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Oil price fluctuations and their impact on oil-exporting emerging economies ☆

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ABSTRACT

How do oil price fluctuations affect economic activity and policy in the context of oil-exporting emerging economies? Past research suggests that the output responses to oil price innovations are asymmetric in nature but does not directly test the asymmetry in the government expenditure adjustments triggered by the shock. Moreover, many studies quantifying these asymmetric responses are fraught with methodological concerns. This paper assesses the empirical relevance of such asymmetries by studying how output and government expenditure respond to oil price shocks. Our estimation, employing unbiased methodologies, allows us to be agnostic regarding asymmetries in the responses depending on the direction and size of the shock. Using data for a diverse group of emerging economies, we find substantial evidence for the presence of asymmetries. Country-specific factors and/or fiscal stabilization incentives are possible explanations for the asymmetric responses. We draw policy recommendations for understanding the growth process specific to resource-rich emerging economies.

1. Introduction

The role of oil in economic activities is of paramount importance in most countries, whether they be developed or developing/emerging economies. Furthermore, it is more crucial for those who export oil, as the revenue generated influences not only fiscal policy in particular but also macroeconomic stability in general. Given their diverse origin, oil price shocks can be of various magnitude, directions, and persistence.[1] Thus, accurately estimating the impact of these shocks on both the aggregate economy and policy, in an unbiased manner, is not only a formidable task but of significant relevance to policy as the findings are often used in large-scale macroeconomic models for policy implementation.

Although the literature extensively studies the effects of oil prices for the OECD and major oil exporters including those in the Middle East, emerging economies have mostly been neglected, and the studies that do exist are flawed with methodological issues. Indeed, oil price shocks in these countries have been known to trigger severe macroeconomic imbalances, as these economies face unique vulnerabilities that distinguish them from advanced economies. When compared to their major oil-exporting counterparts, these countries do not possess the power to influence global oil prices and are also prone to external shocks, such as a shock driven by geopolitical risks (e.g., the Russo-Ukrainian conflict). These shocks result in sharp and persistent movements in oil prices, which, in turn, culminate in heightened volatility in growth, inflation, and policy uncertainty.

Furthermore, during such scenarios, these countries face the negative impact of contractionary monetary policy undertaken by major central banks, and thus downward pressures on exchange rates and external reserves. Since emerging open economies often operate under a regime of pegged or managed floating exchange rates, monetary policy tends to play a lesser role in controlling inflation and reacts sluggishly; hence in most cases, policy is endogenous, determined by fiscal policy (Cukierman et al., 1992; Romelli, 2022). Therefore, examining the impact of oil shocks on fiscal policy, the principal stabilizing tool, has non-trivial implications for maintaining macroeconomic stability. In addition, the diverse sectoral composition within these countries may result in complex outcomes. Thus, this paper aims to fill these gaps by examining a diverse group of emerging market oil exporters.

Economic activities in many oil-exporting countries are determined by the large swings in oil prices due to their heavy dependence on

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[1] For example, Kumar and Mallick (2023) study the sources of the underlying oil price shocks accounting for uncertainties in the impact of shocks and show that the variation in oil prices can be explained by both oil demand and supply shocks.

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revenues accruing from oil exports. While some countries have been successful in using the oil proceeds for economic development, others have not.[2] Empirical evidence from Sachs and Warner (2001), Sala-i Martin and Subramanian (2003) and Smith (2004) illustrates the slow and volatile growth experiences of oil-rich developing countries. What happens to these economies after an unexpected oil price change? Can oil price shocks create a contraction in the economic activity because of the increasing uncertainty about future prices or policy responses? Understanding these questions in the face of volatile energy prices and economic fluctuations has attracted a great deal of attention.

Much of the growth literature has focused on the implications of oil price increases. It is theoretically intuitive that higher oil prices could have positive implications for oil-exporting countries due to the increase in revenues for the same quantity of exports accruing to these countries - *ceteris paribus*. However, the reality is that oil-exporting developing countries have persistently experienced slow, and in some cases, volatile growth even in the periods of oil price increases.[3] Given the growth experience of oil-exporting developing countries, we are interested in studying the macroeconomic implications of oil price shocks that are specific to these countries. In this regard, the objective of this paper is to investigate how the output responses to oil price shocks vary depending on the nature of the shock. This question is more pertinent especially given the recent stagflationary effects of oil price shocks on the macroeconomy. However, these effects depend on various factors such as the size and persistence of the shock, the structure of the economy, and the initial policy responses.

Furthermore, the implications of oil price volatility require frequent adjustments of budgetary expenditure which is costly due to factor reallocation, and their impact on output depends on the complex economic and policy environments. The use of oil proceeds that attempts to provide stabilization reserves in periods of high revenue for future periods of reduction in oil prices can distort the efficient-market mechanism. With policy-induced price rigidities underlying these economies and weak tax systems, fiscal volatility and imbalances are a major issue associated with oil shocks. The implications of the latter on output may become complicated depending on how the expenditure is financed to smooth out the fluctuations in output. These factors may substantially amplify the effects of large external disturbances to the domestic economy.

In view of the importance of fiscal planning in oil-producing countries, the second objective of this paper is to establish whether there is a relationship between oil prices and government expenditure, and then investigate how such a link can impact output fluctuations. In particular, we focus on a possible candidate through which oil price shocks can indirectly affect the real economy: the role of government expenditure that is designed to keep domestic demand stable in the face of fluctuating oil revenues. Can public spending adjustments contribute to the response of output to oil price shocks (at least in the short run)?[4]

Drawing on empirical evidence concerning the oil-macroeconomy relationship examined in empirical models initiated by Hamilton (2003), there is a large body of research investigating the macroeconomic effects of oil prices on oil-producing countries. Recently, economists have focused on the asymmetric nature of oil price shocks on the macroeconomy. However, most of the research suffers from a plethora of methodological problems. Firstly, the literature assumes that a decrease in oil prices does not have the same, mirror-image effect as an increase, leading to the use of censored variables in VAR models, which results in not only biased parameters (Kilian and Vigfusson, 2011a) but also varied outcomes depending on the definition of censored variables. Secondly, in most of the empirical exercises, the impulse responses used are linear and ignore the role of history or magnitude of the shocks. Finally, slope-based tests for asymmetry based on single-equation models are neither necessary nor sufficient for testing the degree of asymmetry.

To tackle these problems, researchers have turned to the methodology proposed by Kilian and Vigfusson (2011a) which has been applied in the context of developed countries. However, research focusing on developing countries is relatively sparse and fraught with the aforementioned methodological issues.[5] Thus, the impetus for our research primarily originates from three fronts. Firstly, given the volatile nature of growth in many developing oil-exporting countries, it becomes imperative to examine the impact of oil price shocks of different magnitude and sign on output. Secondly, since government expenditure contributes a substantial part to GDP and is the major tool for stabilization, understanding how it evolves after oil price shocks is necessary to understand both the transmission mechanism of oil prices and the ensuing policy responses. Thirdly, to augment the existing sparse literature with an unbiased methodological finding further motivates us to undertake the research.

Thus, the paper is structured to answer the following questions: Do oil price shocks lead to nonlinear output responses? How is government expenditure associated with major oil price movements? What are the real effects of oil price instabilities and their implied fiscal volatility? We tackle these questions by testing and evaluating the premise on which the responses from unexpected changes in oil prices to aggregate output and adjustments of public expenditure are asymmetric, using the censored-regressor nonlinear model developed by Kilian and Vigfusson (2011a).

Our test for asymmetries is a crucial first step not only in understanding the transmission channel of oil price shocks in major oil exporters but in constructing theoretical models of the propagation of oil sector shocks for typical resource-rich emerging economies. In addition, understanding the relationship between oil shocks and government spending behaviour is important to evaluate how to address fiscal imbalances.[6] In particular, we systemically examine asymmetries in the oil-macroeconomy relationship to understand how the impulse response trajectories may be affected by the magnitude and direction of the shock as well as the country-specific characteristics, while gauging the empirical relevance of such asymmetries and the impact of shocks. By doing so, we should be able to throw some light on the mechanisms by which the aggregate economy interacts with oil price shocks hitting the economy and provide an empirical assessment of the implications of the different types of oil price shocks considered here.

[2] For example, the economies of the US, the UK and Norway have utilized the advantages of natural resource discovery, at a particular stage of their development, for fast growth and transforming their economies to become industrial.

[3] The problem has been commonly known in the literature as the 'paradox of wealth', and more recently, 'resource curse'.

[4] Early studies, such as Ferderer (1996), Hamilton (1996), Bernanke et al. (1997), and Hamilton (2009), among others, have examined the policy transmission mechanism of oil sector shocks to the economy and the causes for nonlinearities.

[5] More recently, Çatık and Önder (2013) employ a threshold VAR model to investigate the nonlinear relationship between oil price shocks and output in Turkey and find strong evidence of asymmetry that depends on an optimal threshold value of oil price changes. Pal and Mitra (2015) investigate the asymmetric effects of oil price changes in the context of oil product pricing in the US by estimating a nonlinear autoregressive distributed lags (NARDL) model. Relatively few studies have attempted to measure the asymmetry in this relationship using nonlinear models. Traditional nonlinear models such as NARDL use the Wald test to test asymmetry which creates inference problems irrespective of whether the data generating process has nonlinearity properties embedded in it.

[6] The policy issue is particularly relevant in countries where there are urgent needs for public investment in infrastructure, welfare system and the industrial sector which is sensitive to oil price changes.

A distinctive aspect of our analysis is our assumption regarding the macroeconomic policy variable to capture any changes in government fiscal stance in response to major oil fluctuations.[7] This requires nonlinear techniques to describe the co-movements between oil prices and government expenditure. To this end, in addition to the (Kilian and Vigfusson, 2011a) approach, we estimate a univariate unobserved components model to obtain the slope parameter of our time series. Our analysis employs a battery of econometric tests and is closely related to Kilian and Vigfusson (2011a) and Herrera et al. (2015) in that we make contributions to the empirical literature by explicitly accounting for (1) specifications of nonlinearities estimated using unbiased methodologies; (2) an assessment of output and government expenditure in propagating the real effect of oil price shocks in emerging economies; and (3) the asymmetric response to the shock by estimating the impulse response functions (henceforth IRFs) from a nonlinear model that encompasses the linear VAR specification.

We find substantial empirical evidence suggesting the asymmetric impact of oil price shocks in several countries, irrespective of the magnitude of the shock. In addition, we explain how the output and fiscal responses to large oil price shocks are significantly different depending on country-specific characteristics and stabilization incentives. Our applications are able to uncover and describe the distinct co-movements between oil prices and public spending which enable us to evaluate the implications for theoretical models of the transmission of oil price shocks and for policy responses to exogenous energy price fluctuations. By carefully examining a sample of emerging economies consisting of African, Asian and South American countries, our results and analysis can be used to motivate further investigation into the roles of oil price fluctuations and public expenditure cyclicality in understanding the growth process specific to developing oil-exporting countries.

The rest of the paper is organized as follows. Section 2 discusses the key literature related to our paper. Section 3 provides the theoretical discussions behind the asymmetric response to oil price shocks, motivating the empirical analysis. Section 4 describes the data and estimation methodology. Section 5 discusses the test results, model comparison and empirical properties. Section 6 focuses on the oil price shock and fiscal policy interactions. Section 7 concludes. Details of the algorithm designed to implement the test for symmetry are set out in Online Appendix A. Our robustness checks are also appended to the paper.

2. Related literature

There are two strands of literature related to our paper. The first strand is a largely econometrics literature studying oil price shocks, which have been known to generate macroeconomic instability in many resource-rich countries. On the empirical front, in order to illustrate the impact of oil price changes on aggregate output, researchers have primarily relied on time series estimators, mainly VAR models. The early literature employs the linear VAR/VECM framework to identify oil price shocks and is only able to establish weak impacts of unexpected oil price changes on output (e.g. Hooker, 1996; Hamilton, 1996). One major shortcoming of this strand of work is that it lacks the ability to capture the asymmetric and nonlinear nature of oil price shocks (Kilian, 2009). In order to address these inadequacies, subsequent studies by Hamilton (2003, 2009) employ different forms of censored oil prices in VARs by decomposing oil price changes into price increases and decreases. Results from this literature suggest strong asymmetric effects of oil prices on output.

However, the seminal work by Kilian and Vigfusson (2009) demonstrates that the censored-variable VAR models are fundamentally misspecified, irrespective of whether the data generating process -henceforth DGP- is symmetric or asymmetric.[8] Furthermore, based on the earlier work by Koop et al. (1996), they demonstrate that the structural impulse responses generated from the models are invalid as they do not take account of the history and size/magnitude of the shocks. Finally, they demonstrate that the previous results obtained from standard slope-based tests for asymmetry based on single-equation models are neither necessary nor sufficient for judging the degree of asymmetry in the structural response functions. Kilian and Vigfusson (2009) resolve this problem by proposing a direct test which requires the model to be appropriately specified and the nonlinear responses to be correctly simulated. Results employing this methodology, however, tend to find no significant asymmetry of unexpected oil price changes on output (see, for example, Kilian and Vigfusson, 2011a and Herrera et al., 2011).

While the existing literature provides considerable evidence that the relationship between oil shocks and aggregate economy is nonlinear, the evidence is by no means conclusive nor consistent — see, for example, Hamilton (1996), Hamilton (2003), Hamilton and Herrera (2004), Hamilton (2011), Herrera et al. (2011), Kilian and Lewis (2011), Kilian and Vigfusson (2011a,b), Baumeister (2016a), Baumeister and Kilian (2016b), Holm-Hadulla and Hubrich (2017), Hamilton (2018) and Garzon and Hierro (2021). A general theme of these papers is that there remains a wide range of views over the macroeconomic effects of the shock as well as over the variations in these effects with respect to economic conditions and states.[9] A comprehensive review is provided by Kumar and Mallick (2023) which provides several mixed results reporting varied economic responses to an oil price shock by estimating a model allowing for time variation and transition in distinctive oil price episodes.

Our paper is also related to a theoretical literature discussing the effects and transmission of oil shocks. The existing theory states that oil price changes can affect economic activities via direct and indirect supply- and demand-side mechanisms. Among these, the direct channels tend to produce symmetric responses in output whereas the indirect ones can contribute towards asymmetry and amplification in the responses. The direct demand-side effect illustrates the changes in aggregate demand caused by changes in purchasing power subsequent to oil price innovations (Baumeister and Kilian, 2017; Baumeister et al., 2017). Additionally, the direct supply-side effect refers to the symmetrical changes in aggregate supply due to production cost changes, upon oil price innovations (Karaki, 2017).

On the other hand, the indirect demand-side effect on output following an unexpected oil price shock can firstly arise due to the increased precautionary savings owing to heightened uncertainty (Edelstein and Kilian, 2009). Secondly, monetary policy responses to oil price changes can also generate asymmetric effects on output, as most central banks

[7] For example, Nigeria experienced a widening of fiscal deficit and an increase in debt-to-GDP ratio during the recent episodes of oil price reversal but saw mixed movements in GDP.

[8] Kilian and Vigfusson (2011a) demonstrate that the resulting slope coefficients are biased upward in magnitude even when the true relationship is linear.

[9] A series of papers have separately addressed some of these issues, with alternative transformations of oil price increases, a variety of methods, for developed countries, and covering different sample periods. Such analysis however is yet to be carried out for emerging oil-exporting economies and as a cross-country comparative study (except that Herrera et al. (2015) offers perhaps the closest analysis to our paper which focuses on the OECD countries and does not address the effect on adjustments of budgetary expenditure). Another exception is Nusair (2016) who studies the nonlinear relationship between oil prices and real GDP for the Gulf Cooperation Council countries using a NARDL model. In addition, for individual oil-exporting emerging countries, as noted, Çatık and Önder (2013) employs a threshold VAR for Turkey. Using data from Saudi Arabia, Jawadi and Ftiti (2019) also focus on the shock's state-based asymmetry.

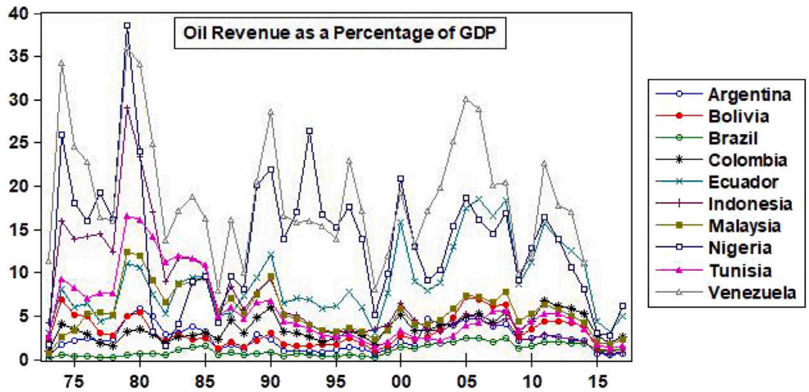

Fig. 1. Contribution of oil revenue to GDP.
Source: World Bank Database.

do not tend to react during oil price downturns but overreact when oil prices rise (Bernanke et al., 1997). Finally, unexpected oil price shocks, which are in essence relative price shocks, create allocative disturbances initiating sectoral shifts in consumption causing aggregate demand to change (see, for example, Mohaddes and Pesaran, 2017). In addition, the indirect supply-side channel refers to the changes in unemployment/output due to costly reallocation of factors of production from the most affected to the least affected sector creating a mismatch in the factor market (Blanchard and Gali, 2007). The magnitude of this channel depends on the sectoral contribution from the oil-producing sector, labour market frictions, and on regional heterogeneities (Karaki, 2017).

3. Asymmetric response to oil price shocks: Theoretical discussions

We start by illustrating the key elements of our empirical analysis with reference to the oil-producing environment that is characterized by the data across the countries in our sample. We explore the potential sources of asymmetries and discuss some possible theoretical channels accounting for amplification of oil price shocks that may lead to asymmetries.

First, Fig. 1 shows that these countries have experienced fluctuations in their oil revenues as percentage of their GDP over the period of 1970–2018 using annual data obtained from the World Bank. Countries that have a high dependence on oil revenues face significant challenges arising from the characteristics of oil revenues which tend to be more volatile than revenues from other export commodity. The volatility of oil revenue inflows implies volatility in budgetary spending which may negatively affect the economy through uncertainty about aggregate demand and costs of sectoral reallocation, and because of the potential macroeconomic imbalances that may arise when oil prices fluctuate.

Furthermore, the implications of oil revenues being a foreign exchange inflow can generally lead to a currency depreciation. In addition to the structural shifts resulting from the use of oil revenues, a currency depreciation can deteriorate the balance sheets of borrowers relying on foreign currency denominated debt and increase the risk premium accrued on top of the international interest rate. A possible source of asymmetries is that the ensuing fall in the demand for capital reduces the value of the borrowers' existing capital stock, further amplifying the increase in the costs of borrowing and the swings in investment and production.

Fig. 2 reports that these countries have different levels of oil production capacity. Countries with high levels of oil production capacity are more vulnerable to the impact of low oil prices as they have a greater dependence on oil. On the other hand, countries with low levels of oil production capacity may be less vulnerable as they tend to have a more diversified economy. One possible explanation for asymmetries is that oil is a crucial input in the production process. Therefore, when the price increases, the cost of production rises, leading to higher aggregate prices. This triggers the precautionary saving motive due to heightened uncertainty in purchasing power on the demand side through which this amplifies positive oil shocks and dampens negative oil shocks (Edelstein and Kilian, 2009).

Fig. 3 measures the share of energy in domestic production, and therefore reflects the energy efficiency of an economy. Furthermore, this factor has important implications for the transmission of oil price shocks through the indirect supply-side effect of capital and labour reallocation. On the one hand, countries with high energy intensity are more vulnerable to oil price shocks because nominal rigidities in the labour market in the most energy-intensive sectors are associated with costly sectoral reallocation from the supply side. When oil prices rise, the cost of energy increases, leading to higher costs for businesses and households.[10] This can result in a decrease in income transfer through consumption, lower profits, and contract output. The labour market imperfection and reallocation disturbances can amplify the recessionary effect. On the other hand, countries with low energy intensity are less vulnerable to oil price shocks because they consume less energy usage per unit of GDP and capital.[11]

4. Time series properties of the methodology and data

This section discusses the associated econometric methodology needed to examine the asymmetric impact of oil price shocks on output (and later on government expenditure). To apprehend the asymmetric effects, we face three major econometric difficulties. Firstly, the need of an appropriate variable/indicator that measures oil price increases and decreases, leading to the use of censored oil prices discussed in Section 4.1. Secondly, selecting a simultaneous-equation framework producing unbiased parameters and identifiable shocks in the presence of censored variables. Finally, using impulse responses that take account of the history and magnitude of the shock. The last two impediments are confronted by using the methodologies proposed by Kilian and Vigfusson (2011a) and Koop et al. (1996), and are discussed in Sections 4.2–4.4.

[10] The RBC model by Finn (2000) postulates that energy is essential to the utilization of capital and there are costs to varying capital utilization which generate amplification of a positive shock to energy prices.

[11] For example, Malaysia has made significant efforts to reduce its energy intensity by investing in renewable energy and implementing energy-efficient policies. This has helped to reduce the country's dependence on oil and other fossil fuels. Malaysia's diversified economy also helps to mitigate the impact of changes in oil prices on its economy.

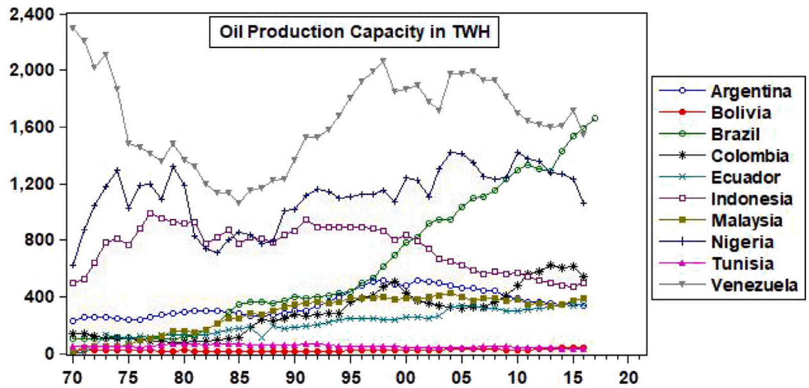

Fig. 2. Oil production capacity.
Source: BP Statistical Review of World Energy

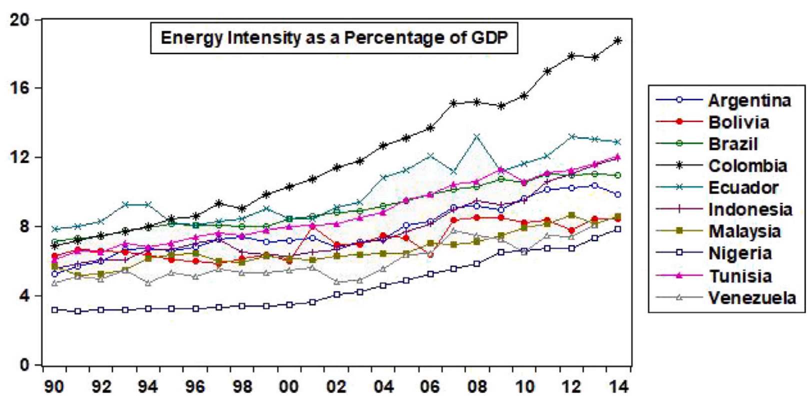

Fig. 3. Importance of energy intensity in GDP.
Source: World Bank Database

4.1. Specifications for censored oil prices

The association between heightened oil price episodes preceding major recessions and deteriorating macroeconomic outcomes has led most economists to suspect strong links between oil price increases and recessions. Furthermore, Bernanke et al. (1997) illustrate that linear indicators of oil price shocks do not produce expected responses of domestic macroeconomic variables in linear VAR models. The literature widely accepts that the most appropriate specification of oil prices involves some measure of oil price increases. This consensus is based on Mork (1989), illustrating that the effects of oil price changes on the economy need not be symmetric in oil-importing countries. In addition to Mork (1989)'s oil price increase measure, we use two more censored indicators that are proposed by Hamilton (2003) and Kilian and Vigfusson (2013), respectively. The censored variables, x_t^{cen}, are represented in the following equations

$$\text{Mork}: \quad x_t^{cen} = OPI_t = \max(0, \ln(o_t) - \ln(o_{t-1})) \tag{1}$$

$$\text{Hamilton}: \quad x_t^{cen} = NOPI_t = \max(0, \ln(o_t)) - \max(\ln(o_{t-1}), \dots, \ln(o_{t-4})) \tag{2}$$

$$\text{Kilian \& Vigfusson}: \quad x_t^{cen} = NOPC_t = NOPI_t + NOPD_t \tag{3}$$

where $NOPD_t = \min(0, \ln(o_t)) - \min(\ln(o_{t-1}), \dots, \ln(o_{t-4}))$ and $\ln(o_t)$ is the logarithm of the real oil price. The benefits of using the Hamilton and Kilian & Vigfusson indicators are that, not only do they produce relatively stable relationship with macroeconomic variables, they also tend to predict declines in the US real GDP. Moreover, by construction, the latter indicator has fewer censored observations of oil prices which is helpful for relatively small samples.

4.2. Associated bias from using censored indicators

While the importance of censored indicators in modelling oil price shocks is well understood in the literature, less attention has been given to their associated issues that impact the validity of standard statistical inference in models that are estimated using ordinary least-squares (OLS). Kilian and Vigfusson (2011a) (henceforth KV) illustrate that, irrespective of whether the DGP is asymmetric or not, the use of censored oil indicators in VAR models can create bias in the estimated parameters. Here we use two simple examples to briefly outline the issue.

The first example considers the linear and symmetric case in the following static model

$$\tilde{x}_t = \alpha_1 + \varepsilon_{1,t} \tag{4}$$

$$\tilde{y}_t = \alpha_2 + \tilde{x}_t \beta + \varepsilon_{2,t} \tag{5}$$

Given this DGP, it is straightforward to show that the OLS estimator of b in the following regression model

$$\tilde{y}_t = a + \tilde{x}_t^{cen} b + u_t \tag{6}$$

$$\tilde{x}_t^{cen} = \begin{cases} \tilde{x}_t, & \text{if } \tilde{x}_t > 0 \\ 0, & \text{if } \tilde{x}_t \le 0 \end{cases} \tag{7}$$

is not a consistent estimator of β. To show this, consider the case in which $a = 0$ and $\tilde{x}_t$ has a standard normal distribution and is uncorrelated with $\varepsilon_{2,t}$, and derive the limit of $\hat{b}$

$$\text{plim}_{n\to\infty}(\hat{b}) = \beta \frac{1}{1 - 0.5\mu} \tag{8}$$

where $E(\tilde{x}_t^{cen}) = 0.5\mu$ and $\mu = E(\tilde{x}|\tilde{x} > 1)$, which means that $\hat{b}$ is overestimated by almost 50 percent.

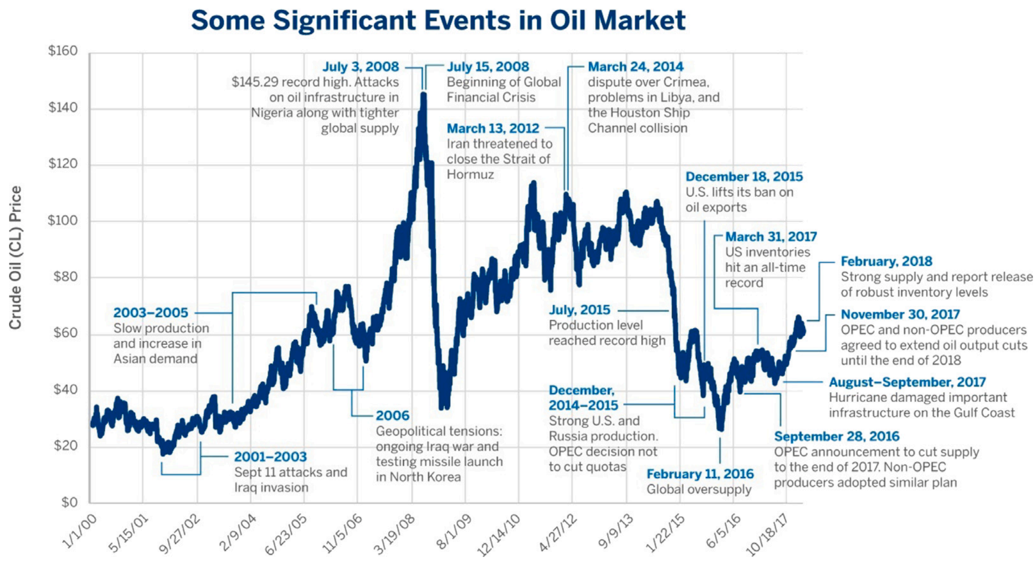

Fig. 4. Oil price fluctuations.
Source: Adapted from Chicago Mercantile Exchange Group (2018).

The same inconsistency problem may arise when the DGP is asymmetric

$$\tilde{x}_t = \alpha_1 + \varepsilon_{1,t} \quad (9)$$

$$\tilde{y}_t = \alpha_2 + \tilde{x}_t \beta + \tilde{x}_t^{cen} \gamma + \epsilon_{2,t} \quad (10)$$

Given this DGP, if one estimates (6), for any values of $\beta \neq 0$, slope-based tests that truncate on x_t^{cen} produce estimates of the slope coefficient that are biased upward in magnitude (e.g. Mork's test (Mork, 1989)).

4.3. The model

Although, for simplicity, we illustrate the problem in a static setting, the same would hold for VAR models, the reason being that the DGP cannot be represented as a bivariate VAR for $(x_t^{cen}, y_t)'$. To examine the responses of macroeconomic variables (y_t in our case) in an unbiased manner, we estimate the following simultaneous-equation model, proposed by KV, via OLS, equation-by-equation

$$x_t = a_{10} + \sum_{i=1}^{p} a_{11,i} x_{t-i} + \sum_{i=1}^{p} a_{12,i} y_{t-i} + \epsilon_{1,t} \quad (11)$$

$$y_t = a_{20} + \sum_{i=0}^{p} a_{21,i} x_{t-i} + \sum_{i=1}^{p} a_{22,i} y_{t-i} + \sum_{i=0}^{p} b_{21,i} x_{t-i}^{cen} + \epsilon_{2,t} \quad (12)$$

where x_t is the log growth in the oil price and y_t is the log growth of real GDP. $\epsilon_t \sim (0, \Sigma)$ is uncorrelated orthogonal white noise. x_{t-i}^{cen} is one of the nonlinear transformations that provide the censoring of the oil price series in Section 4.1.

Since the above model is not a VAR representation for $(x_t^{cen}, y_t)'$, it does not exhibit the above-mentioned bias. Based on KV, to identify the structural system, the following restrictions, $b_{21,0} = 0$ and $b_{21} \neq 0$, are imposed, which are similar to restrictions used in the SVAR literature. The assumption of oil price as a predetermined (contemporaneously exogenous) variable can be justified as the countries that we examine are small oil exporters and do not have the market power to change world oil prices. Since oil prices are assumed to be predetermined in the system, the inclusion of additional macroeconomic variables (e.g. monetary policy) does not affect the outcome of economic results.

4.4. Impulse response-based test for symmetry

We estimate and compare the three nonlinear configurations set out in Section 4.1: namely, OPI ($x_t^{cen} = OPI_t$), NI ($x_t^{cen} = NOPI_t$), NC ($x_t^{cen} = NOPC_t$), and the linear VAR model (where $b_{21,0} = b_{21,1} = \cdots = b_{21,p} = 0$ in (12)). In our test for symmetry, we compare the slope-based tests with the IRF-based test proposed by Koop et al. (1996) which accounts for the past history and the size of the shock.[12] Since the corresponding impulse responses are nonlinear functions of $b_{21,0}, b_{21,1}, \ldots, b_{21,p}$ as well as the other parameters of the model, they are computed by Monte Carlo integration. The IRFs are calculated to an innovation of size δ in $\epsilon_{1,t}$ for a given horizon h conditional on the history $\mathbb{I}_t$. The conditional $IRF_y(h, \delta, \mathbb{I}_t)$ is then averaged over all the histories to obtain the unconditional $IRF_y(h, \delta)$. In a similar manner, for a negative shock of size $-\delta$, the condition $IRF_y(h, -\delta, \mathbb{I}_t)$ is first computed and then averaged over all histories to obtain the unconditional $IRF_y(h, -\delta)$.

The null hypothesis is the VAR linearity where the unconditional IRFs are the same across regimes (the null of symmetry)

$$H_0 : IRF_y(h, \delta) = -IRF_y(h, -\delta) \quad (13)$$

over a specific horizon h. Details of the algorithm are reported in Online Appendix A. The benefit of this test over the slope-based test is that this test depends on the magnitude of δ; hence, the evidence against symmetry depends on the magnitude of the shock considered. Also, the reduced-form representation of the fully specified dynamic structural model can provide us with the IRFs which are informative for assessing the degree of asymmetry.

4.5. Data

This paper constructs a database comprising 8 countries which are oil exporters, non-OECD, developing and emerging economies, and have an average oil contribution to GDP of about 30%–40%. Several

[12] A further robustness check provides a comparison between different (competing) treatments of including contemporaneous regressors – between Mork's test and the Wald test – which focus on the existence of asymmetries in the reduced-form parameters. To conserve space, we only report the results of the KV test in the main paper.

observable variables at quarterly frequency for Bolivia, Brazil, Colombia, Ecuador, Indonesia, Malaysia, Nigeria and Tunisia are used to estimate the model parameters and IRFs. The sample runs from 2000Q1 to 2017Q1 during which there is clear evidence of both positive and negative oil price shocks (see Fig. 4). We subject our data to a wide array of time series tests aimed at studying nonlinearities between oil prices and changes in government expenditure and GDP.

The data are obtained from the International Financial Statistics (IFS) Database of the IMF and are available through the various central banks and include the percentage change in the real price of crude oil using the OPEC benchmark of Brent crude oil price, the growth rate of real GDP,[13] and the growth rate of real government expenditure.[14] The oil price series is transformed and deflated using the nominal exchange rate and domestic CPI, while the government expenditure variable is deflated using the domestic CPI.[15] The details of data sources and Nigeria's data transformation are given in Online Appendix B.

5. Empirical results and analysis for output growth

In this section, we test for two types of asymmetry, in particular, we test (i) whether positive and negative shocks; and (ii) whether typical (measured by 1 s.d.) and large (measured by 2 s.d.) shocks have different effects on each country's aggregate output. The lag order p is set to capture the dynamic effects of oil price on the real economy and determined by performing residual diagnostic checks on each of the estimated models.[16]

Tables 1 and 2 report the corresponding p-values for the Wald statistic set out in Online Appendix A. There is mixed evidence reported as some countries (Malaysia, Indonesia, Tunisia, and Nigeria) show strong statistical evidence of asymmetry (thus, rejecting H_0) while others do not clearly show statistical evidence against the symmetry of the IRFs at 5% level (at least for a typical-sized shock). For the latter countries, the p-values decline with the magnitude of the shock. There is more evidence against the null hypothesis for the 1-year net changes (NI). The number of rejections is larger when we test for symmetry following oil price ups and downs in the response to a large shock at short horizons (e.g. Bolivia).

Next, we turn to some robustness checks because we need to know whether our test results may be dependent on using the alternative slope-based tests, the measure of oil prices (real vs nominal prices)[17] and the magnitude of the asymmetry across the projected horizons of our estimated IRFs. To this end, we compare the impulse response-based test statistics with those from the two slope-based tests as discussed in Online Appendix C as well as providing the cumulative mean square distance as shown in Table 3 in Section 5.1. The additional benefits of both the IRF-based test and the cumulative measure of asymmetry are that they allow us to quantitatively study the degree and effects of asymmetry in the response to a shock. The latter is what we turn to next.

5.1. Cumulative measures of asymmetry

Following Herrera et al. (2015), we further compute a measure of the difference between the responses to positive and negative innovations: the cumulative distance. Table 3 shows the magnitude of asymmetry for the sample countries by reporting the cumulative mean squared distance between the computed IRFs in terms of percentage points

$$d_H^m = \sum_{h=0}^{H} \|[IRF_y^m(h,\delta)] - [-IRF_y^m(h,-\delta)]\| \tag{14}$$

where d_H^m measures the distance between the impulse responses accumulated from $h = 0$ to $h = H$. m is the model index. $\|[IRF_y^m(h,\delta)] - [-IRF_y^m(h,-\delta)]\|$ stands for the Euclidean norm. We present the cumulative of the Euclidean norm for the three nonlinear models as the horizon increases ($H = 1, 4, 8, 12$). We can gain further understanding on how the cumulative of the Euclidean distance changes over time with the horizon after the shock hits the system, e.g., before and after a year.

Based on the statistics reported, not surprisingly, Table 3 shows that the cumulative differences between the 1 s.d. shock and 2 s.d. shock are quite large across all countries. Malaysia reports the largest cumulative distance between the responses to a positive and a negative shock generated by the models with OPI and NI, which is again consistent with our results above based on the IRF- and slope-based tests. With NI and NC, nearly all the countries are close to being economically insignificant in terms of their cumulative responses to the typical shock (i.e. $d_H < 10$ percentage points). In almost all countries except for Brazil, the distance measures do not change very much as the horizon increases, suggesting that the degree of asymmetry decreases shortly after the shock for these countries.

Another notable finding from this exercise is that, apart from the NC specification, all our oil-exporting countries experience some significant degree of asymmetric responses, over the projected horizon, to a large oil price innovation. This is not surprising and becomes much clearer when we look at the estimated IRFs in Section 5.2. Apart from Malaysia, the magnitude of asymmetry seems to remain strong over time for Colombia, Ecuador, and Brazil where the effect is also amplified after 1 quarter. Intuitively, this could be explained by Figs. 1 and 3, which show that these are the countries that depend heavily on oil in terms of either the production intensity or overall share of oil in GDP.

5.2. Impulse response analysis for output growth

To further investigate the degree of asymmetry in response to a shock, in this section, we study the estimated IRFs for the oil price shocks. As mentioned, we consider a typical shock of 1 s.d. and a larger shock of 2 s.d. of the shock's innovations, and we depict the mean responses of a positive and negative oil price shock, respectively, from our estimated models. The variable of interest is the observable GDP growth (in %) and each response is for a 12-period horizon (3 years).

The aim of this exercise is two-fold. First, we can evaluate (a)symmetry in the responses more closely across our three nonlinear specifications, *vis-à-vis* the responses from the linear counterpart, by understanding how the IRF trajectories may be affected by the magnitude of the shock and the types of the censored variable. Second, we are interested in assessing the impact of shocks (small and large)

[13] Except for the Nigerian GDP and the transformation of which is discussed in Online Appendix B.

[14] Disintegrating the government expenditure variable into recurrent and capital expenditure would provide us the opportunity to independently analyse their responses following an oil windfall and any asymmetric effects on government spending composition especially in a case where capital expenditure is sensitive to fluctuation of oil prices. However, the choice of using the aggregate government expenditure measure was based on data availability for the sample countries.

[15] The real variables are seasonally adjusted with ARIMA X-12.

[16] Different lag orders have been applied for different countries. The lag length of $p = 6$ and $p = 8$ are chosen based on the following motives. First, Hamilton and Herrera (2004) show that using smaller number of lags leads to underestimating the effects of oil price as the response of real GDP to these shocks is very sluggish. Second, for the results of the nonlinear models to be robust, sufficiently long lags are needed.

[17] We also estimate our models and carry out our tests using the nominal oil price as an observable. While it is correct to point out that the real price would be the relevant measure in theoretical models for the oil price shock transmission, it is possible that, as argued by Hamilton (1996, 2003), deflating it by a particular number such as the CPI introduces a new source of measurement error which could affect the forecasting performance. The check aims to access whether this increases (decreases) the evidence of asymmetries and whether this reduces the power of our original tests. For the model with nominal oil prices, the p-values are presented in parentheses and included in Tables 1 and 2. Our main findings regarding the test results of the benchmark estimation are upheld.

Table 1
p-Values of tests of the null of symmetric response functions: Output responses to oil price innovations.

	Bolivia Lag=8						Brazil Lag=6					
Horizon	Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
1	0.19	0.08	0.96	0.25	0.06	0.51	0.22	0.11	0.86	0.36	0.10	0.96
	(0.15)	(0.17)	(0.87)	(0.12)	(0.02)	(0.28)	(0.11)	(0.08)	(0.49)	(0.23)	(0.10)	(0.67)
2	0.13	0.08	1.00	0.10	0.01	0.81	0.47	0.14	0.94	0.66	0.10	1.00
	(0.22)	(0.20)	(0.93)	(0.20)	(0.00)	(0.55)	(0.27)	(0.16)	(0.54)	(0.49)	(0.19)	(0.81)
3	0.09	0.14	1.00	0.01	0.01	0.84	0.12	0.07	0.93	0.23	0.01	1.00
	(0.14)	(0.33)	(0.98)	(0.02)	(0.00)	(0.69)	(0.02)	(0.01)	(0.70)	(0.09)	(0.01)	(0.92)
4	0.13	0.24	1.00	0.01	0.03	0.91	0.17	0.11	0.64	0.29	0.02	1.00
	(0.21)	(0.49)	(1.00)	(0.02)	(0.01)	(0.83)	(0.04)	(0.02)	(0.38)	(0.15)	(0.01)	(0.75)
5	0.21	0.36	1.00	0.02	0.05	0.93	0.12	0.14	0.77	0.09	0.01	1.00
	(0.31)	(0.63)	(1.00)	(0.04)	(0.02)	(0.90)	(0.04)	(0.03)	(0.43)	(0.03)	(0.01)	(0.79)
6	0.30	0.47	1.00	0.03	0.08	0.95	0.16	0.20	0.84	0.11	0.02	1.00
	(0.43)	(0.75)	(1.00)	(0.01)	(0.04)	(0.94)	(0.06)	(0.04)	(0.54)	(0.03)	(0.01)	(0.86)
7	0.32	0.56	1.00	0.01	0.05	0.95	0.19	0.26	0.89	0.06	0.01	1.00
	(0.48)	(0.82)	(1.00)	(0.02)	(0.01)	(0.97)	(0.06)	(0.07)	(0.66)	(0.02)	(0.01)	(0.92)
8	0.41	0.65	1.00	0.01	0.07	0.97	0.27	0.35	0.90	0.10	0.02	1.00
	(0.59)	(0.88)	(1.00)	(0.03)	(0.02)	(0.98)	(0.10)	(0.10)	(0.76)	(0.03)	(0.01)	(0.96)
9	0.51	0.70	1.00	0.01	0.06	0.98	0.35	0.44	0.94	0.14	0.04	1.00
	(0.68)	(0.92)	(1.00)	(0.04)	(0.02)	(0.99)	(0.14)	(0.15)	(0.78)	(0.05)	(0.01)	(0.98)
10	0.58	0.78	1.00	0.02	0.09	0.99	0.44	0.52	0.96	0.19	0.06	1.00
	(0.77)	(0.95)	(1.00)	(0.06)	(0.04)	(0.99)	(0.19)	(0.20)	(0.85)	(0.08)	(0.02)	(0.99)
11	0.67	0.84	1.00	0.03	0.13	0.99	0.53	0.61	0.98	0.26	0.08	1.00
	(0.83)	(0.97)	(1.00)	(0.06)	(0.05)	(0.99)	(0.25)	(0.27)	(0.90)	(0.11)	(0.04)	(1.00)
12	0.74	0.89	1.00	0.04	0.17	1.00	0.61	0.69	0.98	0.33	0.12	1.00
	(0.88)	(0.99)	(1.00)	(0.09)	(0.07)	(0.99)	(0.28)	(0.34)	(0.92)	(0.15)	(0.06)	(1.00)

	Colombia Lag=6						Ecuador Lag=6					
Horizon	Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
1	0.02	0.13	0.91	0.05	0.04	0.87	0.30	0.02	0.13	0.50	0.01	0.37
	(0.02)	(0.11)	(0.61)	(0.03)	(0.01)	(0.37)	(0.44)	(0.00)	(0.06)	(0.60)	(0.00)	(0.15)
2	0.05	0.22	0.85	0.12	0.11	0.92	0.11	0.04	0.28	0.35	0.02	0.66
	(0.03)	(0.12)	(0.55)	(0.06)	(0.04)	(0.46)	(0.15)	(0.02)	(0.14)	(0.33)	(0.00)	(0.34)
3	0.11	0.27	0.95	0.22	0.20	0.98	0.22	0.10	0.39	0.54	0.04	0.78
	(0.06)	(0.21)	(0.74)	(0.11)	(0.07)	(0.66)	(0.28)	(0.04)	(0.26)	(0.52)	(0.00)	(0.52)
4	0.11	0.39	0.95	0.20	0.33	0.99	0.28	0.14	0.41	0.66	0.04	0.89
	(0.08)	(0.29)	(0.82)	(0.12)	(0.13)	(0.80)	(0.36)	(0.06)	(0.41)	(0.63)	(0.00)	(0.68)
5	0.17	0.41	0.98	0.27	0.26	0.99	0.37	0.23	0.55	0.77	0.08	0.95
	(0.14)	(0.37)	(0.86)	(0.18)	(0.11)	(0.89)	(0.44)	(0.11)	(0.55)	(0.73)	(0.00)	(0.81)
6	0.25	0.53	0.99	0.39	0.26	1.00	0.40	0.32	0.64	0.76	0.13	0.98
	(0.21)	(0.49)	(0.89)	(0.27)	(0.15)	(0.93)	(0.41)	(0.17)	(0.66)	(0.64)	(0.01)	(0.88)
7	0.31	0.56	0.99	0.47	0.33	1.00	0.51	0.37	0.75	0.83	0.13	0.99
	(0.30)	(0.56)	(0.86)	(0.37)	(0.21)	(0.91)	(0.50)	(0.24)	(0.77)	(0.70)	(0.02)	(0.93)
8	0.39	0.65	0.99	0.58	0.43	1.00	0.62	0.48	0.83	0.90	0.19	1.00
	(0.37)	(0.65)	(0.92)	(0.47)	(0.29)	(0.94)	(0.60)	(0.33)	(0.85)	(0.79)	(0.03)	(0.96)
9	0.49	0.74	1.00	0.67	0.53	1.00	0.71	0.58	0.88	0.94	0.26	1.00
	(0.47)	(0.74)	(0.95)	(0.57)	(0.38)	(0.97)	(0.70)	(0.42)	(0.89)	(0.86)	(0.05)	(0.98)
10	0.58	0.81	1.00	0.76	0.62	1.00	0.79	0.65	0.92	0.97	0.32	1.00
	(0.57)	(0.82)	(0.97)	(0.66)	(0.47)	(0.98)	(0.78)	(0.50)	(0.92)	(0.91)	(0.06)	(0.99)
11	0.67	0.87	1.00	0.82	0.71	1.00	0.85	0.73	0.95	0.98	0.40	1.00
	(0.65)	(0.87)	(0.99)	(0.74)	(0.56)	(0.99)	(0.80)	(0.59)	(0.95)	(0.94)	(0.09)	(1.00)
12	0.75	0.91	1.00	0.88	0.78	1.00	0.90	0.80	0.97	0.99	0.48	1.00
	(0.73)	(0.92)	(0.99)	(0.81)	(0.64)	(1.00)	(0.89)	(0.67)	(0.97)	(0.97)	(0.13)	(1.00)

Notes: This table reports the p-values (at 5%) for the Wald statistic set out in Online Appendix A. For simulating paths of x_t and y_t, we use 10,000 draws of simulations for computing the IRF given the history. For the number of bootstrapping draws over the model, our simulations are based on 10,000 bootstrapped pseudo-series using the estimated coefficients. The lag order is selected for all our models by carrying out residual diagnostics. While including additional lags could result in a reduction in test power, omitting extra lags can give rise to the test outcome of nonlinearity. The p-values based on the model with nominal oil prices are presented in parentheses.

on the model dynamics so that we can investigate the importance of shocks to aggregate output in order to gain a better understanding of the innovation and forecasting uncertainties, and thus the model uncertainties faced by policymakers.

A positive oil price shock has the usual negative impact on output (in terms of the level effects) for all the countries. For example, Fig. 5 shows that, after just over 1 year, the cumulative (growth) effect of a 1 s.d. positive innovation in oil prices results in an almost 1% contraction of GDP in Malaysia. However, when there is the supply-side effect depending on energy intensity in production (as discussed in Section 3), oil production often responds with a lag to a positive shock, followed by production contraction in most countries. Nevertheless, this effect dies out relatively rapidly (less than 1 year) when affecting output for all the affected countries.

The oil-exporting countries are also affected by the demand push factor that results in an initial increase in GDP with the lagged effect which again depends on the oil share in GDP (e.g. Ecuador). From the IRF dynamics, any correlation between the presence or absence of asymmetry and the oil share in GDP (Fig. 1) appears to be much less notable. Finally, as expected, there are marked differences in IRFs when there are strong asymmetric effects on output (based on the size and direction of the shock). The results from the estimated IRFs confirm our key findings discussed above, i.e., there is substantial evidence in the data to support the presence of asymmetry in the real effects

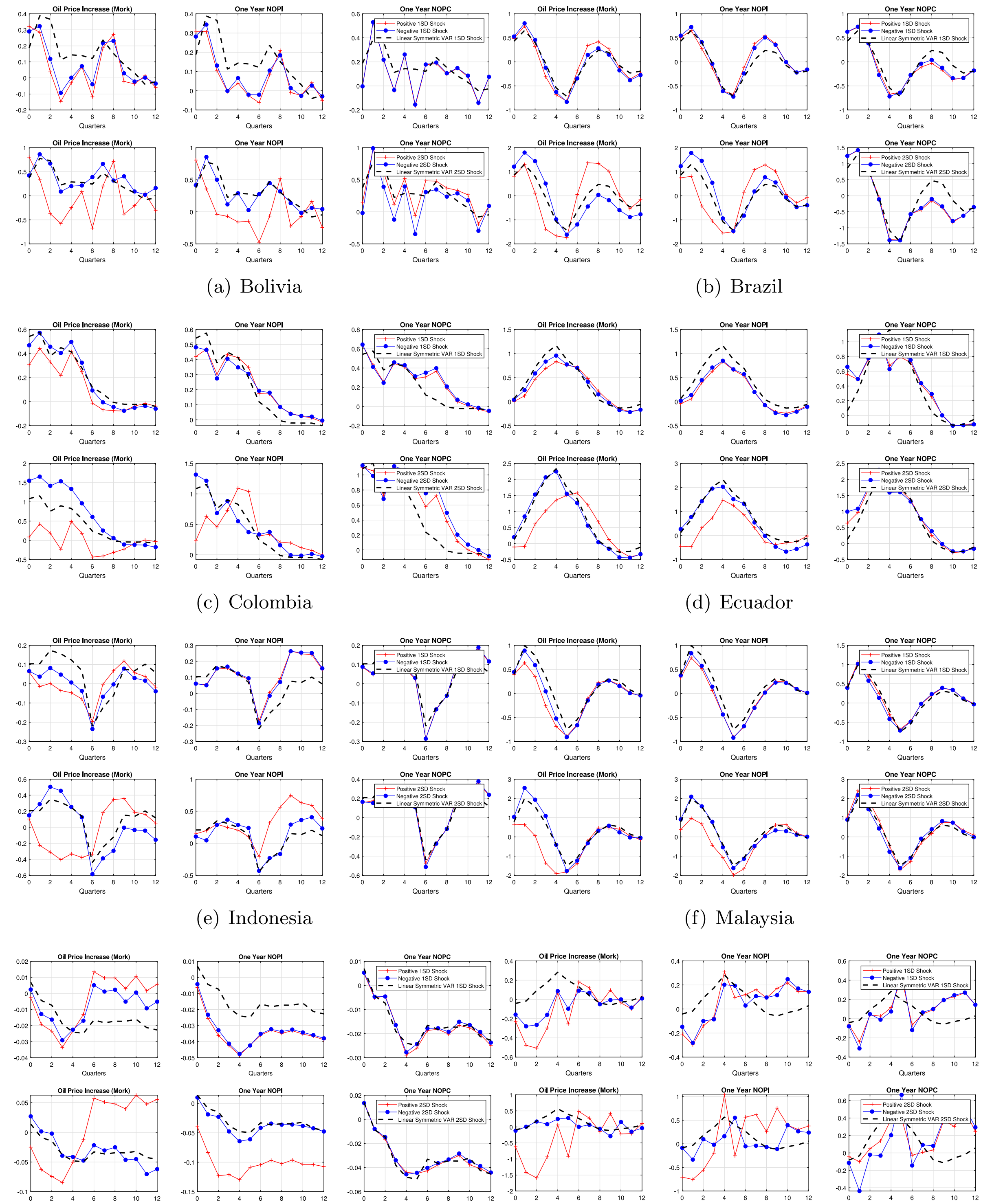

Fig. 5. Impulse response functions of output growth.
Notes: Each panel plots the mean response corresponding a one and two standard deviation of the shock's innovation. Each response is for a 12 period (3 years) horizon and is the percentage deviation.

Table 2
p-values of tests of the null of symmetric response functions: Output responses to oil price innovations - contd.

Indonesia Lag=8							Malaysia Lag=6					
Horizon	Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
1	0.56	0.96	0.87	0.76	0.68	0.82	0.15	0.03	0.33	0.33	0.06	0.38
	(0.85)	(0.88)	(0.82)	(0.99)	(0.94)	(0.93)	(0.14)	(0.07)	(0.15)	(0.22)	(0.06)	(0.23)
2	0.01	0.84	0.84	0.01	0.44	0.91	0.00	0.06	0.61	0.00	0.03	0.68
	(0.08)	(0.92)	(0.92)	(0.05)	(0.90)	(0.96)	(0.00)	(0.11)	(0.35)	(0.00)	(0.03)	(0.45)
3	0.01	0.85	0.95	0.00	0.46	0.98	0.01	0.13	0.52	0.00	0.07	0.81
	(0.06)	(0.73)	(0.90)	(0.02)	(0.85)	(0.77)	(0.00)	(0.22)	(0.42)	(0.00)	(0.07)	(0.62)
4	0.02	0.78	0.99	0.00	0.37	0.99	0.00	0.12	0.69	0.00	0.02	0.90
	(0.10)	(0.63)	(0.90)	(0.01)	(0.50)	(0.87)	(0.00)	(0.19)	(0.54)	(0.00)	(0.02)	(0.71)
5	0.04	0.87	1.00	0.00	0.50	1.00	0.01	0.19	0.81	0.00	0.04	0.96
	(0.17)	(0.72)	(0.95)	(0.03)	(0.56)	(0.93)	(0.01)	(0.28)	(0.67)	(0.00)	(0.03)	(0.82)
6	0.07	0.93	1.00	0.01	0.56	1.00	0.02	0.27	0.89	0.00	0.04	0.98
	(0.25)	(0.81)	(0.98)	(0.04)	(0.53)	(0.96)	(0.02)	(0.40)	(0.76)	(0.00)	(0.04)	(0.88)
7	0.06	0.93	1.00	0.00	0.17	1.00	0.03	0.37	0.92	0.00	0.05	0.99
	(0.22)	(0.77)	(0.97)	(0.00)	(0.20)	(0.98)	(0.04)	(0.49)	(0.85)	(0.00)	(0.05)	(0.93)
8	0.09	0.95	1.00	0.00	0.02	1.00	0.05	0.47	0.94	0.00	0.08	1.00
	(0.29)	(0.80)	(0.99)	(0.00)	(0.03)	(0.99)	(0.05)	(0.56)	(0.91)	(0.00)	(0.09)	(0.96)
9	0.13	0.97	1.00	0.00	0.01	1.00	0.07	0.52	0.97	0.01	0.12	1.00
	(0.37)	(0.87)	(1.00)	(0.00)	(0.02)	(0.99)	(0.09)	(0.56)	(0.95)	(0.01)	(0.13)	(0.98)
10	0.18	0.97	1.00	0.00	0.02	1.00	0.11	0.61	0.98	0.01	0.16	1.00
	(0.46)	(0.88)	(1.00)	(0.00)	(0.03)	(0.99)	(0.13)	(0.65)	(0.97)	(0.01)	(0.17)	(0.99)
11	0.24	0.96	1.00	0.00	0.03	1.00	0.15	0.69	0.99	0.02	0.22	1.00
	(0.55)	(0.92)	(1.00)	(0.00)	(0.04)	(1.00)	(0.18)	(0.74)	(0.98)	(0.02)	(0.23)	(1.00)
12	0.30	0.97	1.00	0.00	0.04	1.00	0.20	0.77	1.00	0.04	0.29	1.00
	(0.64)	(0.95)	(1.00)	(0.00)	(0.07)	(1.00)	(0.23)	(0.80)	(1.00)	(0.02)	(0.30)	(1.00)

Nigeria Lag=6							Tunisia Lag=6					
Horizon	Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
1	0.00	1.00	1.00	0.04	1.00	1.00	0.11	0.02	0.49	0.30	0.03	0.61
	(0.01)	(0.91)	(1.00)	(0.09)	(0.80)	(1.00)	(0.23)	(0.02)	(0.20)	(0.41)	(0.03)	(0.36)
2	0.00	1.00	1.00	0.10	1.00	1.00	0.02	0.04	0.54	0.11	0.07	0.65
	(0.03)	(0.98)	(1.00)	(0.25)	(0.94)	(1.00)	(0.04)	(0.03)	(0.29)	(0.16)	(0.07)	(0.42)
3	0.02	1.00	1.00	0.20	1.00	1.00	0.03	0.09	0.53	0.18	0.11	0.80
	(0.08)	(0.98)	(1.00)	(0.43)	(0.79)	(1.00)	(0.03)	(0.05)	(0.36)	(0.27)	(0.13)	(0.59)
4	0.03	1.00	1.00	0.26	1.00	1.00	0.03	0.11	0.66	0.12	0.11	0.91
	(0.16)	(0.98)	(1.00)	(0.60)	(0.86)	(1.00)	(0.03)	(0.06)	(0.52)	(0.17)	(0.10)	(0.75)
5	0.02	1.00	1.00	0.09	1.00	1.00	0.04	0.12	0.78	0.13	0.03	0.96
	(0.09)	(0.97)	(1.00)	(0.40)	(0.92)	(1.00)	(0.04)	(0.06)	(0.66)	(0.17)	(0.02)	(0.86)
6	0.02	0.10	1.00	0.07	1.00	1.00	0.02	0.11	0.86	0.01	0.00	0.98
	(0.07)	(0.98)	(1.00)	(0.26)	(0.95)	(1.00)	(0.03)	(0.05)	(0.71)	(0.01)	(0.00)	(0.89)
7	0.03	1.00	1.00	0.03	1.00	1.00	0.02	0.16	0.91	0.00	0.00	0.99
	(0.08)	(0.94)	(1.00)	(0.17)	(0.87)	(1.00)	(0.03)	(0.08)	(0.80)	(0.00)	(0.00)	(0.94)
8	0.05	1.00	1.00	0.06	1.00	1.00	0.03	0.21	0.95	0.01	0.00	1.00
	(0.11)	(0.81)	(1.00)	(0.24)	(0.88)	(1.00)	(0.05)	(0.12)	(0.87)	(0.01)	(0.00)	(0.96)
9	0.07	1.00	1.00	0.09	1.00	1.00	0.04	0.27	0.97	0.01	0.00	1.00
	(0.16)	(0.91)	(1.00)	(0.32)	(0.86)	(1.00)	(0.08)	(0.18)	(0.92)	(0.02)	(0.00)	(0.98)
10	0.10	1.00	1.00	0.13	1.00	1.00	0.07	0.27	0.99	0.02	0.00	1.00
	(0.21)	(0.93)	(1.00)	(0.40)	(0.93)	(1.00)	(0.11)	(0.18)	(0.95)	(0.02)	(0.00)	(1.00)
11	0.14	1.00	1.00	0.18	1.00	1.00	0.10	0.35	0.99	0.03	0.00	1.00
	(0.27)	(0.96)	(1.00)	(0.48)	(0.98)	(1.00)	(0.15)	(0.22)	(0.97)	(0.04)	(0.00)	(1.00)
12	0.17	1.00	1.00	0.23	1.00	1.00	0.13	0.40	1.00	0.04	0.01	1.00
	(0.32)	(0.90)	(1.00)	(0.57)	(0.99)	(1.00)	(0.21)	(0.26)	(0.98)	(0.06)	(0.00)	(1.00)

of oil price shocks, which can be significantly magnified or altered, depending on certain country-specific characteristics that exacerbate their vulnerabilities to the shock. Such characteristics include high oil dependence, on-going economic structure changes, and high fiscal volatility (Abdih et al., 2010, Barsky and Kilian, 2004).

It is also interesting to note that, for a large shock, the initial difference between the two IRFs (to the positive and negative shocks) might not seem large. However, for many countries, the responses diverge more as the response horizon increases (Bolivia, Brazil, Indonesia and Nigeria). For instance, for Indonesia and Nigeria, the response to a positive shock is more than twice the size of the response to a negative shock at $h = 12$.

Indeed, the impact of oil price shocks on output is not homogeneous across oil-exporting countries for a number of reasons. Now we focus on the individual country and discuss evidence of (a)symmetry and their responses to the shock based on a number of country-specific factors (e.g. export volume, income group and sectoral decomposition of GDP) and the magnitude of the shock.

In the case of Malaysia, where, overall, we have seen the smallest p-values associated with oil price shocks, we examine closely the estimated IRFs, and discuss the possible reasons behind our results. Fig. 5 shows that an unexpected positive shock tends to increase oil revenues but, given that the export volume is small, this effect is small. At the same time, the large oil-dependent industrial sector (36% in Malaysia) tends to be negatively affected.[18] Also, as most of the people work in non-oil-producing sector, aggregate demand is likely to be negatively affected. Thus, the net effect of an oil price increase is contractionary over time. On the other hand, due to the small size of the oil-exporting

[18] The country-specific data and information presented in this section are obtained from the World Bank database.

Table 3
Cumulative mean square distance for output responses.

h=1							h=4					
Countries	Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
Bolivia	0.04	0.04	0.01	0.46	0.45	0.11	0.05	0.03	0.01	0.66	0.43	0.17
Brazil	0.06	0.08	0.02	0.47	0.79	0.02	0.13	0.09	0.04	1.13	1.24	0.04
Colombia	0.17	0.06	0.02	1.38	0.89	0.05	0.16	0.05	0.02	1.37	0.62	0.05
Ecuador	0.09	0.08	0.07	0.71	1.02	0.27	0.11	0.06	0.06	0.86	1.00	0.22
Indonesia	0.04	0.00	0.00	0.37	0.11	0.02	0.07	0.01	0.00	0.64	0.10	0.02
Malaysia	0.21	0.10	0.04	1.41	0.90	0.19	0.25	0.07	0.08	1.80	0.92	0.33
Nigeria	0.02	0.01	0.00	0.27	0.21	0.01	0.02	0.02	0.00	0.21	0.26	0.01
Tunisia	0.16	0.05	0.06	1.07	0.53	0.25	0.17	0.06	0.04	1.15	0.60	0.18

h=8							h=12					
Countries	Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
Bolivia	0.05	0.03	0.01	0.64	0.45	0.18	0.04	0.02	0.01	0.59	0.40	0.16
Brazil	0.14	0.09	0.04	1.20	1.05	0.04	0.11	0.07	0.04	1.08	0.88	0.03
Colombia	0.13	0.03	0.02	1.14	0.51	0.08	0.10	0.03	0.02	0.93	0.43	0.09
Ecuador	0.09	0.05	0.04	0.72	0.79	0.17	0.08	0.04	0.04	0.60	0.67	0.14
Indonesia	0.06	0.01	0.00	0.59	0.33	0.02	0.05	0.01	0.00	0.51	0.31	0.02
Malaysia	0.18	0.06	0.06	1.34	0.73	0.29	0.14	0.04	0.06	1.10	0.61	0.24
Nigeria	0.02	0.01	0.00	0.20	0.20	0.02	0.07	0.06	0.02	0.52	0.57	0.06
Tunisia	0.14	0.07	0.05	0.96	0.62	0.18	0.11	0.06	0.04	0.82	0.56	0.15

sector, the impact on aggregate export revenues is negligible. Also, given that the large industrial sector depends on oil production, an oil price increase can promote aggregate demand and hence output (from the supply side). This may explain the initial expansion seen from the output responses which seems to be persistent for less than two quarters, as discussed above.

Another case exhibiting strong nonlinear effect of oil price shocks is Indonesia, in which the volume of oil exports as percentage of GDP is declining, accounting for about 8% of total exports. The economy is moving towards the service sector (about 45% of GDP). Given the small volume of oil exports, an oil price increase does not tend to play a significant role in improving its current account surplus. Rather, due to the substantial industrial sector, an increase in oil prices increases production costs. Also, as most of the labour force is employed in the non-oil sector, an oil price increase reduces aggregate demand. Thus, similar to Malaysia, the net effect shows a reduction in output. The effect is greater and more persistent when considering a large oil price shock.

Finally, we look at Ecuador in Fig. 5, from which we find, on average, the largest p-values based on almost all our model specifications, forms of tests, and size of shocks. The country has a relatively large oil sector in which oil contributes towards 40% of exports. An oil price increase improves its current account balance and pushes the exchange rate upwards which might negatively affect revenues from the agricultural sector. However, being the major producer of some of the agricultural commodities, this tends to give Ecuador the price setting power. As a result, agricultural revenues may not actually go down. The net effect on output may actually be positive (and persistent for over a year). As most of the people are employed in the service and industrial sectors, a decrease in oil prices also acts to boost aggregate demand, and hence, output. As expected, the positive and negative oil price shocks have symmetric effects on output.

6. Oil price shocks and government expenditure

Oil price shocks can be associated with disrupting a country's fiscal position for a number of reasons. Given the fact that many net oil-exporting countries are highly dependent on oil, the resource sector provides a major source for the foreign exchange earnings and fiscal revenues.[19] Thus, during episodes of oil price drop, it is evident that fiscal policy responses are usually procyclical by necessity, witnessed by cuts to public expenditure as government budgets are strained (unless there is availability of fiscal buffers), hence hindering long-term growth (Lopez-Murphy and Villafuerte, 2010). The macroeconomic impacts of oil price disturbances have been found to be more severe in these economies exhibiting fiscal volatility and procyclicality (Abdih et al., 2010).

However, with increasing policy reforms, structural transformations and diversification towards non-oil exports, the government spending pattern begins to change among some oil-exporting countries. For some countries, public spending remains stable even in the face of increasing revenues. Some oil-producing countries cut spending modestly after the oil price fall (e.g. the Middle East oil-producing countries after the 1990s), while many of the sub-Saharan African countries continue to record significant budget deficits. Policy-induced price regulations also have huge fiscal implications. Considering the high level of pre-tax fuel subsidies in many developing and emerging economies with low refining capacity and high dependence on fuel imports, the response to the positive oil price shock faced prior to the financial crisis of 2008–09 contributes to the pressure mounted on fiscal policy as some countries respond to this shock by increasing price subsidies on local fuels (Coady et al., 2007). Oil price shocks in these countries have been known to cause fiscal and macroeconomic imbalances.

Therefore, how important is the nature of fiscal cyclicality for understanding the real effects of oil price shocks? Here is a summary of our results below. For the oil exporters where strong asymmetry is found, a negative oil price shock has a negligible effect, even though these countries face a sharp revenue loss, negative impact on non-oil activity, and an increased spending pressure. The asymmetric output effect seems to depend on the size of government spending even though many of our oil exporters currently possess limited fiscal space. Following the sharp oil price reversal during 2008–09, these countries mobilize more government spending to mitigate the adverse effect. In the short run, there is increasing fiscal prudence and the size of the oil price drop may induce large policy responses, particularly where automatic stabilizers are less effective, although the size of fiscal responses can depend on country-specific factors.

6.1. Testing symmetry in the government expenditure responses

We use the same bivariate model for the three different nonlinear specifications to test (i) whether positive and negative shocks; and (ii)

[19] Particularly among the countries in the Middle East oil-producing region and sub-Saharan Africa which typically face the challenge of weak tax systems.

Table 4
p-Values of tests of the null of symmetric response functions: Government expenditure responses to oil price innovations.

Horizon	Bolivia Lag=8						Brazil Lag=6						Colombia Lag=6					
	Typical shock			Large shock			Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
1	0.88	0.81	0.63	0.93	0.77	0.44	0.21	0.00	0.30	0.45	0.00	0.68	0.28	0.47	0.90	0.46	0.43	0.98
2	0.03	0.74	0.49	0.00	0.69	0.51	0.13	0.02	0.57	0.30	0.00	0.89	0.21	0.31	0.99	0.46	0.04	0.97
3	0.06	0.89	0.66	0.00	0.86	0.70	0.02	0.04	0.77	0.04	0.00	0.97	0.27	0.50	1.00	0.55	0.08	0.99
4	0.11	0.90	0.81	0.00	0.63	0.81	0.03	0.03	0.89	0.02	0.00	0.99	0.42	0.59	1.00	0.71	0.14	1.00
5	0.17	0.73	0.90	0.00	0.11	0.78	0.04	0.03	0.95	0.01	0.00	1.00	0.48	0.66	1.00	0.77	0.20	1.00
6	0.24	0.56	0.95	0.00	0.06	0.85	0.06	0.05	0.97	0.01	0.00	1.00	0.59	0.74	1.00	0.85	0.16	1.00
7	0.31	0.64	0.98	0.00	0.03	0.91	0.09	0.07	0.99	0.02	0.00	1.00	0.70	0.81	1.00	0.91	0.09	1.00
8	0.41	0.69	0.99	0.00	0.03	0.95	0.14	0.10	1.00	0.03	0.00	1.00	0.79	0.88	1.00	0.95	0.13	1.00
9	0.51	0.78	1.00	0.00	0.05	0.97	0.20	0.14	1.00	0.05	0.00	1.00	0.86	0.87	1.00	0.98	0.19	1.00
10	0.59	0.82	1.00	0.00	0.06	0.98	0.25	0.20	1.00	0.08	0.00	1.00	0.91	0.90	1.00	0.99	0.25	1.00
11	0.68	0.85	1.00	0.00	0.08	0.99	0.31	0.26	1.00	0.12	0.01	1.00	0.95	0.94	1.00	0.99	0.31	1.00
12	0.75	0.90	1.00	0.00	0.12	0.99	0.38	0.32	1.00	0.15	0.01	1.00	0.97	0.96	1.00	1.00	0.39	1.00

Horizon	Ecuador Lag=6						Malaysia Lag=6						Indonesia Lag=6					
	Typical shock			Large shock			Typical shock			Large shock			Typical shock			Large shock		
	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC	Model OPI	Model NI	Model NC
1	0.38	0.01	0.34	0.51	0.01	0.66	0.61	0.48	0.51	0.79	0.68	0.49	0.66	0.99	0.97	0.78	0.95	0.84
2	0.14	0.03	0.25	0.20	0.01	0.77	0.25	0.66	0.73	0.53	0.50	0.77	0.59	0.98	1.00	0.80	0.99	0.97
3	0.27	0.06	0.38	0.35	0.02	0.87	0.42	0.84	0.89	0.74	0.68	0.86	0.05	1.00	1.00	0.22	1.00	0.99
4	0.41	0.12	0.52	0.50	0.03	0.94	0.54	0.93	0.96	0.83	0.82	0.94	0.06	1.00	1.00	0.25	1.00	1.00
5	0.38	0.20	0.66	0.37	0.04	0.97	0.67	0.97	0.98	0.91	0.91	0.97	0.08	1.00	1.00	0.25	1.00	1.00
6	0.40	0.28	0.78	0.37	0.07	0.99	0.57	0.99	0.99	0.87	0.95	0.99	0.02	1.00	1.00	0.00	1.00	1.00
7	0.28	0.34	0.86	0.12	0.09	1.00	0.28	0.99	1.00	0.48	0.97	1.00	0.04	1.00	1.00	0.00	1.00	1.00
8	0.37	0.43	0.91	0.17	0.11	1.00	0.37	1.00	1.00	0.58	0.99	1.00	0.06	1.00	1.00	0.00	1.00	1.00
9	0.47	0.52	0.95	0.24	0.16	1.00	0.44	1.00	1.00	0.68	1.00	1.00	0.09	1.00	1.00	0.00	1.00	1.00
10	0.56	0.60	0.97	0.32	0.22	1.00	0.54	1.00	1.00	0.77	1.00	1.00	0.12	1.00	1.00	0.01	1.00	1.00
11	0.64	0.67	0.98	0.40	0.28	1.00	0.63	1.00	1.00	0.83	1.00	1.00	0.17	1.00	1.00	0.01	1.00	1.00
12	0.72	0.74	0.99	0.47	0.36	1.00	0.71	1.00	1.00	0.88	1.00	1.00	0.22	1.00	1.00	0.02	1.00	1.00

Notes: This table reports the p-values (at 5%) for the Wald test statistic set out in Online Appendix A for the case of government spending. For simulating paths of x_t and y_t, we use 10,000 draws of simulations for computing the IRF given the history. For the number of bootstrapping draws over the model, our simulations are based on 10,000 bootstrapped pseudo-series using the estimated coefficients.

whether typical and large shocks have different effects on government expenditure. We focus on explaining the transmission of the oil price shocks to the real economy. Table 4 reports the corresponding p-values for the Wald statistic set out in Online Appendix A.

Clear evidence of asymmetry in the impulse response functions (IRFs) at a 5% significance level is observed for Bolivia and Brazil, while the other countries do not show statistical evidence of asymmetry. The initial result helps in explaining some public spending co-movements with the oil price changes. This means that, for Bolivia and Brazil, a large, positive oil price shock has a significant effect on government spending adjustments whereas a negative shock has a negligible effect. Interestingly, this is mostly in line with the above results that most of the countries displaying clear time series patterns of a negative relationship between the two variables are the ones where no evidence of nonlinearity is found. We examine the responses of each country in more details.

6.2. Impulse response analysis for government expenditure

We repeat the exercise conducted in Section 5.2 for government expenditure. Fig. 6 depicts the mean responses. Indeed, upon impact, a positive oil price shock has the negative effect on government expenditure following an increase in government revenue for half of our sample countries except for Ecuador, Indonesia and Malaysia. Overall, there is a negative correlation between oil prices and government spending in Brazil and Malaysia (exhibiting evidence of fiscal policy countercyclicality when observing the output responses). For instance, the result shows that, just after 1 year, the cumulative (growth) effect of a typical shock's (1 s.d.) positive innovation in oil prices results in approximately 1% to 2% contraction in government spending for these countries, exacerbating the effects on output. It is evident that some governments (for example, Malaysia) can restrict fiscal expansion during price booms thus presenting a useful scenario for joint monetary policy evaluation and counterfactual simulations. Not surprisingly, this is again consistent with the result explained in Sections 3 and 5.2 for Malaysia given its economic diversification from the oil sector, and improved financial sector and institutions.

Our IRF results reveal an interesting finding for Ecuador. There is clear evidence of fiscal volatility and procyclicality, especially when there is a surge in the international oil price. It is interesting to compare with its significant decline in output after about 4 quarters shown in Fig. 5. For Ecuador, the effect of the positive shock is expected to pose a positive impact on the economy, as initially, the country's revenue is likely to rise (Bjornland, 2009; Jimenez-Rodriguez and Sanchez, 2005). As a result, the magnitude of investment and consumption is expected to increase and then boost productivity in the service and goods sectors as well as reducing unemployment rate. However, this era of growth is likely to end given the emergence of demand-driven inflation. Examining the demand-side effect of oil price shock in oil-exporting developing countries such as Ecuador and the possible reason for the linearity in responses found in these countries can be linked to government's extreme role and its size in their economies.[20]

A similar case is Colombia as shown in Fig. 6. Likewise, the economy is on the verge of battling higher inflation resulting from the excessive investment action taken by the government which is more than the economy's absorptive capacity. Moreover, when these countries are faced with a negative oil price shock, most of their state-backed economic activities fail due to the lack of adequate support. This puts their economy under additional pressure as many capital-intensive investment projects are left uncompleted and the government results in running a huge budget deficit financed by borrowing from abroad and respective central banks in order to mitigate any form of political or social unrest and meet any recurrent cost obligations. Such procyclical fiscal stance can further exacerbate the output volatility projected in our previous figures.[21]

As a result of the fiscal inflexibility, our results demonstrate the typical symptoms of the 'resource curse' which can lead to a non-Pareto-efficient outcome, i.e., a positive shock in the oil market may

[20] For example, the recent studies of Tazhibayeva et al. (2008) and Frankel (2010) find that the fiscal policy in these countries is often procyclical rather than countercyclical as a positive oil price shock forces the governments to engage in excessive spending on investment projects and social programs that may not necessarily contribute (or have little to contribute) to economic growth.

[21] Van der Ploeg and Arezki (2008) show that fiscal policies adopted in these resource-rich emerging market countries have indeed performed poorly in terms of stabilizing economic cycles.

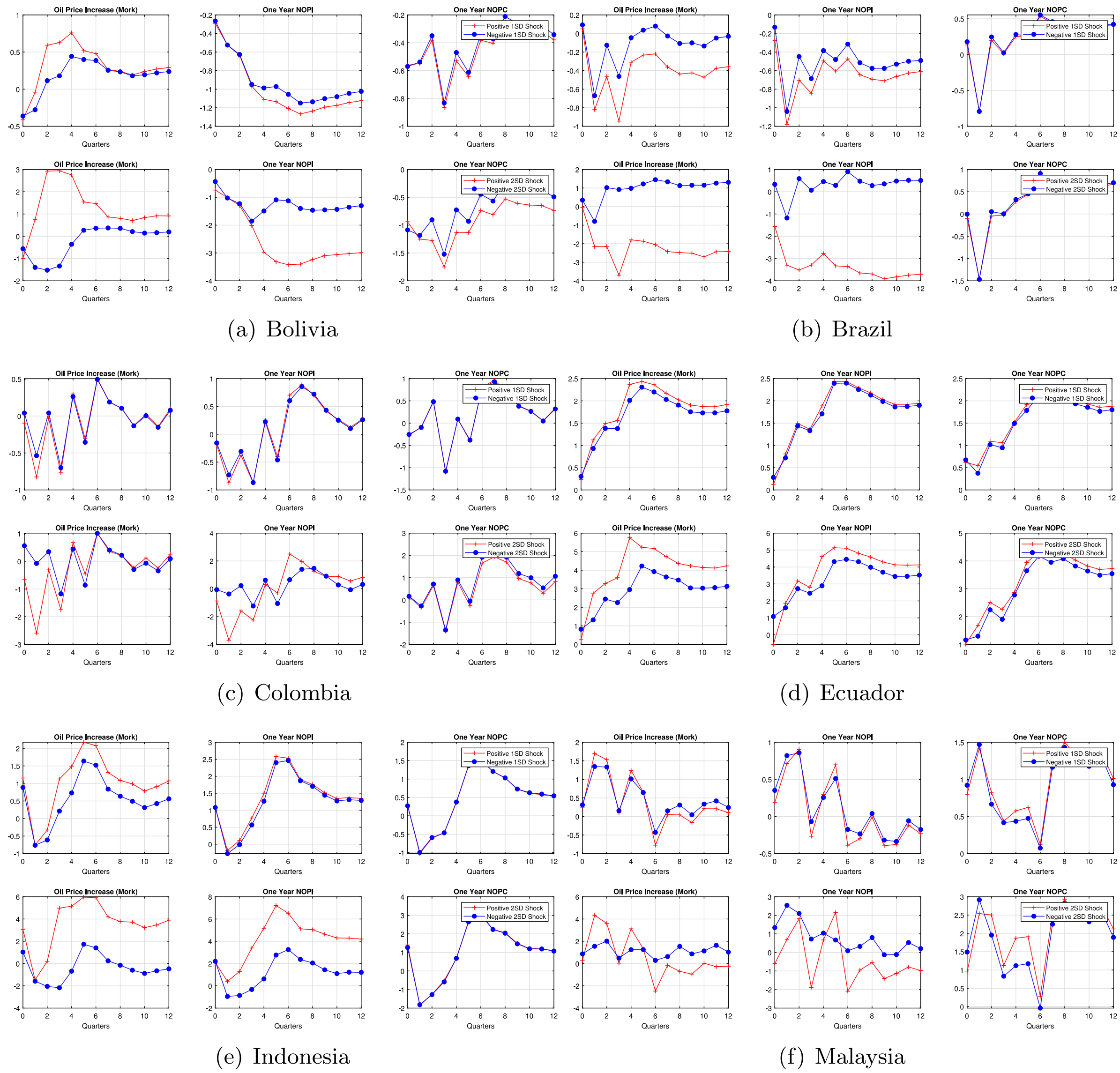

Fig. 6. Impulse response functions of government expenditure.
Notes: Each panel plots the mean response corresponding a one and two standard deviation of the shock's innovation. Each response is for a 12 period (3 years) horizon and is the percentage deviation.

have a detrimental long-term effect on economic growth. There are clear observations that these two oil-rich exporters tend to experience more macroeconomic instability and clearly this can be partially attributed to weak institutions and the lack of central bank/policy independence. Some studies have explained the effect of oil sector shocks on oil-exporting countries using different approaches to capture the transmission of shocks (such as the quality of institutions and access to credit markets). For example, Sala-i Martin and Subramanian (2003) find that natural resources have a significantly negative effect on the quality of institutions, which in turn can determine the shifts in the cyclical behaviour of fiscal policy.

6.3. Implications for fiscal policy

Observing the projected policy responses to oil price shocks for emerging market oil exporters implies the need to act and focus on adjusting government expenditure temporarily through available policy buffers (by tapping into their net borrowing, liquid assets, and grants) to mitigate a procyclical fiscal stance, especially when the prices are volatile and subject to larger shocks and abrupt regime switching. In cases where this action proves unachievable, the government can also look into re-balancing its expenditure as a way to provide relief to non-essential current expenditure where fiscal multipliers are relatively low. Furthermore, the government can decide to look into generating more resources by removing the energy subsidies that might not be necessary for the maintenance of stable retail energy prices.

However, it is important to also note that the nature and size of fiscal policy responses differ across countries as oil exporters can be classified into diverse groups, including the levels of income and economic development. Therefore, the magnitude and role of fiscal policy response is dependent on country-specific factors and policy preferences, including the availability of policy buffers, level of fiscal space in line with the country's debt sustainability, weight of oil income loss, competitiveness in the non-commodity economy, and other macroeconomic policy responses (in particular monetary policy that is sometimes restricted as a result of exchange rate (in)flexibility), as well as the size and duration of the oil price shocks.

Table 5
Signs of the $t = 0$ impact IRFs of $gexp^{obs}$ and y^{obs} to a large negative shock.

	Bolivia	Brazil	Colombia	Ecuador	Indonesia	Malaysia
2 s.d. Shock to $\widetilde{g}_{c,t}$	+	–	–	–	–	–
2 s.d. Shock to y_t	–	–	–	–	–	–
Asymmetry in $\widetilde{g}_{c,t}$ IRFs	Y	Y	N	N	N	N
Asymmetry in y_t IRFs	Y	Y	N	N	Y	Y

Note: The blue responses in Fig. 6 measure $-[-IRF^m_y(h, -\delta)]|$ if one compares this table with Fig. 6.

6.4. Government expenditure with sharp decline in oil prices

In line with the recent trend among emerging economies, many central banks are considering the adoption of inflation targeting, an examination of this regime operating in conjunction with a particular fiscal framework will be of particular interest. Based on the estimated models, Table 5 shows evidence of some simulated patterns for the public spending in response to a state of large decline in oil prices analogous to those of 2008–09 (less persistent) and from the more recent 2013–16 episode of oil price decreases (prolonged). Our results below suggest an explanation for some notable fiscal responses, given that monetary policy can be constrained, as intended, to tackle the heightened inflationary pressures from the exchange rate pass-through to domestic prices, following a severe, negative supply shock.

Two results are worth noting. First, Bolivia appears to be an interesting case here. With the accumulated budget surpluses, there seems to be an increase in deficit that comes about through a rise in government purchases. The fiscal policy is ‘active’ for demand stabilization, although this is not an abrupt change in fiscal stance, as the increase stays at a relatively low level, less persistent and more moderate during the period when the oil price falls sharply. This is clearly a case where the country is able to sustain government increased spending even during periods of oil price falls, in order to sustain growth in the real non-oil sectors for the periods of economic downturn. If the negative shock is large but not persistent, it seems likely to have negligible output effects (confirmed by our tests summarized in Table 5), the monetary policy is active as intended, then the risk of stagflation is relatively low. It is important to also note that Bolivia’s economy has become more diversified, which helps to mitigate the impact of changes in oil prices on its economy.[22]

Second, Brazil seems to experience a similar scenario except that the impact of public spending falls slightly and rises moderately and subsequently to accommodate the monetary stance. This follows the fact that, although Brazil’s economy is highly dependent on the price of exported oil, the country has also received recognition as a significant exporter of agricultural products, which has helped to mitigate the impact of oil price shocks on its economy. Thus, our findings suggest that these countries need to diversify towards non-oil exports and industrialization, and to manage to separate government expenditure from oil revenues therefore reducing the dependence on oil exports.

Finally, the countries that seem to have symmetrically followed the net oil export inflows are the ones that procyclically cut fiscal spending after the large price fall.[23] Apart from the temptation or political pressures to adjust spending proportionately, there are several key determinants of cyclicality for explaining procyclical government spending in emerging and developing countries which are identified as financial market imperfections, low degree of financial integration and depth, and weak institutions (Frankel et al., 2013; Fernandez et al., 2021). Our models and applications are able to uncover and describe the distinct co-movements between oil prices and fiscal spending which enable us to evaluate how to address fiscal imbalances and cyclicality. However, their impact on GDP depends on how the expenditure is financed to smooth out the fluctuations in revenue and requires further empirical investigations. This is beyond the scope of the present paper and we leave this for future research.

6.5. A robustness check on the measure of government expenditure

In our analysis, government consumption is measured as aggregate government expenditure based on the World Bank data classification. While the use of this measure is in line with the one often adopted in growth regressions, an important concern is whether our results are sensitive to an alternative measure of the government consumption variable when oil price shocks are considered. Since we have conducted the estimations using two bivariate models to separately examine the effect of oil price shocks on government expenditure, we need to consider an alternative variable that separates the components of government expenditure from those that may not directly be affected by oil prices. To do this, we place more emphasis on a direct connection between oil prices and government expenditure in oil-exporting countries in which oil income accrues to government revenues and propose a ‘filtering’ of government consumption composition to capture this connection. This enables us to perform a final robustness check on our results based on a more independent measure of fiscal policy which is sensitive to oil price fluctuations.[24]

We specify a Taylor-type backward-looking fiscal policy reaction function as in Bergholt et al. (2017) and Algozhina (2022) where government consumption responds to the state of the economy, lagged debt and oil revenues. The linearized form of the fiscal rule is specified as follows

$$g_{c,t} = \rho_g g_{c,t-1} + \left(1 - \rho_g\right) \left(\omega_b b_{t-1} + \omega_{gy} y_{t-1} + \omega_{or} or_t\right) + \epsilon^{g_c}_t \tag{15}$$

where ρ_g represents the degree of smoothing in government spending. ω_b, ω_{gy} and ω_{or} are the government consumption feedback coefficients with respect to lagged domestic debt, lagged output and oil revenues, respectively. The government spending shock is represented by $\epsilon^{g_c}_t$. We then run a regression on (15) using two-stage least squares[25] and obtain $\hat{\epsilon}^{g_c}_t$ which is used as a proxy for the alternative measure of government expenditure in this robustness exercise. Scaling public expenditure by generating this simulated variable allows the analysis to extract part

[22] Bolivia is a significant producer of natural gas and has been successful in using its natural gas resources to fuel its government spending and economic growth. In recent years, the country has also made efforts to increase its production of renewable energy, including solar and wind power as well as agricultural products.

[23] For example, Ecuador — knowing that this country has a high level of energy intensity, which makes it more vulnerable to oil price shocks. The country’s economy is highly dependent on the price of oil, and changes in oil prices can have a significant impact on its government spending policy and overall economic growth.

[24] While we acknowledge that oil price shocks affect monetary policy in an indirect manner, in view of the political inflexibility faced by the monetary authorities in developing countries because of the lack of central bank communications combined with weak governance, we assume that, in terms of the scope of the paper, our focus is on the role of fiscal policy in managing aggregate demand for these countries rather than an analysis that involves the behaviour of monetary policy.

[25] We construct our instrumental variables by taking the lagged terms of the dependant variable $g_{c,t}$.

of the expenditure that has a higher degree of exposure to oil price shocks.[26]

We proceed by re-estimating our models with the generated data from which we compute the IRFs for carrying out the tests for symmetry. To focus the presentation, this exercise is only performed for two countries, Brazil and Indonesia, i.e., based on Table 4, the former is the one where the most substantial evidence is found for asymmetry *vis*-à-*vis* the latter case where there is no evidence against symmetry. As before, we report our table for the p-values and depict the IRFs of the generated government expenditure variable in Online Appendix E in which we also report the regression outputs.

While we acknowledge that some of the estimated responses are different from those found in the benchmark estimation (e.g. the magnitude of the impact responses), our main findings regarding the test results of the benchmark estimation remain robust. In Table 3 in Online Appendix E, there is substantial evidence of asymmetry of the IRFs for Brazil following a large oil price disturbance whereas, at 5%, we cannot reject the null of symmetry for Indonesia. Moreover, the response trajectories are consistent with the original findings. As expected, with the alternative measure, the impact of public expenditure in Brazil following a large shock replicates the simulated patterns explained in Section 6.4.

7. Conclusions

Are the real effects of unexpected oil price changes asymmetric and empirically relevant in emerging market oil-exporting economies? How can fiscal spending cyclicality be associated with the asymmetric and macroeconomic response of output to oil price shocks in these economies? In this paper, we tackled these questions by developing and estimating several nonlinear models based on the censored-variable assumptions for a selection of eight oil-exporting emerging economies. We found ample econometric evidence of asymmetry for three countries and some evidence for a number of other countries in our sample. This is a new result in the empirical literature focusing on testing for the null of joint symmetry and nonlinearity in nonlinear systems coming from global oil price innovations. We carried out a procedure that thoroughly examined the evidence in the data and showed that our tests based on the identified impulse responses and the more conventional slope-based hypothesis-testing produced similar results, but the former provided us with a closer inspection on the dynamic responses to an oil price shock and some theoretical explanations for the transmission and magnitude of responses.

Our second contribution focused on studying an explicit role for the government fiscal spending adjustments in propagating the real effect of the shock of different magnitude and under different states of the economy. The main empirical results withstood various robustness checks. The main check involved the use of the nominal oil price in place of the real price in the nonlinear specifications for the output responses. In all cases, this did not affect the main findings. The other extended checks involved the comparison of an exclusive range of models including 3 nonlinear system equations, a linear model, a metric to measure the squared distance from responses, 2 OLS slope-based regressions, and an alternative measure of government expenditure.

Our results imply that the effectiveness of policy (fiscal and exchange rate policy for example) should depend on the premise that GDP responses are asymmetric in nature after an oil price shock and should be carefully analysed especially considering large oil price shocks. Our empirical findings are robust enough to be relevant for the study of propagation of energy price shocks in emerging market oil exporters and can help make a clear recommendation for the empirical researchers studying macroeconomic dynamics in these economies. Our results and analysis motivate further investigation into the roles of oil price fluctuations, foreign exchange inflows, and government expenditure cyclicality in understanding the growth process specific to oil-exporting open economy emerging countries.

We further illustrate that the outcome of an oil price shock on output and government expenditure varies over countries, depending on their country-specific factors, such as sectoral composition of the economy or institutional quality, and that large shocks can cause severe macroeconomic imbalances. Given the heterogeneity among the countries, we do not suggest a one-size-fits-all policy. Instead, based on the findings of our study, we propose the following policy recommendations. Firstly, fiscal prudence should be of paramount importance and a countercyclical fiscal policy can be used for stabilizing inflation and output volatility. Secondly, most of these countries lack an independent monetary authority. The presence of monetary independence with a rule-based policy (preferably an inflation targeting regime) can help reduce the economic volatility and most likely to improve the inflation-output trade-off. Finally, increasing the quality of institutions would not only supplement the earlier two recommendations but also increase the efficiency of domestic firms enabling them to absorb oil shocks more.

The issue of potential endogeneity in our estimation needed to be taken into consideration because three countries in our sample are either members or former members of OPEC (Ecuador, Indonesia and Nigeria). Historical series of exogenous OPEC events may affect oil prices, for example, the civil unrest in Venezuela in 2002–03 led to a drop in oil production. The potential issue would then be that the assumption of endogeneity may be too strong and one needs to control for the oil supply shocks driven by OPEC (political) events. This in turn has implications on the measure of oil price shocks that considers price disruptions due to these events. Our simple answer to this is that the individual economies that we consider here are all small open economies and the most recent variation in oil prices may be mainly due to changes in aggregate demand.[27] Indeed, given the size of the economy, the issue of endogeneity for the case of the US has been studied by Kilian (2009) and Kumar and Mallick (2023) which decompose innovations of oil prices into oil supply, aggregate demand, and oil-specific demand shocks, for the unexpected fluctuations in prices. A possible avenue for future research will utilize (Kilian, 2009)'s exogenous oil production shock series to assess the effect of OPEC oil production.

Finally, discretionary fiscal policy is a key transmission channel for the oil price movements to the real economy, especially for the oil-rich countries which can benefit from the windfall profits and fiscal revenues from the previous price hikes. The question of whether fiscal stabilization is state-dependant is left unanswered. Future work will consider a different way of modelling the nonlinear relationships using a parametric nonlinear VAR to capture the asymmetric fiscal transmission of oil price shocks in different states of policy environment when fiscal adjustment happens.

Declaration of competing interest

We declare that we have no relevant, personal, or material financial interests that relate to the research described in this paper.

[26] Alternatively, as noted, decomposing government expenditure into recurrent and capital expenditure would help us focus on the capital expenditure component which is responsive to oil price changes. Farzanegan (2011) suggests that recurrent expenditure is inflexible and sticky downward during an oil price drop as the fiscal authority may keep a high level of current payments by financing them through non-oil sources (e.g. taxes) while capital/developmental expenditure responds sensitively to oil price fluctuations. However, for the countries that we have studied, only annual data are available for capital expenditure.

[27] Although this view has been challenged by Kumar and Mallick (2023) which takes account of time-dependent uncertainties in modelling the impact of oil shocks.

Data availability

I have shared the link to our data/code at the Attach File step

Replication Folder (Reference data) (Mendeley Data)

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econmod.2024.106665.

References

Abdih, Y., Lopez-Murphy, P., Roitman, A., Sahay, R., 2010. The cyclicality of fiscal policy in the Middle East and Central Asia: Is the current crisis different? IMF Working Papers 1–26.

Algozhina, A., 2022. Monetary policy rule, exchange rate regime, and fiscal policy cyclicality in a developing oil economy. Energy Econ. 112 (106126).

Barsky, R.B., Kilian, L., 2004. Oil and the macroeconomy since the 1970s. J. Econ. Perspect. 18 (4), 115–134.

Baumeister, C., Kilian, L., 2016b. Understanding the decline in the price of oil since June 2014'. J. Assoc. Environ. Resource Economists 3 (1), 131–158.

Baumeister, C., Kilian, L., 2017. Lower oil prices and the U.S. economy: Is this time different? Brook. Pap. Econ. Act. 287–336.

Baumeister, C., Kilian, L., Zhou, X., 2017. Is the discretionary income effect of oil price shocks a hoax? Bank of Canada Staff Working Paper 2017-50.

Baumeister, L., 2016a. Forty years of oil price fluctuations: why the price of oil may still surprise us'. J. Econ. Perspect. 30 (1), 139–160.

Bergholt, D., Larsen, V.H., Seneca, M., 2017. Business cycles in an oil economy. J. Int. Money Finance.

Bernanke, B.S., Gertler, M., Watson, M., Sims, C.A., Friedman, B.M., 1997. Systematic monetary policy and the effects of oil price shocks. Brookings Pap. Econ. Activity 1997 (1), 91–157.

Bjornland, H.C., 2009. Oil price shocks and stock market booms in an oil exporting country. Scottish J. Political Econ. 56 (2), 232–254.

Blanchard, O.J., Gali, J., 2007. The Macroeconomic Effects of Oil Shocks: Why are the 2000s so different from the 1970s? National bureau of economic research Cambridge, Mass., USA.

Çatık, A.N., Önder, A.Ö., 2013. An asymmetric analysis of the relationship between oil prices and output: The case of Turkey. Econ. Model. 33, 884–892.

Coady, D., Baig, M.T., Ntamatungiro, M.J., Mati, A., 2007. Domestic Petroleum Product Prices and Subsidies: recent Developments and Reform Strategies. (no. 7–71), International Monetary Fund.

Cukierman, A., Webb, S., Neyapti, B., 1992. Measuring independence of central banks and its effect on policy outcomes. World Bank Econ. Rev. 6 (3), 353–398.

Edelstein, P., Kilian, L., 2009. How sensitive are consumer expenditures to retail energy prices? J. Monetary Econ. 56 (6), 766–779.

Farzanegan, M.R., 2011. Oil revenue shocks and government spending behavior in Iran. Energy Econ. 33 (6), 1055–1069.

Ferderer, J.P., 1996. Oil price volatility and the macroeconomy. J. Macroecon. 18 (1), 1–26.

Fernandez, A.D., Guzman, Lama, R.E., Vegh, C.A., 2021. Procyclical fiscal policy and asset market incompleteness. NBER Working Papers 29149, National Bureau of Economic Research, Inc..

Finn, M.G., 2000. Perfect competition and the effects of energy price increases on economic activity. J. Money Credit Bank. 32 (3), 400–416.

Frankel, J.A., 2010. The natural resource curse: A survey. National Bureau of Economic Research No. w15836.

Frankel, J.A., Vegh, C.A., Vuletin, G., 2013. On graduation from fiscal procyclicality. J. Dev. Econ. (100), 32–47.

Garzon, A.J., Hierro, L.A., 2021. Asymmetries in the transmission of oil price shocks to inflation in the Eurozone. Econ. Model. 105.

Hamilton, J.D., 1996. This is what happened to the oil price-macroeconomy relationship? J. Monetary Econ. 38, 215–220.

Hamilton, J.D., 2003. What is an oil shock? J. Econometrics 113, 363–398.

Hamilton, J.D., 2009. Causes and Consequences of the Oil Shock of 2007-08. Technical Report, National Bureau of Economic Research.

Hamilton, J.D., 2011. Nonlinearities and the macroeconomic effects of oil prices. Macroecon. Dynam. 15 (S3), 364–378.

Hamilton, J.D., 2018. Why you should never use the Hodrick-Prescott filter. Rev. Econ. Stat. 100 (5), 831–843.

Hamilton, J.D., Herrera, A.M., 2004. Comment: Oil shocks and aggregate macroeconomic behavior: The role of monetary policy. J. Money Credit Bank. 265–286.

Herrera, A.M., Lagalo, L.G., Wada, T., 2011. Oil price shocks and industrial production: Is the relationship linear? Macroecon. Dynam. 15 (S3), 472–497.

Herrera, A.M., Lagalo, L.G., Wada, T., 2015. Asymmetries in the response of economic activity to oil price increases and decreases? J. Int. Money Finance 50, 108–133.

Holm-Hadulla, F., Hubrich, K., 2017. Macroeconomic implications of oil price fluctuations: A regime-switching framework for the Euro area. ECB Working Paper Series No 2119.

Hooker, M.A., 1996. What happened to the oil price-macroeconomy relationship? J. Monetary Econ. 38 (2), 195–213.

Jawadi, F., Ftiti, Z., 2019. Oil price collapse and challenges to economic transformation of Saudi Arabia: A time-series analysis. Energy Econ. 80, 12–19.

Jimenez-Rodriguez, R., Sanchez, M., 2005. Oil price shocks and real GDP growth: empirical evidence for some OECD countries. Appl. Econ. 37 (2), 201–228.

Karaki, M.B., 2017. Nonlinearities in the response of real GDP to oil price shocks. Econom. Lett. 161, 146–148.

Kilian, L., 2009. Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. Amer. Econ. Rev. 99 (3), 1053–1069.

Kilian, L., Lewis, L.T., 2011. Does the fed respond to oil price shocks? Econom. J. 121, 1047–1072.

Kilian, L., Vigfusson, R.J., 2009. Pitfalls in estimating asymmetric effects of energy price shocks. FRB International Finance Discussion Paper 970.

Kilian, L., Vigfusson, R.J., 2011a. Are the responses of the us economy asymmetric in energy price increases and decreases? Quant. Econ. 2 (3), 419–453.

Kilian, L., Vigfusson, R.J., 2011b. Nonlinearities in the oil price–output relationship. Macroecon. Dyn. 15 (S3), 337–363.

Kilian, L., Vigfusson, R.J., 2013. Do oil prices help forecast us real GDP? the role of nonlinearities and asymmetries. J. Bus. Econom. Statist. 31 (1), 78–93.

Koop, G., Pesaran, M.H., Potter, S.M., 1996. Impulse response analysis in nonlinear multivariate models. J. Econometrics 74 (1), 119–147.

Kumar, A., Mallick, S., 2023. Oil price dynamics in times of uncertainty: Revisiting the role of demand and supply shocks. Energy Econ. 129 (107152).

Lopez-Murphy, P., Villafuerte, M., 2010. Fiscal policy in oil producing countries during the recent oil price cycle. pp. 1–23, IMF Working Papers.

Sala-i Martin, X., Subramanian, A., 2003. Addressing the natural resource curse: An illustration from Nigeria. International Monetary Fund Working Paper WP/03/139.

Mohaddes, K., Pesaran, M.H., 2017. Oil prices and the global economy: Is it different this time around? Energy Econ. 65, 315–325.

Mork, K.A., 1989. Oil and the macroeconomy: When prices go up and down: An extension of hamilton's results. J. Polit. Econ. 97 (3), 740–744.

Nusair, S.A., 2016. The effects of oil price shocks on the economies of the Gulf Co-operation Council countries: Nonlinear analysis. Energy Policy 91, 256–267.

Pal, D., Mitra, S.K., 2015. Asymmetric impact of crude price on oil product pricing in the united states: An application of multiple threshold nonlinear autoregressive distributed lag model. Econ. Model. 51, 436–443.

Romelli, D., 2022. The political economy of reforms in central bank design: Evidence from a new data set. Econ. Policy 37, 641–688.

Sachs, J.D., Warner, A.M., 2001. The curse of natural resources. Eur. Econ. Rev. 45 (4–6), 827–838.

Smith, B., 2004. Oil wealth and regime survival in the developing world, 1960–1999. Am. J. Political Sci. 48 (2), 232–246.

Tazhibayeva, K., Ter-Martirosyan, A., Husain, A., 2008. Fiscal policy and economic cycles in oil-exporting countries. International Monetary Fund Working Paper WP/08/253.

Van der Ploeg, R., Arezki, R., 2008. Can the natural resource curse be turned into a blessing? The role of trade policies and institutions. Oxford Centre for the Analysis of Resource-rich Economies Paper No 2008/01.