round effect is classified as the increase in domestic energy prices, whereas second-round effect refers to the increase in non-energy prices, as reflected by the response of core inflation. In the case of oil supply shocks, this argument does not hold as OGRA does not increase domestic fuel prices. Consequently, the response of headline and core inflation is muted, and not significant in a statistical sense.

6. Implications for monetary policy in Pakistan

Our findings in the previous section suggest that not all kinds of oil price shocks are inflationary. Specifically, we establish that oil price increases driven by unanticipated changes in global crude oil production have a muted response on inflation in Pakistan. Whereas oil price increases driven by shocks to global demand have strong and statistically significant effects on inflation. This result has important implications for monetary policy in Pakistan, as it highlights the need for the central bank to account for the source of the oil price shock, and only respond to those that are inflationary in nature.

For an oil-importing economy like Pakistan, an oil price shock is a supply shock since this causes output and inflation to move in the opposite direction.[6] Standard macroeconomic theory suggests that central banks can responds to supply shocks by stabilizing either output or inflation. For an inflation-targeting central bank, however, the optimal response to a shock would involve increasing the interest rate, thus shifting the aggregate demand to the left and reaching a short-term equilibrium. One caveat to bear in mind is that central banks should only respond to supply shocks that seep into various components of inflation, and generate strong second-round effects. In case the central bank responds to a supply shock which only generates first-round effects, the recessionary consequences would be exacerbated as the interest rate hike, and will result in over-tightening, and significant loss in output.

As illustrated in the previous section, if only the oil demand shock has strong second-round inflationary effects while the transitory oil supply shock doesn't, this then calls for the central

[6] An adverse supply shock, i.e. oil price increase, will shift the short-run supply curve to the left. This will result in an increase in inflation and fall in output.

bank to identify the source of the oil shock and respond accordingly. This section presents the augmented-FPAS which distinguishes between oil supply and oil demand shocks.

6.1 Model

The Forecasting and Policy Analysis System (FPAS) for monetary policy analysis in Pakistan developed by Ahmad and Pasha (2015) is used by the central bank to generate inflation projections conditional on the endogenous policy path. The structure of this framework is divided into five blocks: *(i)* aggregate demand, *(ii)* aggregate supply, *(iii)* external sector representation, *(iv)* monetary policy reaction function, and *(v)* fiscal policy. For our purpose, modifications to the aggregate supply and policy reaction function blocks are made. Whereas the aggregate demand and external sector blocks are similar to Ahmad and Pasha (2015).[7] The fiscal policy block is a recent addition to the framework, and will be explained later in the paper.

6.1.1 Oil price block

The preceding sections highlight not all kinds of oil price shocks matter for inflation dynamics in Pakistan. Specifically, we observe that oil price movements driven by changes in global demand led to a protracted rise in the price of domestic petroleum prices, which then translates into an increase in the inflation rate. Consequently, we identify shocks following Kilian (2009), and integrate these shocks into the exogenous equation for global oil prices. This allows FPAS to distinguish between whether changes in oil prices are driven by supply or demand factors. The exogenous equation takes the following form**:**

$$\Delta p_{oil,t}^{w} = h_4 \Delta p_{oil,t-1}^{w} + (1-h_4)\pi_{ss}^{*} + e_t^{\Delta \mathrm{p_{oil,t}}}$$

Where, $\Delta p_{oil,t}^{w}$ is the quarterly growth rate of oil prices, π_{ss}^{*} represents the steady-state inflation in the foreign economy, and $e_t^{\Delta \mathrm{p_{oil,t}}}$ denotes the oil price shock. We impose a structure on the oil price shock by integrating the oil supply and oil demand shocks identified following Kilian (2009), which is expressed as:

$$e_t^{\Delta \mathrm{p_{oil,t}}} = \eta_{10}\varepsilon_t^{oil\ supply} + \eta_{11}\varepsilon_t^{oil\ demand}$$

Where $\varepsilon_t^{oil\ supply}$ is the oil supply and $\varepsilon_t^{oil\ demand}$ is the oil demand shock discussed in Section 3.1. represent the contribution of supply and demand shocks in driving fluctuations in the price of oil. These are calibrated based on historical data. The identified shocks are further modeled as AR(1) processes:

$$\varepsilon_t^{oil\ demand} = \gamma_1 \varepsilon_{t-1}^{oil\ demand} + v_t^{oil\ demand}$$

$$\varepsilon_t^{oil\ supply} = \gamma_2\ \varepsilon_{t-1}^{oil\ supply} + v_t^{oil\ supply}$$

[7] The aggregate demand block links domestic economic activity to its own lag, the real interest rate, the real exchange rate, and foreign economic activity. The external sector block links the level of nominal exchange rate to its backward- and forward-looking component, interest-rate and inflation differentials between the domestic and foreign countries.

The parameters, γ_1, and γ_2, are calibrated by estimating an AR(1) model for both measures of oil price shocks. A discussion on the calibration follows in the subsequent section.

6.1.2 New aggregate supply block

The aggregate supply is the price-setting block that relates inflation to its backward- and forward-looking components, output gap, and real exchange rate gap. The national consumer price index in Pakistan is constructed using the weighted average of prices in urban and rural areas. In line with this practice, the aggregate supply for urban and rural areas is also defined separately.

The structure of the Phillips curve for energy, food, and core inflation across both urban and rural areas is the same, with each of these expressed as the weighted average of the backward- and forward-looking components of inflation, and real marginal cost. The structure of the energy inflation block is the same as in Ahmad and Pasha (2015), and is as follows:

$$\pi_{i,t}^{en.} = b_{31,i}\pi_{i,t-1}^{en.} + \left(1 - b_{31,i} - b_{32,i}\right)E_t\pi_{t+1}^{Nat.} + b_{32,i}rmc_{i,t}^{en.} + \varepsilon_{i,t}^{\pi^{en}}$$

Where $\pi_{i,t}^{en.}$ is the quarterly growth rate of energy inflation, $E_t\pi_{t+1}^{Nat.}$ is the forward-looking component of headline inflation, $rmc_{i,t}^{en.}$ is the real marginal cost, and $i \in [urban, rural]$. Unlike Ahmad and Pasha (2015), both core and food inflation are also modelled to be a function of energy inflation. This is essential for three reasons. First, doing so allows us to incorporate fluctuations in the price of energy-intensive core goods due to energy price shocks (see, Amarasekara et al., 2018), a link that was missing before. Second, there is evidence suggesting that fuel prices are transmitted to agriculture produce prices via transportation costs (see, Volpe et., 2013). Third, as shown in Section 4, the source of the oil shock matters for core inflation. Consequently, including energy inflation separately in non-energy inflation components allows us to capture better the dynamics of overall inflation. The basic structure of the Phillips curve for core and food inflation is the same as in Ahmad and Pasha (2015). However, the real marginal cost is modified to include energy inflation in the following manner:

$$rmc_{i,t}^{core} = b_{3,i}\hat{y}_t + \left(1 - b_{3,i}\right)\hat{z}_t + b_{4,i}\pi_{i,t}^{en.}$$

$$rmc_{i,t}^{food} = b_{23,i}\hat{z}_t + (1 - b_{23,i})\hat{y}_t + b_{24,i}\pi_{i,t}^{en.}$$

Where, $rmc_{i,t}^{j}$ is the real marginal cost, $\hat{y}_t$ represents the output gap, and $\hat{z}_t$ denotes the real exchange rate gap.

6.1.3 Monetary policy reaction function

As shown in the earlier section, oil price shocks driven by changes in global demand generates strong direct and indirect effects on inflation in Pakistan. This response is driven by strong adjustment in administered petroleum prices following an oil demand shock. On the other hand, we do not find any evidence of oil supply shocks being inflationary. This suggests that the central bank does not need to respond to all types of oil price shocks, as some of these might not be inflationary in nature. Not accounting for the source of the oil price shock might result in over-tightening, and thus a loss of output. These results highlight the need for the central bank to account for the source of the oil price shock before setting the policy rate. Accordingly, the monetary policy rule is defined as follows:

$$i_t = g_1[(s_{t+1} - s_t) + i_t^* + prem_t] + (1 - g_1)[f_1 i_{t-1} + (1 - f_1)(i_t^n + f_2(\pi 4_{t+4} - \pi_t^T) + f_3 \hat{y}_t)] + \varepsilon_t^i$$

Where, i_t denotes the policy rate, s_t represents the nominal exchange rate, i_t^* is the U.S. federal funds rate, $prem_t$ is the risk-premium, i_t^n indicates the neutral interest rate, and $\pi 4_{t+4}$ represents the 4-quarter ahead year-on-year inflation.

6.1.4 Fiscal policy block

Given Pakistan's history of running large and persistent fiscal deficits, it is essential for the QPM to be extended such that it captures the effects of fiscal policy. This would allow us to analyze the impact of changes in tax and expenditure policies on output and inflation.

6.2 Parameter calibration

The parametrization strategy employed in this paper is the same as Ahmad and Pasha (2015), which is guided by the use of historic data series at the quarterly frequency. For brevity, we only present the discussion of parameters related to the Phillips Curve for various components of inflation. Whereas calibrated values for the remainder of the parameters are the same as presented in Ahmad and Pasha (2015).

γ_1 and γ_2 represent the persistence of oil demand and oil supply shocks, which have been calibrated to be 0.19 and 0.07 respectively, based on estimates from an AR(1) model. η_{10} and η_{11} represent the contribution of supply and demand shocks in driving fluctuations in the price of oil. Decomposition of changes in oil price suggest that across our entire sample period, the proportion of episodes where these changes are predominantly influenced by demand factors is 0.76. On the other hand, 24% of the episodes across our entire sample period are driven by supply factors. Consequently η_{10} is calibrated to 0.76, whereas η_{11} is 0.24. Next, we calibrate parameters for the Phillips Curve by calculating the correlation coefficient conditional on the nature of the oil price shock. The yielded estimates for these parameters are reported in Table 3.

6.3 Economic properties

In this section we demonstrate the dynamic properties of the model by analyzing the impulse response functions (plotted in Figure 7) to the identified structural oil shocks. In principle, oil price shocks impact inflation through the direct and indirect channels. The direct channel implies that an increase in oil prices results in higher energy inflation, which pushes up headline inflation. Whereas the indirect mechanism suggests that this increase in headline inflation will lead to expectations of higher prices in the future, which would push up both core and food inflation. In this case, the central bank would respond by raising the interest rate to keep inflation expectations anchored.

The impulse response functions in Figure 7 confirm the mechanism at play, as a 10% unexpected increase in the price of global crude oil leads to an increase in energy inflation, which passes through to headline inflation. This results in a tightening of the monetary policy stance, and leads to a decline in output, as illustrated by the negative output gap. Keeping in view the empirical assessment from the preceding section that not all kinds of all oil price shocks have strong effects on domestic petroleum prices and inflation, the impulse response functions to an oil demand shock imply a much larger response of headline inflation and consequently the policy rate, as opposed to the case when oil price movements are driven by supply-side factors.

7. Conclusion

Using data on Pakistan's economy from 2002 to 2021, this paper examines whether the source of the oil price shock matters for the response of inflation, and highlights the implications of our findings for monetary policy. Consistent with existing literature, we find that a one-standard deviation increase in the price of oil leads to higher inflation. This methodology, however, does not distinguish between oil price changes driven by supply or demand factors. To address this, structural oil price shocks are identified as in Kilian (2009), and the impact on various measures of inflation is studied. Further, we highlight the implications of our results for monetary policy in Pakistan using FPAS. To conclude, we find that oil demand shocks, unlike oil supply shocks, have a stronger impact on inflation.

Our results are in line with the existing literature stressing the need for central banks to not respond to transitory supply shocks. The underlying reason for this is entrenched in monetary policy having an adverse impact on economic activity over the duration of the monetary transmission mechanism in case of over-tightening. Moreover, central banks should respond to supply shocks that are protracted in nature appropriately in a bid to manage the second-round impact of such shocks. This helps to contain the wage-price spiral, and allows the central bank to build its credibility. An inappropriate response in the face of an oil price shock would exacerbate the inflation outcome, and also result in the economy paying a higher price, in terms of output loss, higher inflation and central bank credibility.

Therefore, it is essential for policy makers to continuously monitor international oil prices, and make an assessment about the source and duration of the oil price shock, while calibrating its monetary policy response.

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Figures

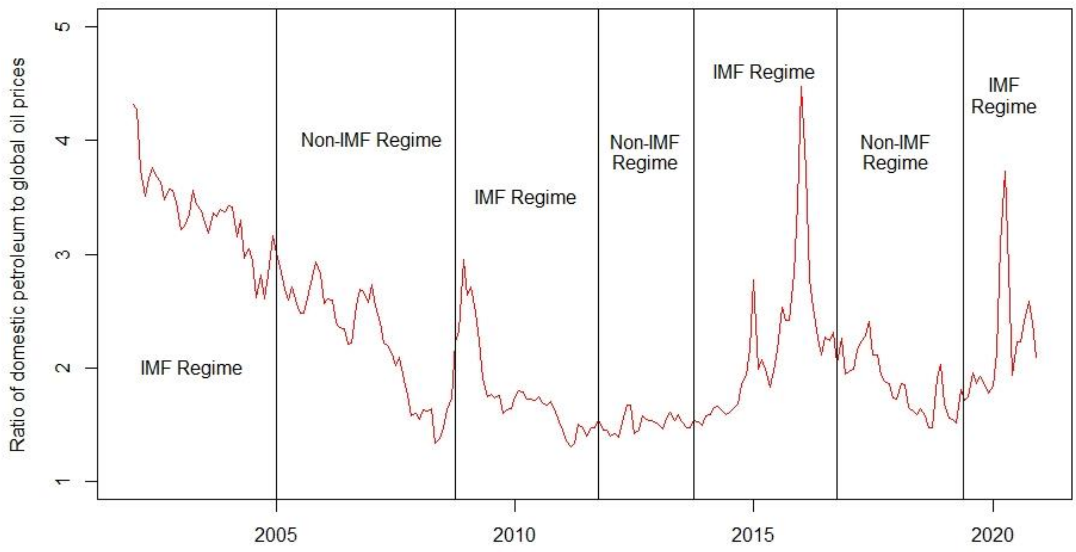

Figure 1. Ratio of domestic fuel to global crude oil prices, and time periods when Pakistan was under the IMF programme.

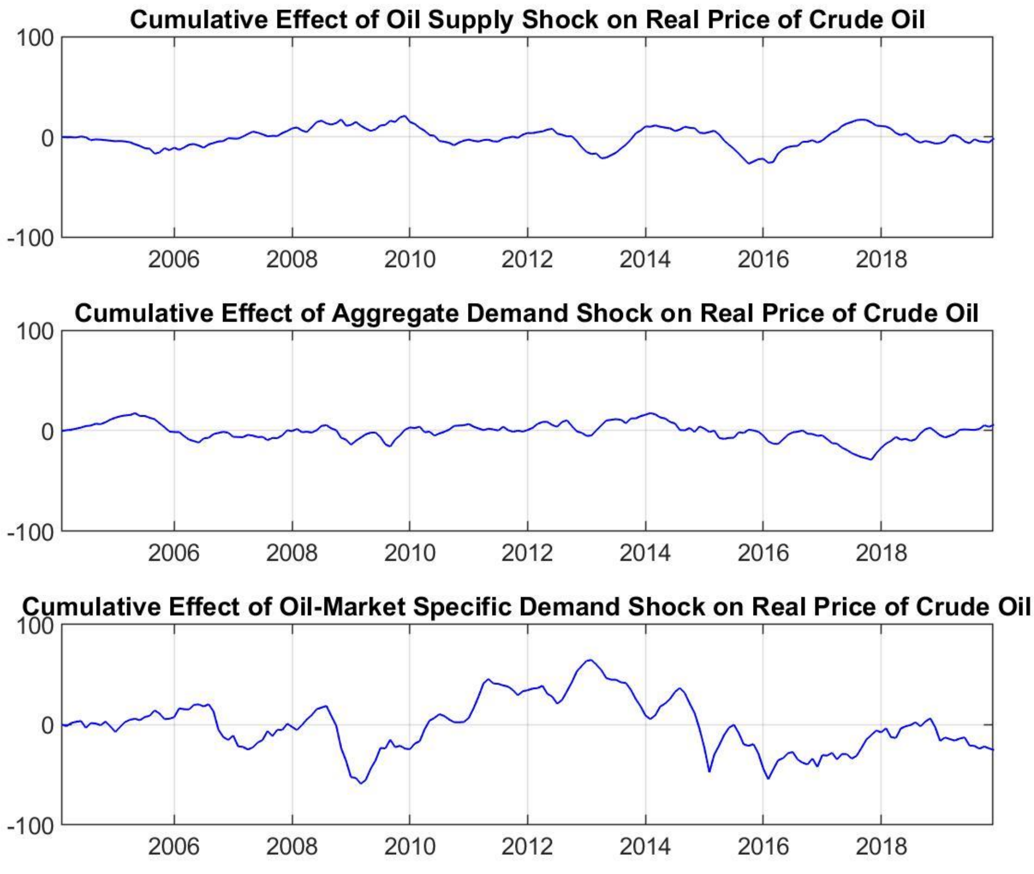

Figure 2. Historical contribution of each structural shock on the real price of crude oil.

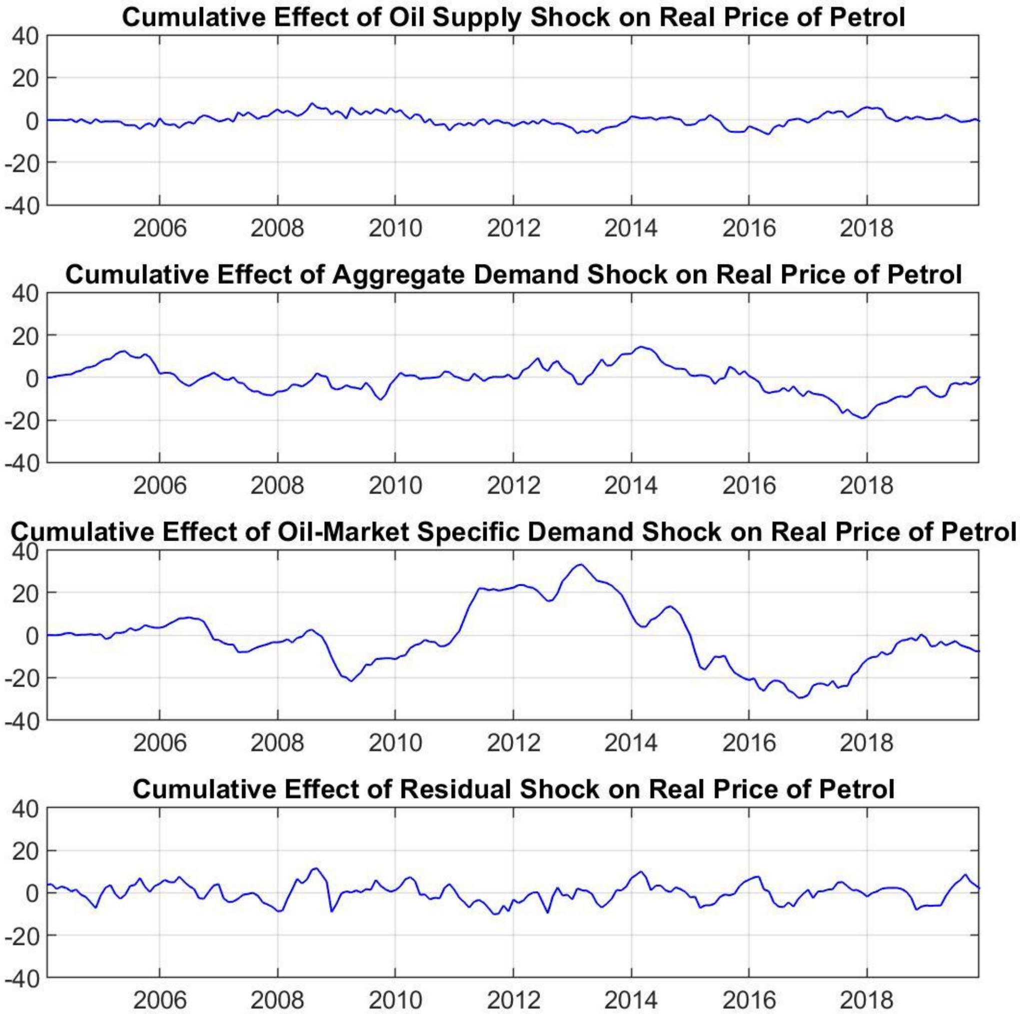

Figure 3. Historical contribution of each structural shock on the real price of fuel.

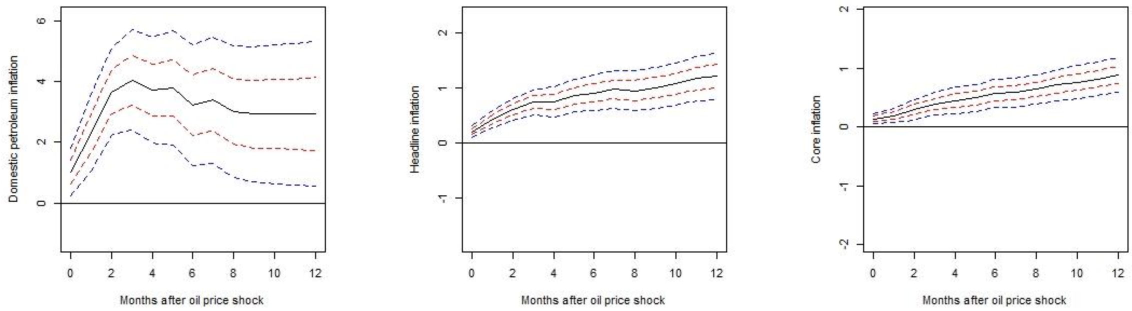

Figure 4. Impulse response functions of domestic fuel prices and inflation to a one-standard deviation oil price increase.

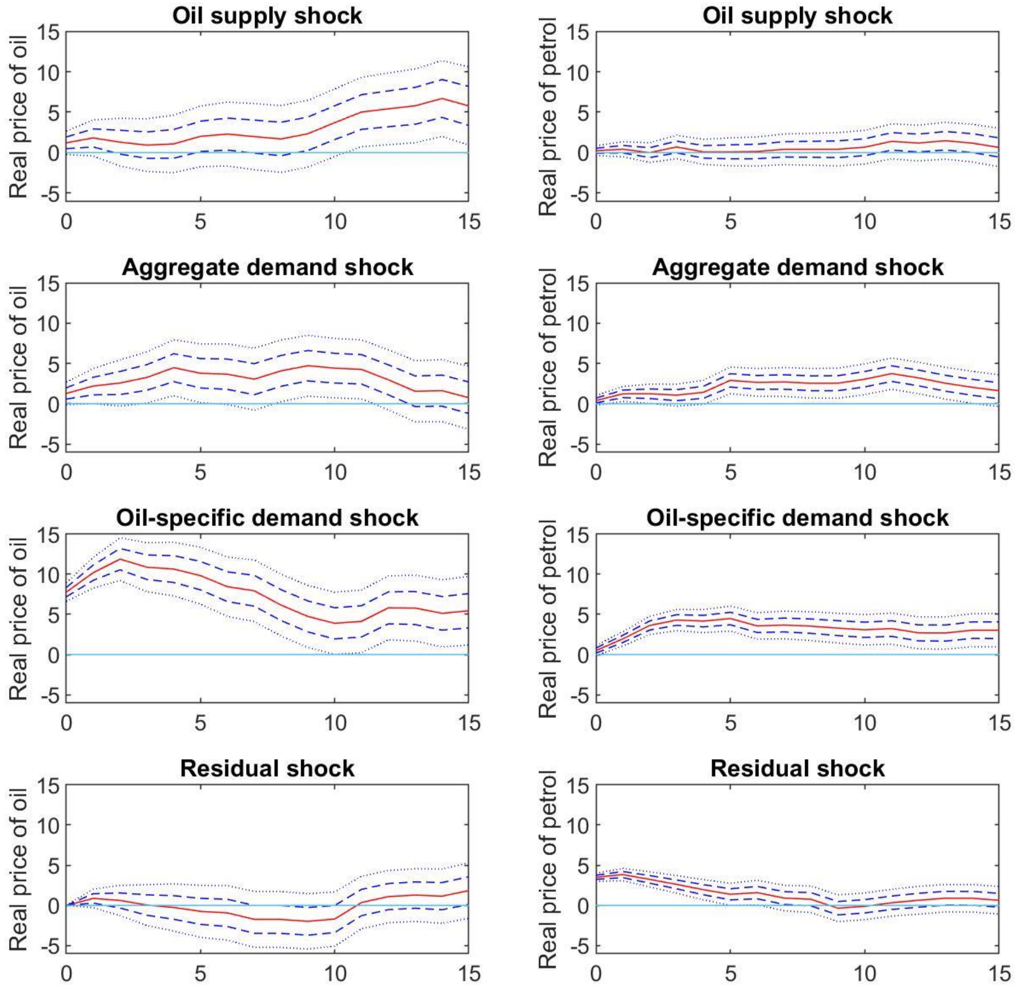

Figure 5. Impulse response functions of real oil and fuel price to one-standard-deviation structural shocks. (Point estimates with one- and two-standard error bands)

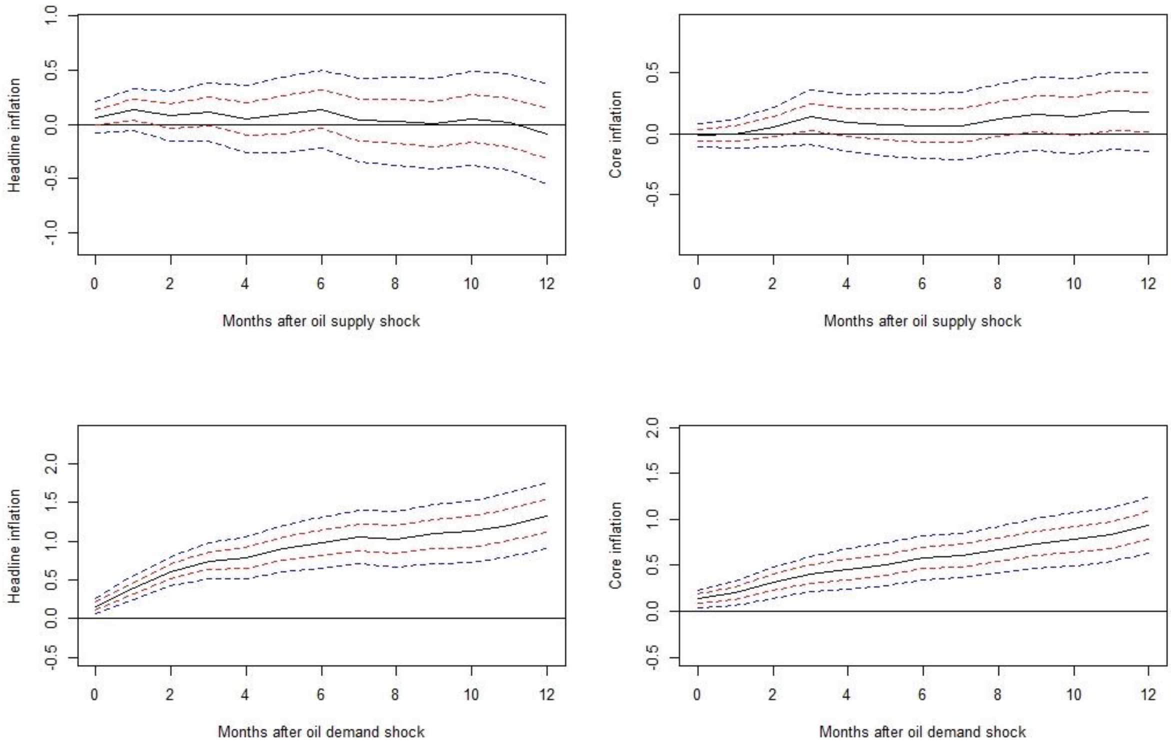

Figure 6. Impulse response functions of inflation to a one-standard deviation structural shock.

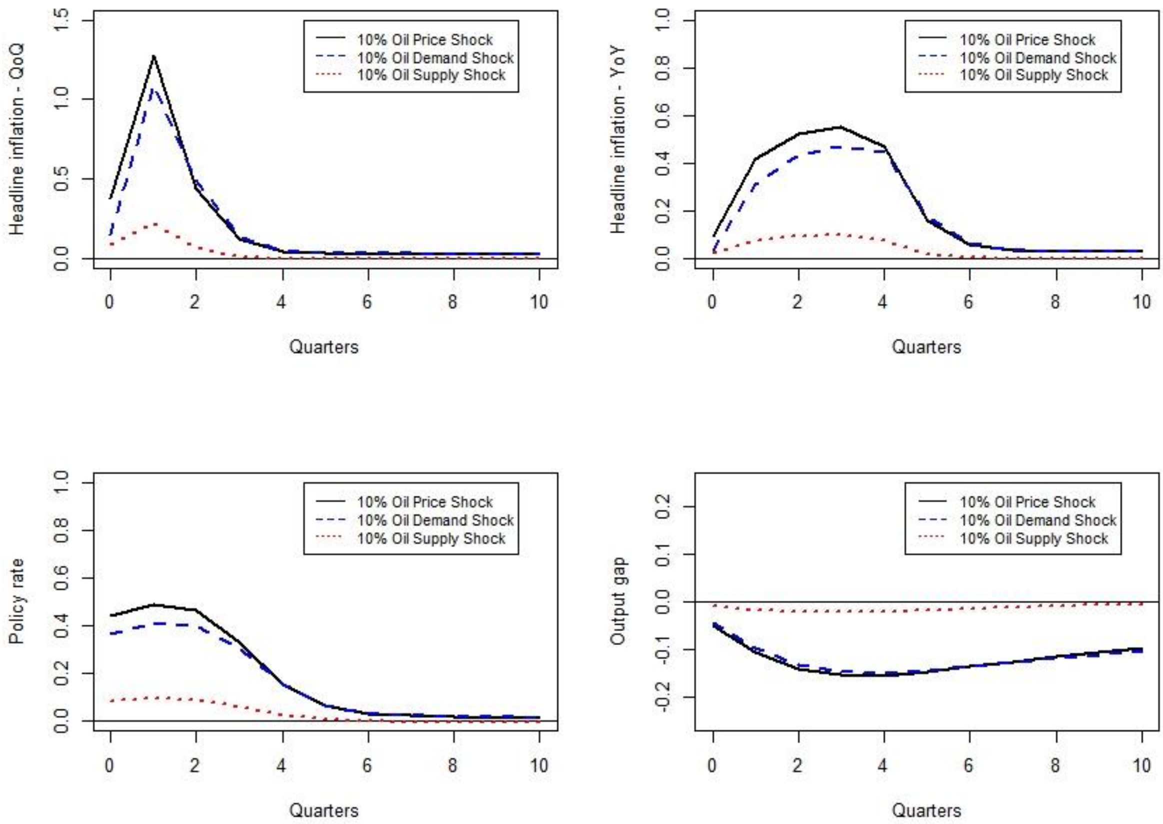

Figure 7. Impulse response functions of inflation, policy rate, and output gap to a 10% oil price shock.

Tables

Regime	Ratio	Time Periods
Under IMF programme	2.41	Jan. 2002 - Dec. 2004, Nov. 2008 - Sep. 2011,
		Sep. 2013 - Sep. 2016, Jul. 2019 - Present
No IMF programme	1.97	Jan. 2005 - Oct. 2008, Oct. 2011 - Aug. 2013,
		Oct. 2016 - Jun. 2019
Sample average	2.21	

Table 1. Average ratio of domestic fuel to global crude oil prices under IMF and non-IMF regimes.

Oil Shock	Elasticity Sign	No. of Events	Adverse Shock	Favorable Shock	Avg. Elasticity
		(Months)			
Supply	+ve	18	10	8	0.7
	-ve	6	3	3	-
	Zero	12	8	4	0
Demand	+ve	82	49	33	1.2
	-ve	33	21	12	-
	Zero	60	35	25	0

Table 2. Events in which oil prices were predominantly driven by a supply or demand shock, and the elasticities of domestic fuel prices with respect to global oil prices during each event.

Oil Shock	Parameter	Description	Value
Demand	γ_1	Oil demand persistence	0.19
	η_{11}	Share of oil demand shocks	0.75
	$b_{2,r}b_{4,r}$	The impact of domestic energy prices on core prices (rural)	0.39
	$b_{2,u}b_{4,u}$	The impact of domestic energy prices on core prices (urban)	0.48
	$b_{22,r}b_{24,r}$	The impact of domestic energy prices on food prices (rural)	0.39
	$b_{22,u}b_{24,u}$	The impact of domestic energy prices on food prices (urban)	0.62
	$b_{32,r}$	The impact of oil demand shocks on energy inflation (rural)	0.34
	$b_{32,u}$	The impact of oil demand shocks on energy inflation (urban)	0.34
Supply	γ_2	Oil supply persistence	0.07
	η_{10}	Share of oil supply shocks	0.25
	$b_{2,r}b_{4,r}$	The impact of domestic energy prices on core prices (rural)	0.06
	$b_{2,u}b_{4,u}$	The impact of domestic energy prices on core prices (urban)	0.05
	$b_{22,r}b_{24,r}$	The impact of domestic energy prices on food prices (rural)	0.01
	$b_{22,u}b_{24,u}$	The impact of domestic energy prices on food prices (urban)	0.53
	$b_{32,r}$	The impact of oil demand shocks on energy inflation (rural)	0.39
	$b_{32,u}$	The impact of oil demand shocks on energy inflation (urban)	0.29

Table 3: Calibrated values of parameters.