Oil Price Elasticities and Oil Price Fluctuations*

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Abstract

Studies that identify oil shocks using structural vector autoregressions (VARs) have reached different conclusions on the relative importance of supply and demand factors in explaining oil market fluctuations. We show that this disagreement is due to different assumptions on the oil supply and demand elasticities that determine the identification of the oil shocks. We then provide new estimates of oil-market elasticities by combining a narrative analysis of episodes of large drops in oil production with country-level instrumental variable regressions. When the estimated elasticities are embedded into a structural VAR, supply and demand shocks play an equally important role in accounting for fluctuations in oil prices and oil quantities.

KEYWORDS: Oil Market; Oil Elasticity; Vector Autoregressions; Narrative Analysis; Instrumental Variables.


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1 Introduction

Academics, practitioners, and policymakers attribute swings in the price of oil to a variety of forces, such as changes in global demand, disruptions in supply, and precautionary motives. However, the relative importance of these forces remains highly debated. In their chapter in the Handbook of Macroeconomics, Stock and Watson (2016) summarize the academic debate by comparing an early literature that finds an important role for oil supply shocks in driving oil market fluctuations to a more recent literature that finds that most movements in oil prices are demand-driven.\(^1\)

In this paper, we assess the relative importance of supply and demand factors in explaining oil market fluctuations, and find that supply and demand shocks are equally important in accounting for fluctuations in oil prices and oil quantities. We reach this conclusion in two steps. First, we combine narrative analysis with a panel of observations on country-specific oil production and consumption to estimate oil supply and demand elasticities. Second, we embed these elasticities in a vector autoregression (VAR) to identify the oil supply and demand equations and, consequently, the associated oil supply and oil demand shocks.

Our starting point is to show how the cross-equation restrictions that are inherent in standard VARs of the oil market impose an inverse, nonlinear relation between the short-run price elasticities of oil supply and demand. This relation implies that seemingly plausible restrictions on the oil supply elasticity may map onto implausible values of the oil demand elasticity, and vice versa. For instance, if one imposes a short-run oil supply elasticity of zero, a common value in the literature, the resulting oil demand elasticity is \(-1\), a value which is in the high end of the empirical estimates.\(^2\) Similarly, if one imposes an oil demand elasticity of \(-0.05\), a value in the ballpark of the empirical estimates, the resulting supply elasticity is large, close to 0.5.

We next argue that the selection of the elasticities is essential for understanding sources and con-

\(^1\)The early literature, initially used to study the 1970s oil shocks, assumes that oil prices are predetermined, and interprets innovations in prices as the outcome of oil supply shocks. Examples of papers adopting this approach are Shapiro and Watson (1988), Rotemberg and Woodford (1996), and Blanchard and Galí (2010). Blanchard and Galí (2010) identify an oil shock that explains about 80 percent of oil prices, and interpret the shock as being mostly driven by oil supply factors. The more recent literature, promoted by Kilian (2009), assumes that the short-run oil supply elasticity is zero, and explicitly allows for oil prices to contemporaneously respond to movements in oil production and in global demand. This literature finds that oil-specific demand shocks are important drivers of oil prices.

\(^2\)See Hamilton (2009) for a survey of the estimates of the short-run price elasticity of demand for crude oil: the average estimate of the demand elasticity is \(-0.06\).
sequences of oil market fluctuations, and that seemingly small changes in these elasticities have large
effects on the relative importance of demand and supply forces. In particular, with a configuration
of the oil market characterized by a zero supply elasticity, all movements in oil prices are attributed
to oil-specific demand shocks. By contrast, setting the supply elasticity to 0.1 implies that oil supply
and oil demand shocks are equally important drivers of oil price fluctuations.

To understand the relationship between oil price elasticities and oil price fluctuations, Figure 1
shows a scatter plot between monthly surprises in oil prices and global oil production implied by
simple univariate AR(1) regressions. The dots show that oil prices and global oil production are un-
correlated. This lack of correlation could be the outcome of very different oil market configurations.
On one hand, as shown by the dashed lines in Figure 1, the supply curve could be inelastic, while the
demand curve could be very elastic. As a result, fluctuations in oil prices and oil production would
be disconnected, with prices driven uniquely by demand shocks, and production driven uniquely by
supply shocks. On the other hand, a market characterized by a very elastic oil supply curve and an
inelastic demand curve—the dotted lines in Figure 1—would also lead to a disconnect of movements
in oil prices and oil production. In between these two extremes lies an oil market with a downward-
sloping demand curve and an upward-sloping supply curve—the solid lines in Figure 1—which would
imply that demand and supply shocks jointly affect oil prices and production. These market config-
urations, which we picked among many for illustrative purposes, are equally consistent with the data
but have different implications for the causes and the consequences of oil price fluctuations.

In order to estimate oil supply and demand elasticities, we combine narrative analysis with
instrumental-variable regressions for a large panel of countries. For each country, we instrument
the price of oil with large, exogenous drops in oil production occurring in other countries. Using this
approach, we find a supply elasticity of 0.08, and a demand elasticity of −0.08. We use these esti-
mated elasticities as external information to identify the structural shocks in our VAR. In particular,
we propose an identification scheme that minimizes the distance between the elasticities consistent
with the cross-equation restrictions of the VAR, and the elasticities using external information. In
doing so, we derive VAR-consistent elasticities of 0.10 for supply, and of −0.14 for demand.

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3We would obtain a similar figure by plotting the reduced-form residuals for oil prices and oil production estimated using a VAR.
Even with this identification strategy in hand, an additional challenge is to disentangle demand shocks that are specific to the oil market from demand shocks that originate from changes in global economic activity. To this end, we use three indicators of global activity that provide a broad characterization of the global demand for oil. We construct two separate indicators based on industrial production, one for emerging economies, and another for advanced economies, dating back to the mid 1980s. These indicators allow us to measure the distinct consequences of oil shocks on advanced versus emerging economies in a parsimonious model. Our third indicator is an index of industrial metal prices, which are often viewed by policymakers and practitioners as leading indicators of swings in economic activity and global risk sentiment.

Our analysis delivers the following results. First, oil supply shocks are the main driving force of oil market movements, accounting for about 35 percent of the volatility of oil prices, and about 45 percent of the volatility of oil production. Shocks to global economic conditions also play an important role, explaining 35 percent of the volatility of oil prices, and about 20 percent of the volatility of oil production. Second, a drop in oil prices driven by either oil demand or supply shocks depresses economic activity in emerging economies. A drop in oil prices boosts economic activity in advanced economies only when driven by supply shocks.

Our contribution to the literature is twofold. First, we provide a transparent analysis that highlights the importance for inference of selecting the restrictions on the oil supply and demand elasticities in a VAR framework. We stress how in a structural VAR there is a tight equivalence between setting a specific value for the oil supply elasticity, on the one hand, and imposing a particular value for the oil demand elasticity on the other. Second, we jointly select oil supply and demand elasticities in a manner that combines external information from country-specific episodes of oil shocks with the cross-equations restrictions that are inherent in the VAR.

Our paper is related to Kilian and Murphy (2012), Lippi and Nobili (2012), and Baumeister

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The use of IP indicators for advanced and emerging countries to measure global activity hews closely to the work of Baumeister and Hamilton (2015) and Aastveit et al. (2015). The use of metal prices follows the lead of Barsky and Kilian (2001), who propose the use of an index of industrial commodity prices—excluding oil—to identify broad-based shifts in global demand, as well as the more recent work of Arezki and Blanchard (2014), who exploit the idea that metal prices typically react to global activity even more than oil prices. Other studies that find a meaningful link between cyclical fluctuations in global economic activity and movements in metal prices include Pindyck and Rotemberg (1990), Labys et al. (1999), Cuddington and Jerrett (2008), Lombardi et al. (2012), Issler et al. (2014), Delle Chiaie et al. (2015), and Stuermer (2016).
and Hamilton (2015), who embed prior distributions for the elasticities in structural VARs of the oil market in order to identify shocks to oil supply and demand. Compared with these studies, we show that small differences in the elasticities have a substantial effect on inference, in particular on the decomposition of oil price movements. The use of narrative analysis on oil shocks builds off the work of Hamilton (2003) and Kilian (2008), who use country-specific episodes of exogenous disruptions in oil production to estimate the macroeconomic effects of oil supply shocks. Unlike these earlier studies, we use country-specific oil supply shocks as instruments to identify both supply and demand curves in the oil market. Our estimate of the global oil supply elasticity is within the range of estimates available in the literature, in line with the estimates by Baumeister and Hamilton (2015), but nearly three times as large as Kilian and Murphy (2012). Importantly, we find larger supply elasticities for OPEC members—especially for Saudi Arabia—than for non-OPEC producers. This finding reinforces the plausibility of our estimation approach, as OPEC producers are the group with the largest volume of oil capacity that can be used to offset disruptions in oil supply within a short period of time. Similarly, our estimates of the oil demand elasticity are in line with existing empirical studies.\(^5\) Finally, our approach of combining country-specific data on oil production with an aggregate VAR echoes the approach of the global VAR (GVAR) literature pioneered by Dees et al. (2007), and Mohaddes and Pesaran (2016).

2 Identifying Oil Market and Global Activity Shocks

2.1 Model Overview

The structure describing the oil market and its relationship with the global economy is given by the following structural VAR:

\[
AX_t = \sum_{j=1}^{p} \alpha_j X_{t-j} + u_t, \tag{1}
\]

\(^5\)See Hamilton (2009) and Baumeister and Hamilton (2015) for a summary of the existing empirical evidence on the short-run price elasticity of crude oil demand. Gelman et al. (2016), using daily transaction-level data for a large panel of individuals, find a demand elasticity of gasoline close to \(-0.2\). Coglianese et al. (2017) estimate an elasticity of gasoline demand of \(-0.37\) that is not statistically significant. As discussed in Hamilton (2009), since crude oil represents about half of the retail cost of gasoline, the price elasticity of demand for crude oil should be about half of that for retail gasoline.
where $X$ is a vector of oil–market and macroeconomic variables, $u_t$ is the vector of structural shocks, $p$ is the lag length, and $A$ and $\alpha_j$ for $j = 1, \ldots, p$ are matrices of structural parameters. The vector $u_t$ is assumed to have a Gaussian distribution with zero mean and variance–covariance matrix $E[u_t u_t'] = \Sigma_u$. Without loss of generality, we normalize one entry on each row of $A$ to 1 and we assume that $\Sigma_u$ is a diagonal matrix. The reduced-form representation for $X_t$ is the following:

$$X_t = \sum_{j=1}^{p} \gamma_j X_{t-j} + \varepsilon_t,$$

where the reduced-form residuals $\varepsilon_t$ are related to the structural shocks $u_t$ as follows:

$$\varepsilon_t = Bu_t,$$

$$\Sigma_{\varepsilon} = B\Sigma_u B',$$

where $B = A^{-1}$, so that $u_t$ can be alternatively expressed as $u_t = A\varepsilon_t$. Estimation of the reduced-form VAR allows us to obtain a consistent estimate of the $n(n+1)/2$ distinct entries of $E[\varepsilon_t \varepsilon_t'] = \Sigma_{\varepsilon}$.

To recover the $n^2$ unknown entries of $B$ and $\Sigma_u$, we make $(n-1)n/2$ identifying assumptions on the parameters of matrix $A$.

To discuss our identification strategy, it is useful to distinguish between an oil–market block and a global–activity block, which we jointly characterize using five endogenous variables. The oil block includes (1) the log of world crude oil production, $q_t$; and (2) the log of oil prices, $p_t$. The global activity block consists of: (3) the log of advanced economies IP, $y_a$; (4) the log of emerging economies IP, $y_e$; and (5) the log of the IMF metal price index, $m_t$. All series are linearly detrended.\(^6\) Oil prices and metal prices are expressed in real terms.\(^7\)

The model, which includes a constant and 24 lags of the endogenous variables, is estimated on monthly data from 1985 to 2015 employing Bayesian techniques.\(^8\) We start the sample in the

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\(^6\)The detrending method has modest impact on our results. The supplementary material presents results when our baseline VAR is estimated on variables that are not detrended.

\(^7\)In the supplementary material, we describe in detail the data and the construction of the IP indexes.

\(^8\)We impose a Minnesota prior on the reduced-form VAR parameters by using dummy observations (Del Negro and Schorfheide, 2011). The vector of hyper-parameters of the prior is $\lambda = [1, 2, 1, 1, 1]$. We use the first two years of data as a training sample for the Minnesota prior. Results are based on 10,000 draws from the posterior distribution of the structural parameters, with the first 2,000 draws used as a burn-in period.
mid-1980s as it coincides with the decision by the Organization of Petroleum Exporting Countries (OPEC) to abandon an administered official selling price and to adopt a market–based system. In addition, Baumeister and Peersman (2013a,b) show that large changes in the time-series properties of oil–market variables took place around the mid-1980s. In the supplementary material, we show that results under our baseline model are robust to alternative specifications.

The following five equations describe—abstracting from lags—the joint modeling of the oil–market and the global–activity blocks, and summarize the restrictions that we impose on the parameters in matrix A:

\begin{align*}
q_t &= \eta_S p_t + u_{S,t}, \\
q_t &= \eta_A y_{A,t} + \eta_E y_{E,t} + \eta_D p_t + u_{D,t}, \\
y_{A,t} &= \nu Q q_t + u_{A,t}, \\
y_{E,t} &= \mu Q q_t + \mu_A y_{A,t} + u_{E,t}, \\
m_t &= \psi Q q_t + \psi_A y_{A,t} + \psi_E y_{E,t} + \psi_D p_t + u_{M,t}.
\end{align*}

Equations (5) and (6) describe the oil market block. Equation (5) describes the oil supply schedule. We assume that oil production \( q_t \) responds contemporaneously only to changes in oil prices. The parameter \( \eta_S \) denotes the short-run price elasticity of supply. The supply shock \( u_{S,t} \) captures disturbances to oil supply due to, for instance, geopolitical events, natural disasters, and technological innovations in oil extraction. Equation (6) describes the oil demand schedule: oil demand is allowed to respond contemporaneously to the level of economic activity in advanced and emerging economies, \( y_{A,t} \) and \( y_{E,t} \), and to oil prices. The parameter \( \eta_D \) denotes the short-run price elasticity of demand, and is defined as the change in desired demand \( q_t \) for a given change in oil prices \( p_t \), holding activity in advanced and emerging economies constant. The oil-specific demand shock \( u_{D,t} \) captures changes in oil prices due to, for instance, speculation and shifts in the precautionary demand for oil caused by oil price volatility.\(^9\)

Equations (7) to (9) describe the global activity block. Equation (7) determines activity in advanced economies. We assume that \( y_{A,t} \) responds within the period only to oil production. Equa-

\(^9\)See for instance Beidas-Strom and Pescatori (2014) and Juvenal and Petrella (2015).
tion (8) determines activity in emerging economies, $ye_t$. We assume that $ye_t$ responds within the period to $ya_t$ and to oil production. Our assumption that $ye_t$ reacts contemporaneously to $ya_t$ is meant to capture the idea that exports to advanced economies are an important component of aggregate demand in emerging economies. Our model assumes that the oil market has a contemporaneous and direct effect on both $ya_t$ and $ye_t$ only through changes in $q_t$, as oil is an input in the production of manufactured goods. However, changes in oil prices have an indirect contemporaneous effect on real activity by inducing changes in oil production. Equation (9) determines metal prices, which are allowed to respond within the period to all variables in the system. The shock $u_{M,t}$ captures movements in global demand over and above the innovations in IP.\(^\text{10}\)

The use of zero restrictions to model the interaction between the oil market and global activity is consistent with the assumptions in Kilian (2009), who also assumes that oil supply does not respond to shocks to global activity, while oil demand does. The key difference between Kilian’s (2009) identification strategy and ours lies in the choice of the oil supply and demand elasticities $\eta_S$ and $\eta_D$.

### 2.2 Identification of The Oil Market Block

We now show how seemingly plausible restrictions on the oil supply elasticity $\eta_S$ may map into implausible values of the oil demand elasticity $\eta_D$, and vice versa. Figure 2 illustrates this result. The black line depicts all combinations of $\eta_S$ and $\eta_D$ that are consistent with the data—as summarized by setting $\Sigma$ at its OLS estimate—and with the zero restrictions described above. For instance, the same model can be identified restricting the oil supply elasticity to zero, a common value in the literature, only to imply an oil demand elasticity of about $-1$, which is at the high end of the empirical estimates; by contrast, the model can be identified restricting the oil demand elasticity to a value in the ballpark of empirical estimates (for instance $-0.05$), only to imply an oil supply elasticity which is implausibly large.

The blue circle indicates a pair of elasticities that represent an oil market configuration featuring

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\(^{10}\)Our restrictions imply that metal prices can directly respond to contemporaneous movements in oil prices, but we rule out the reverse interaction. We estimated a model that imposes the alternative assumption that oil prices respond contemporaneously to metal prices—by allowing metal prices to enter into the oil demand equation—while imposing $\psi_P = 0$. We found very similar results to those reported below. In addition, we find that removing metal prices from the VAR model slightly diminishes the importance of global activity shocks to explain movements in oil market variables, but has a very modest influence on the remaining results of the paper. See Subsection 4.4 and the supplementary material for details.
moderately inelastic supply ($\eta^*_S = 0.081$) and demand ($\eta^*_D = -0.080$) elasticities. These oil price elasticities are based on the country-level, instrumental-variable panel regressions presented in Section 3. We refer to these elasticities as external information, as they are derived from data and identification assumptions that are external to the structural VAR model.

We propose to use the external information on both elasticities to discipline the identification of VAR model. Specifically, our identification strategy selects a pair of admissible elasticities $\eta_S$ and $\eta_D$ by minimizing the Euclidean distance between the VAR-admissible elasticities and the target elasticities. Consider $\eta_D$ as a function of $\eta_S$ and of the variance-covariance matrix of the estimated reduced-form residuals, $\eta_D(\eta_S; \Sigma_\epsilon)$. Our identification strategy solves the following problem:

$$\min_{\eta_S} \begin{bmatrix} \eta_S - \eta^*_S \\ \eta_D(\eta_S; \Sigma_\epsilon) - \eta^*_D \end{bmatrix} V^{-1} \begin{bmatrix} \eta_S - \eta^*_S \\ \eta_D(\eta_S; \Sigma_\epsilon) - \eta^*_D \end{bmatrix},$$

where $\eta^*_S$ and $\eta^*_D$ are the target values for the supply and demand elasticities, respectively, and $V$ is a diagonal matrix of weights. We summarize the external information into a mean component, the targets $\eta^*_S$ and $\eta^*_D$, and into a variance component, which we use to calibrate the weights $V$. If the external information is perfectly consistent with the VAR, $\eta^*_S$ and $\eta^*_D$ are on the curve plotted in Figure 2 and the distance between the VAR-implied elasticities and the targets is zero. By contrast, if the external information is not consistent with the VAR, $\eta^*_S$ and $\eta^*_D$ are not on the curve and the identification selects the pair of elasticities on the curve that are as close as possible to the targets, assigning a larger weight to the elasticity that is more precisely estimated.

In our application, the identification selects $\eta_S = 0.10$ and $\eta_D = -0.14$, denoted by the green square in Figure 2. Both values are close to their target.

In sum, standard VAR models of the oil market face a trade–off in the selection of the oil supply and demand elasticities. For instance, the same model can be identified restricting the oil supply elasticity to using a common value in the literature (for instance 0), only to imply an oil demand elasticity which is at the high end of the empirical estimates; by contrast, the model can be identified restricting the oil demand elasticity to a value in the ballpark of empirical estimates (for instance

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$^{11}$We parameterized the problem by expressing $\eta_D$ as a function of $\eta_S$ so that matrix $A$ satisfies the necessary and sufficient conditions for identification of Rubio-Ramirez et al. (2010). Thus, the structural parameters $(\nu_Q, \mu_Q, \mu_A, \eta_A, \eta_D, \psi_Q, \psi_A, \psi_E, \psi_P, \Sigma_u)$ are uniquely identified given information from $\Sigma_\epsilon$. 

—0.05), only to imply an oil supply elasticity which is implausibly large. Our approach eases this potential tension by making use of external information on both elasticities to select a model with oil elasticities that are as close as possible to empirically plausible values.

2.3 The Role of Oil Demand and Oil Supply Elasticities

One could argue that an oil supply elasticity of, say, 0.01 is not meaningfully different from an elasticity of, say, 0.05. In this subsection, we show that this is not the case. Small changes in the oil price elasticities have large and material implications for quantifying the determinants of fluctuations in oil prices and oil production. Figure 3 illustrates this result by plotting—for our baseline model—the share of the forecast error variance at horizon zero for oil prices and for oil production that is attributable to oil shocks, as a function of the oil supply elasticity $\eta_S$.

Consider the case in which the supply elasticity is assumed to be zero, the value used in Kilian (2009). By assumption, setting a zero supply elasticity implies that oil production is exogenous within the month, as the supply curve is perfectly inelastic. Accordingly, as shown by the red line in the right panel of Figure 3, all of its forecast error variance is accounted for by the oil supply shock. However, an additional implication of setting a zero supply elasticity is that, as shown in the left panel, almost all of the forecast error variance of oil prices—about 95 percent—is explained by the oil-specific demand shock. This is due to the fact that the demand curve implied by the VAR is highly elastic. Thus, setting $\eta_S = 0$ implies a disconnect between the drivers of oil production and the drivers of oil prices: oil production moves in response to shocks to oil supply, whereas oil prices move in response to shocks to oil demand.

Figure 3 also shows that small variations in the oil supply elasticity significantly alter the relative importance of oil-specific supply and demand shocks in accounting for fluctuations in the price of oil. In particular, a value of $\eta_S$ close to 0.1, similar to that selected by our identification strategy, implies that the two shocks are equal drivers of oil prices and oil production. Thus, for sufficiently upward-sloping supply curves and sufficiently downward-sloping demand curves, the two oil shocks jointly affect oil prices and production, and there is no disconnect between drivers of oil production and drivers of oil prices.$^{12}$

$^{12}$In the supplementary material, we place our identification strategy in the context of the old and new VAR
3 IV Estimates of Oil Supply and Demand Elasticities

In this section, we provide empirical evidence about the price elasticity of global supply and demand for crude oil by estimating instrumental variable (IV) panel regressions. This evidence provides the basis for the target elasticities that we impose to identify the structural VAR.

3.1 A Stylized Model of the Global Oil Market

We start from a small, stylized empirical model that provides the basis for estimating oil supply and oil demand elasticities starting from individual countries’ oil production data. In the empirical model we assume that the global oil market consists of $N$ countries, and has the following structure:

$$\Delta q_{S,i,t} = \eta_S \Delta p_t + u_{S,i,t}, \forall i = 1, \ldots, n,$$  \hspace{1cm} (11)

$$\Delta q_{D,i,t} = \eta_D \Delta p_t + u_{D,i,t}, \forall i = 1, \ldots, n,$$  \hspace{1cm} (12)

$$\sum_{i=1}^{N} \omega_{S,i} \Delta q_{S,i,t} = \sum_{i=1}^{N} \omega_{D,i} \Delta q_{D,i,t},$$  \hspace{1cm} (13)

Equation (11) is the oil supply schedule in country $i$. According to this equation, the log change in country $i$’s production of crude oil ($\Delta q_{S,i,t}$) for month $t$ depends on the log change in the price of crude oil ($\Delta p_t$) and on a country-specific oil supply shock ($u_{S,i,t}$). Equation (12) is the oil demand schedule in country $i$. According to this equation, the log change in country $i$’s consumption of crude oil ($\Delta q_{D,i,t}$) for month $t$ depends on the log change in the price of crude oil and on a country-specific oil demand shock ($u_{D,i,t}$). The coefficients $\eta_S$ and $\eta_D$ denote the price elasticity of supply and demand, respectively.

We assume, for simplicity, that there are common demand and common supply elasticities across countries, but we relax these assumptions in the robustness exercises presented below.

Finally, Equation (13) is the global market-clearing condition. According to this condition, changes in global oil production (weighted by the country’s production share $\omega_S$) must be equal to changes in global oil consumption (weighted by the country’s consumption share $\omega_D$). This formulation of the global oil market allows for individual countries to run oil trade imbalances. Through this formulation we implicitly assume that changes in global oil inventories play a secondary role in literature—surveyed in Stock and Watson (2016)—studying the macroeconomic effects of oil shocks.
shaping the ups and downs of oil supply and oil demand. This working hypothesis is supported by the analysis in the supplementary material, in which we show that augmenting the baseline VAR to include the change in global oil inventories has only a modest effect on the results.

We can express the change in the equilibrium oil price as follows:

\[ \Delta p_t = \sum_{i=1}^{N} c_{S,i} u_{S,i,t} + \sum_{i=1}^{N} c_{D,i} u_{D,i,t}, \]

where the reduced-form coefficients \( c_{S,i} \) and \( c_{D,i} \) depend on the elasticities \( \eta_S \) and \( \eta_D \), and on the country weights \( \omega_{S,i} \) and \( \omega_{D,i} \).

Equation (14) shows that the equilibrium oil price depends on the supply and demand shocks realized in each country. The straightforward implication is that running country-specific OLS regressions based on either Equation (11) or Equation (12) would yield biased estimates of \( \eta_S \) and \( \eta_D \), since, for each country \( i \), the regressor \( \Delta p_t \) is correlated with the shocks \( u_{S,i,t} \) and \( u_{D,i,t} \). In order to circumvent this problem, we use large exogenous drops in oil production in other countries as instrumental variables for oil prices in Equations (11) and (12). Intuitively, if events leading to oil supply disruptions in other countries are truly exogenous, they should affect oil supply and oil demand in a particular country only through their effect on prices. This way, we obtain unbiased estimates of \( \eta_S \) and \( \eta_D \) by regressing production and consumption in each country against the component of prices that is explained by the exogenous shocks in other countries.

Our approach yields unbiased estimates when the oil supply and oil demand shocks identified in a specific country are orthogonal to oil shocks taking place in other countries within the same month. In our application, this condition is violated during the Iraq invasion of Kuwait in August 1990, which led to supply disruptions in multiple countries. For this reason, we classify shocks that take place in multiple countries within the same month as one single episode, and impose the orthogonality assumption at the episode-level aggregation. Additionally, in our stylized model, we rule out any

\[ \text{With two countries only, the equilibrium price can be written as follows (omitting the time subscripts for simplicity): } \Delta p = \frac{\omega_S}{\eta_S - \eta_D} u_{S,1} + \frac{\omega_D}{\eta_S - \eta_D} u_{D,1}, \]

so that \( c_{S,1} = \frac{-1}{\eta_S - \eta_D} \omega_{S,1} \), and \( c_{D,1} = \frac{1}{\eta_S - \eta_D} \omega_{D,1} \), for instance. Accordingly, a sufficient condition for supply shocks to reduce the price and demand shocks to increase the price is that the supply elasticity \( \eta_S \) is positive and the demand elasticity \( \eta_D \) is negative.

Mohaddes and Pesaran (2016) use a GVAR to analyze the international transmission of country-specific oil supply shocks. As in the GVAR approach, we study the global oil market by exploiting the information contained in country-level data on oil production and oil consumption. However, an upshot of our approach is that we focus on episodes of large changes in a country’s oil production in order to derive estimates of both oil demand and oil supply elasticity.
interactions between the oil market and global economic activity, unlike in our structural VAR model, in which industrial production affects, and responds to, global oil production. We control for these channels by controlling for industrial production in the estimation of the country-specific regressions.

3.2 Construction of the Instruments

We describe the construction of the instruments in three steps. First, we use the example of the Gulf War to revisit the evidence on the oil supply elasticity presented in Kilian and Murphy (2012), in which a single episode of a large drop in oil production in two countries is used to infer the global oil supply elasticity. Second, we generalize this example using data on oil production for 21 countries for the sample from 1985 to 2015, and compile a list of 29 episodes of large, country-specific drops in oil production. Third, we use narrative records to classify these episodes as either exogenous (e.g., the result of wars or natural disasters) or endogenous (e.g., the response to falling oil prices). For each individual country we construct an instrument that sums for, each month, all the exogenous drops in oil production occurring in the other countries.

The Example of the Gulf War. Prima facie, the events of the Gulf War appear ideal candidates to derive estimates of the oil supply elasticity. On August 2, 1990, Iraqi forces invaded Kuwait. Within one month, oil production in Iraq and Kuwait fell by about 4 and 2.9 percent of global production, respectively. Amidst such drop in production and the associated fears about a potential escalation of the war, the real price of crude oil rose in August 1990 by 44.3 percent. Kilian and Murphy (2012) argue that in August 1990 there was ample spare capacity in global oil production, as well as unanimous willingness among oil producers to increase production to offset the adverse price effects of market fears about a wider war. In August 1990, all oil producers excluding Iraq and Kuwait increased production only by 1.17 percent. According to their analysis, the implied oil supply elasticity could not exceed $\eta_S = 1.17/44.3 \equiv 0.0258$, a value that they take as an upper bound. However, case studies can be deceptive, and the same event can easily lend itself to multiple interpretations. In fact, our interpretation is that geopolitical events that unfolded in August 1990 show how even this single episode can be used to rationalize an oil supply elasticity that is larger than this upper bound.
In August 1990 oil production in the United Arab Emirates (U.A.E.) was disrupted by geopolitical events that were clearly linked to the inception of the Gulf War. In other words, there was a shock to $u_{S,i}$ for the U.A.E. that was also related to the same sequence of events that ultimately led to the shocks $u_{S,i}$ in Iraq and Kuwait. On July 17, 1990, then-Iraq’s President Saddam Hussein openly threatened to use force against Arab oil-exporting nations if they did not curb their excess production. Even though President Hussein did not mention countries by name, all commentators agreed that the threats were clearly aimed at the U.A.E and Kuwait (Ibrahim, 1990). During the same week, Abu Dhabi National Oil Co. announced that it intended to reduce crude production by up to 30 percent for an indefinite period. While this action was officially taken to ensure that the U.A.E. complied with the OPEC production agreement, the timing and the fact that the U.A.E. had been in violation of the agreement for a prolonged period suggest that the move was taken in reaction to the pressure imposed by the unprecedented barrage of strong political intimidation by Iraq’s top officials. All told, the U.A.E. lowered oil production in August by 19.5 percent, about 0.66 percent of global production. The implication for the analysis at hand is that oil production in the U.A.E. should be excluded from global oil production for the calculation of the oil supply elasticity. Consequently, since in August 1990 global oil production excluding Iraq, Kuwait, and the U.A.E. increased by 1.97 percent, the estimate of $\eta_S$ becomes 0.045, nearly twice as large as the estimate in Kilian and Murphy (2012).

**Identifying Large Drops in Oil Production.** We generalize the analysis of the Gulf War by using quantitative criteria to detect similar episodes of large drops in oil production.

Table 1 presents the candidate country–month pairs selected using our criteria. Our first criterion—the narrow criterion—selects observations for which oil production in country $i$ during month $t$ drops by more than 2 percent of global oil production, a threshold inspired by the drop in oil production experienced by Iraq and Kuwait in August 1990. As shown in the table, the narrow criterion selects only eight country–month pairs: Saudi Arabia in September 1986, January 1987, and January 1989; Iraq and Kuwait in August 1990; Iraq in December 2000 and June 2001, and Venezuela in 2002.

Our second criterion—the broad criterion—defines multiple thresholds calibrated to select a larger set of drops in a country’s oil production. These drops are either large relative to a country’s own past production, or relative to global production. In particular, the three thresholds that comprise the
broad criterion—described in the note to Table 1—are designed to capture the drops in oil production of Iraq, Kuwait, and the U.A.E. in August 1990. All told, as shown in Table 1, the broad criterion singles out 29 country-month pairs.

### 3.3 Narrative Analysis: Sources of Oil Shocks

After selecting candidate country-month pairs, we move to the construction of the instruments, starting with the identification of the causes underlying each episode. Our goal is to classify these episodes as either endogenous—cuts in production taken in response to oil price changes—or as exogenous, cuts in production due, for instance, to geopolitical events or natural disasters. The supplementary material describes our narrative classification in greater detail.

Two sources are the backbones of the narrative characterization and classification of the episodes selected through our quantitative criteria. For the episodes before 1991, we rely exclusively on the Oil Daily published by the Energy Intelligence Group. For the episodes from 1991 onward, we rely on information from the Oil Market Report (OMR) of the International Energy Agency (IEA). To complement the information from the Oil Market Report, we also use the Oil Daily.

In our sample, the quantitative criteria detect two instances of concurrent large production drops in more than one country. In April 1986, large production drops occurred in Qatar and Norway. We classify the drop in Qatar as endogenous, and the drop in Norway as exogenous. In August 1990, large production drops occurred in Iraq, Kuwait, and the U.A.E., which we classify as exogenous.

Based on our narrative analysis, we find that country-month pairs identified using the narrow criterion exhibit, on average, larger drops than those selected with the broad criterion, an outcome which had to be expected. Interestingly, we also find that endogenous episodes were typically characterized by drops that were, on average, smaller than those associated with exogenous episodes. More specifically, through the narrow criterion we select three endogenous and five exogenous country-month pairs, with all five exogenous episodes related to wars and geopolitical events. Among these eight episodes, the average production drop expressed as percent of global oil production was 2.5 and 2.9 percent for endogenous and exogenous episodes, respectively. Using the broad criterion, we select 12 endogenous and 17 exogenous country-month pairs. Among these 29 episodes, the average
production drop was 1.15 and 1.7 percent for endogenous and exogenous episodes, respectively. Furthermore, when we aggregate the August 1990 drops for Iraq, Kuwait, and the U.A.E. into a single episode, the average output drop for the 15 exogenous episodes was 1.9 percent.

**Endogenous Large Oil Production Drops.** Out of the 29 episodes selected through the broad criterion, we classify 12 of them as endogenous. Ten of these 12 episodes involved output cutbacks by oil producers aimed at curbing conditions of oversupply glutting the global oil market and, therefore, at either stabilizing or shoring up prices. Eight of these cutbacks emerged as outcomes of decisions taken by OPEC countries, namely Saudi Arabia, Nigeria, and the U.A.E. These decisions to restrain production were part of efforts by OPEC to bring its overall output in line with the agreed quota structure and to help support prices. As such, they represented the responses of cartel members to developments in the global oil market that caused global production and benchmark prices to deviate from their preferred targets. Two other episodes of deliberate output cutbacks involved one non-OPEC producer, Egypt, and reflected its willingness to cooperate with the cartel’s efforts to keep global production in check and help stabilize prices.

The remaining two country-month pairs classified among the endogenous episodes are related to production drops in Qatar during April 1986 and in Russia during May 1992. For the former, we were not able to find any information about a major event leading to an exogenous disruption in oil production. Considering that Qatar is an OPEC member, we classify the April 1986 drop as endogenous. As for the May 1992 episode involving Russia, it was largely anticipated by market participants, being the continuation of a decline in crude oil output amidst the deep economic and political crisis that followed the dissolution of the Soviet Union.

**Exogenous Large Oil Production Drops.** Wars and adverse geopolitical events account for nine of the 15 exogenous episodes. Among these, the Gulf War in August 1990 represents the largest event encompassing the concurrent cutbacks in production in Iraq, Kuwait and the United Arab Emirates. The set of large, exogenous output drops caused by wars and geopolitical events also includes two episodes in the course of the Iran–Iraq war that had started in 1980. In January 1985 and September 1987, Iran experienced two drops in oil production following attacks by Iraqi warplanes on oil tankers
calling at Iranian ports and on Iranian oil installations. Moving down Table 2’s timeline of wars and geopolitical events, between the late 1990s and the early 2000s, Iraq suffered four large output drops prompted by developments relative to the United Nations’ “oil-for-food” program. During April 2003 and March 2011, output drops in Iraq and Libya, respectively, were caused by the disruptions following the military actions that marked the start of the Iraq War and by the attacks of government forces on rebel-held oil fields and infrastructure in the context of the Libyan civil war.

Large exogenous output drops were also triggered by other categories of events in oil producing countries such as natural disasters and domestic political tensions. During March 1987, two devastating earthquakes in Ecuador led to extensive damage of its oil production and transportation equipment. Hurricane Roxanne in Mexico in October 1985, hurricanes Katrina and Rita in September 2005 and hurricanes Gustav and Ike in September 2008 in the U.S. caused severe damages to oil infrastructures, leading to substantial losses of crude output. As for output drops caused by domestic political tensions, during April 1986 a sizable portion of Norwegian crude production was shut off after a major strike by unionized caterers working on offshore fields and the subsequent lockout of oil production workers of all affiliated offshore unions, whereas during December 2002 a general national strike in Venezuela led to a substantial fall in its oil output.

Comparison to Existing Narrative Shock Series. Figure 4 plots the time series of the exogenous production shortfalls. For comparison, our time series is plotted alongside the measure of oil supply shocks constructed following Kilian (2008). The latter is based on large drops in oil production in some OPEC countries relative to a counterfactual based on the production of other OPEC countries which did not experience such shocks and which were otherwise subject to the same global macroeconomic conditions and economic incentives.\textsuperscript{15}

When we compare our non-zero shocks with Kilian’s shocks in the same month—as shown in the inset panel—the magnitudes are similar, and correlation between the two series is very high (0.92). However, when the comparison is extended to the full set of observations in which the two series overlay, the correlation drops to 0.68, as Kilian’s series, by construction, displays large swings also.

\textsuperscript{15}We reconstruct Kilian’s monthly series following the methodology described in his paper, since Kilian’s published oil shocks (downloaded from http://www-personal.umich.edu/~lkilian/oilshock.txt) are only made available at quarterly frequency. When we convert the monthly shocks to a quarterly frequency, the resulting series is virtually indistinguishable from the published series (their correlation is 0.9929).
in periods without well-defined exogenous movements in oil production. Importantly, our shocks series signals a larger exogenous oil supply drop in August 1990—consistent with the inclusion of the United Arab Emirates along Iraq and Kuwait in the group of countries that were responsible for the shortfall in oil production—and includes shocks to non-OPEC producers.

3.4 Estimation Results

We use monthly data from 1985 to 2015 on production and consumption of crude oil available from the U.S. Department of Energy. Data on crude oil production are available for 21 countries, while data on petroleum consumption are available for eight OECD countries. We estimate the following instrumental variable specifications:

\[ \Delta p_{i,\tau} = \pi_i + \gamma \Delta v_{i,\tau} + \epsilon_{i,\tau}, \quad (15) \]
\[ \Delta q_{i,\tau}^S = \alpha_{S,i} + \eta ^S \Delta p_{i,\tau} + u_{i,\tau}^S, \quad (16) \]
\[ \Delta q_{i,\tau}^D = \alpha_{D,i} + \eta ^D \Delta p_{i,\tau} + \Psi X_{i,\tau} + u_{i,\tau}^D, \quad (17) \]

where \( \pi_i, \alpha_{S,i}, \) and \( \alpha_{D,i} \) are country fixed effects, \( \tau \) is the time-subscript identifying the episodes of exogenous drops in oil production. Equation (15) is the first-stage regression, where \( \Delta v_{i,\tau} \) is the instrument, given by the percent change in global oil production directly accounted for by the episodes listed in Table 2. Equations (16) and (17) are the IV regressions for supply and demand. In line with the structural VAR presented in Section 2, Equation (17) controls for contemporaneous and lagged country-specific, advanced economies, and emerging economies log changes in IP, all denoted by the vector \( X_{i,\tau} \). For each country \( i \), we construct country-specific instruments by excluding exogenous episodes involving that country. For instance, the instrument for the U.S. excludes the months of September 2005 and September 2008, the two months during which hurricanes Katrina and Gustav disrupted crude oil and petroleum products production in the U.S.

Panels (A) and (B) in Table 3 report results from the estimation of equations (16) and (17). The OLS column presents the estimates when, trivially, \( \widehat{\Delta} p = \Delta p \), while the last two columns show the IV estimates using the narrow and broad instruments discussed in the previous section.\(^{16}\)

\(^{16}\)The IV regressions do not include the months in which no exogenous oil shocks occur. We verified that including
Starting with Panel (A), column 1 reports the OLS estimate of the global oil supply elasticity $\eta_S$, which is 0.021. Column 2 presents the IV estimates using the narrow instrument. The oil supply estimate constructed using IV is 0.054, larger than its OLS counterpart and statistically different from zero.\(^{17}\) The last column presents the IV estimates using the broad instrument. The estimated oil supply elasticity is even larger, 0.081, and remains statistically significant (with a standard error of 0.037). As shown in the table, our instrumental variables are strong instruments for oil prices, with F-statistics above 15. Importantly, if we treat the August 1990 drop in production in the U.A.E. as endogenous, using the narrow instrument, the estimate of $\eta_S$ drops to 0.029. This number is very close to the 0.026 estimate of Kilian and Murphy (2012) discussed earlier. By contrast, using the broad instrument, the estimate of $\eta_S$ is 0.056.\(^{18}\) The use of a larger set of episodes induces a larger estimate of the oil supply elasticity irrespective of the classification of the drop in oil production in the U.A.E.

The results for the oil supply elasticity are robust to the use of alternative estimation methods. For instance, using the broad instrument, the estimate of the oil supply elasticity becomes 0.133 using the mean group estimator of Pesaran and Smith (1995). In addition, to rationalize our aggregate estimate of the supply elasticity, it is instructive to look at country-specific estimates, which uncover some heterogeneity across countries, confirming the wisdom that not all oil producers respond uniformly to movements in oil prices. When we estimate the broad instrument specification allowing for different oil supply elasticities across (1) Saudi Arabia, (2) OPEC countries excluding Saudi Arabia, and (3) non-OPEC countries, we find values of 0.212, 0.191, and −0.004, respectively.\(^{19}\) These results are consistent with the observation that OPEC producers have the largest volume of spare capacity that can be used to offset disruptions in oil supply within a short period of time.

Panel (B) shows the estimates of $\eta_D$, the oil demand elasticity. The OLS estimate is −0.017. A

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\(^{17}\)The standard errors in Table 3 are double clustered by country and time using Stata’s IVREG2 command—see Baum (2010). Clustering by country addresses the concern that either the data or the elasticities might be more precisely estimated for some countries than for others. Clustering by time addresses the concern that the countries are subject to a common shock each month.

\(^{18}\)The estimate of $\eta_S$ by Kilian and Murphy (2012) has a natural interpretation as an IV regression based on two observations: one baseline observation in which changes in oil prices and changes in oil production are assumed to be zero, and another in which prices rise by 44.3 percent, and the endogenous response of global production is 1.17 percent.

\(^{19}\)The associated standard errors are 0.152, 0.086, and 0.023, respectively. As OPEC producers account for about 40 percent of global output, the “production-weighted” average of these estimates is again close to the estimated value of 0.081 for the global supply elasticity reported in Table 3.
higher elasticity in absolute value is obtained using the narrow instrument: in this case, the elasticity is $-0.031$, although it appears less precisely estimated than its oil supply counterpart, with a standard error of 0.037. Finally, using the broad instrument, the demand elasticity becomes larger in absolute value, with a point estimate of $-0.080$, and associated standard error of 0.079. The results for the oil demand elasticity obtained using the broad instrument are also robust to the use of alternative estimators. For instance, the estimate of the oil demand elasticity is $-0.055$ using the mean group estimator of Pesaran and Smith (1995).

All told, the demand estimates—albeit less precise than their supply counterparts—are consistent with the existing empirical evidence. In line with Dahl (1993) and Cooper (2003), we find that the demand elasticity of crude oil is small and around $-0.05$. Compared to these studies, our contribution is to provide an alternative identification strategy based on IV regressions. We also find that the demand elasticity of crude oil is substantially smaller than the demand elasticity of gasoline, which is typically estimated to be around $-0.3$. There are at least three reasons for this difference. First, as discussed in Hamilton (2009), crude oil represents about half the retail cost of gasoline, and thus the price elasticity of demand for crude oil should be about half that for retail gasoline. Second, data on petroleum consumption measure, among other things, refinery production and crude oil products supplied. The contracts underlying the deliveries of such products are typically negotiated at least a month in advance, and thus petroleum consumption might be less responsive to changes in prices within a given month relative to gasoline consumption. Third, similarly to the oil supply elasticity, the events of August 1990 have a large weight in shaping the estimates of the oil demand elasticity. In that month, despite a large rise in oil prices, oil consumption fell sharply in the European countries included in our dataset, but rose in Korea, Japan, Canada, and the United States.

### 4 VAR Results

In our identification strategy, we set the target supply and demand elasticities to the point estimates reported in Table 3 for the case of the broad instrument, that is, $(\eta^*_S, \eta^*_D) = (0.081, -0.080)$. We choose the estimates obtained using the broad instrument as they rely on a large set of observations, and as they hew closely to the VAR admissible set shown in Figure 2. We set the weights matrix
V in Equation (10) to be diagonal, with the entries equal to the variances associated with the point estimates of the elasticities from Table 3. The resulting elasticities are $\eta_S = 0.10$ and $\eta_D = -0.14$.

### 4.1 Impulse Responses

The solid lines in the left column of Figure 5 show the impulse responses to a one-standard deviation oil supply shock. An unanticipated disruption in oil supply reduces production by about 0.8 percent and leads to a persistent increase in oil prices, which rise by 6 percent on impact and remain elevated thereafter. On the activity side, IP in advanced economies declines gradually, bottoming out at -0.4 percent two and a half years after the shock. In contrast, IP in emerging economies rises somewhat, peaking after six months at 0.2 percent above its pre-shock level.

The increase in industrial production among emerging countries is puzzling given that our sample does not include some of the largest oil exporters, thus being, in the aggregate, oil independent. To investigate this result, we compute the response to an oil supply shock of country-specific IP for the eight largest emerging economies. The responses are indicative of a broad-based increase in industrial production, except for Mexico and India. These responses also seem to corroborate the evidence of an “Asian puzzle”: Aastveit et al. (2015) find, using a FAVAR model, that activity—measured by GDP—in many emerging Asian economies rises after a contractionary oil supply shock, even for oil-importing countries. They suggest that the “Asian puzzle” can be explained by the low consumption and high investment shares in GDP, by their high trade openness, and by the prevalence, in many countries, of price controls that attenuate the pass-through of changes in oil prices.

The right column of Figure 5 shows the responses to an oil demand shock. The shock leads to an increase in oil prices of about 6 percent and induces a rise in oil production of about 0.6 percent. The near-term response of IP in advanced and emerging economies is similar, with IP increasing mildly in both groups of economies for six months. Thereafter, real activity contracts in advanced economies while remaining elevated in emerging economies, even though the responses are quantitatively small.

Figure 6 traces out the effects of the three global activity shocks. The left and middle columns plot

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20 Monthly data on IP are not available for many OPEC countries, including Saudi Arabia, Iran, Iraq, and Nigeria.
21 The disaggregated VAR impulse responses are shown in the supplementary material.
22 Peersman and Van Robays (2012) find that oil supply shocks that temporarily increase oil prices boost activity in all emerging economies in Asia as well as in Brazil and Peru. Iacoviello (2016) finds that oil-exporting countries experience a rise in consumption and GDP following supply-driven increases in oil prices.
the responses to a shock to activity in the advanced and emerging economies, respectively, while the right column shows the responses to a metal price shock. The three shocks generate correlations that are typical of demand-driven business cycle fluctuations: The increase in real activity in advanced and emerging economies—the latter accompanied by a persistent increase in metal prices—is associated with a rise in both oil prices and oil production.

Positive shocks to activity in emerging economies and positive shocks to metal prices induce a persistent increase in oil prices. By contrast, higher activity in advanced economies induces only a mild and short-lived increase in oil prices. The positive response of IP in advanced and emerging economies to a shock to the metal price index supports the view that metal prices are a leading indicator of current and expected global activity. Additionally, our findings are also consistent with the literature that emphasizes shocks to commodity prices as drivers of business cycles in emerging economies (IMF, 2015).

4.2 Forecast Error Variance Decomposition

Table 4 shows the variation in the two-year-ahead forecast error variance in oil prices, oil production, advanced economies’ IP and emerging economies’ IP that is attributable to the five structural shocks identified by our structural VAR model. As shown in the first row of Table 4, about two-thirds of the fluctuations in oil prices are due to disturbances that originate in the oil market, with supply and demand shocks accounting for 37 and 27 percent, respectively. Movements in global demand—mostly captured by innovations in emerging economies’ IP and in metal prices—explain the remaining one-third. The second row of Table 4 shows that oil production is mostly driven by oil supply and oil demand shocks, which account for 43 percent and 36 percent of its volatility, respectively.

The third and fourth rows of Table 4 show that, on average, oil-specific shocks contribute little to the volatility in real activity. Oil supply shocks account for 8 and 5 percent of the forecast error variance of advanced economies’ and emerging economies’ IP, respectively. The contribution of oil-specific demand shocks is about 1 and 8 percent for advanced and emerging economies’ activities, respectively. Although activity variables are mostly driven by their own shocks, we find that shocks

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22 The point estimates reported in the table are computed using the OLS estimates of the reduced-form parameters. The sample used for the estimation of the reduced-form coefficients includes both actual data and the dummy observations used to implement the Minnesota prior.
to metal prices, which are ordered last in our structural VAR model, account for about 19 and 28 percent of the forecast error variance of IP in advanced and emerging economies, respectively.

4.3 Historical Decomposition

Figure 7 displays the historical decomposition of oil prices and oil production in terms of the contribution of the separate structural shocks. One takeaway is that while on average demand and supply factors both matter for the oil market, their relative importance varies across episodes. To illustrate this point, we zoom in on four important episodes involving large changes in the price of oil: the Gulf War, the Asian financial crisis, the global financial crisis, and the 2014-2015 oil price slump.24

Panel 7a reports the decomposition for the period of the Gulf War. In line with the narrative analysis, the model attributes all the drop in oil production in August 1990 and the associated increase in oil prices to an oil supply shock, caused by simultaneous drop in production in Iraq, Kuwait, and the U.A.E. Starting in September 1990, the model attributes the continued rise in oil prices both to oil supply and oil demand, in roughly equal proportions.

Panel 7b focuses on the Asian Financial Crisis. The decline in the demand of oil from emerging economies—which the model captures through shocks to emerging economies’ activity and to metal prices—induced downward pressure on oil prices, accounting for about one-third of their decline. Throughout this period, our model also attributes a nontrivial role in the decline of the price of oil to supply shocks. We rationalize this finding by noting that, despite a lower demand for oil from emerging countries, a few oil exporters, most notably Iraq, increased production.

Panel 7c shows the decomposition during the global financial crisis from July 2008 to December 2009. Initially, the model attributes much of the decline in the price of oil to negative oil-specific demand shocks, because of the simultaneous decline in oil production and the relatively small movements in measures of global activity. Global activity shocks become prominent drivers of oil prices toward the end of 2008, when IP for both advanced and emerging economies begins to rapidly decline. We also find that supply shocks over 2007-2008 (showing up as unexpected increases in global oil

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24 We compute the historical decomposition using the OLS estimates of the reduced-form parameters. The sample used for the estimation of the reduced-form coefficients includes both actual data and the dummy observations used to implement the Minnesota prior. We calculate the cumulative effects on each variable of shocks that materialized from the onset of the event onwards, setting all previous shocks to zero, which explains why the vertical bars in Figure 7 do not sum to the actual data.
production) were partly responsible for the decline in oil prices.

Finally, Panel 7d displays the estimated historical decompositions for the July 2014–December 2015 period, characterized by a major slump in the real price of oil. Our decomposition attributes most of this decline to supply shocks, likely resulting from the enduring expansion in shale oil production in Canada and the United States.

### 4.4 Accounting for the VAR Results

What are the modeling assumptions driving the main results? Table 5 compares the two-year forecast error variance decomposition of oil prices in our VAR to that of alternative models which differ for the choice of variables, sample period, and identification assumptions. The central finding is that the short-run oil supply elasticity is the key determinant for the importance of oil supply shocks in oil price fluctuations.

The top row summarizes our baseline VAR, estimated from 1985 through 2015, and identified assuming a supply elasticity of 0.10, with a resulting demand elasticity of $-0.14$. Under our baseline identification, shocks to oil supply and shocks to global demand account for 36.5 and 37 percent of the fluctuations in oil prices, respectively. By contrast, under an identification scheme in which the oil supply elasticity is restricted to be zero (row 2), the volatility of oil prices that is explained by oil supply shocks drops to 2 percent, while the contribution of global demand shocks remains as high as in the baseline. Rows 3, 4 and 5 modify the baseline VAR with a different set of variables. Row 3 shows that adding oil inventories to our VAR, as done by Kilian and Murphy (2014) and Baumeister and Hamilton (2015), does not materially change our results. Row 4 considers the role of the metal price index. Dropping metal prices from our specification enhances the contribution of oil supply shocks to fluctuations in oil prices, while reducing the contribution of global demand shocks. Row 5 replaces our activity indicators with Kilian (2009)’s indicator of real activity based on ocean freight rates ($rea$). Oil supply shocks remain important drivers of oil prices, while global demand shocks contribute to 33.5 percent of the volatility of oil prices, somewhat less than in our baseline VAR.

Rows 6 and 7 show that the selection of the elasticities in explaining the role of supply shocks in oil price fluctuations remains essential when we re-estimate our VAR both with the variables and the

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25 The supplementary material contains details as well as a number of other robustness checks.
sample period used by Kilian (2009) (see the supplementary material for details). The assumption of a zero short-run oil supply elasticity results here in a VAR-consistent demand elasticity of $-3.48$, a very large number, and implies that oil supply shocks play a negligible role in accounting for oil price fluctuations. By contrast, when we minimize the distance between the elasticities derived in our panel and those that are implied by Kilian’s VAR specification, we derive VAR-consistent elasticities of $0.18$ for supply, and of $-0.36$ for demand. These elasticities in turn imply that supply shocks account for about one quarter of the two-year volatility in oil prices.

In sum, our findings show that the selection of the elasticities is the key reason why our baseline VAR attributes an important role to oil supply shocks as drivers of oil prices.

5 Conclusion

We identify a structural VAR model of the global oil market by using external information from a large panel of countries in order to impose restrictions on the values of the short-run price elasticities of both oil supply and oil demand. In the estimating framework, global demand for oil is jointly captured by industrial production in advanced and emerging economies as well as by an index of metal prices. Shocks to oil supply and shock to global demand each account for about one-third of the fluctuations in oil prices at business cycle frequencies. An increase in oil prices driven by oil supply shocks depresses industrial production in advanced economies, while it boosts industrial production in emerging economies, thus helping explain the muted effects of changes in oil prices on global economic activity.
References


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Figure 1: Quantities and Prices in the Oil Market

Note: The figure depicts the scatter plot between the residuals from a regression of oil prices and oil production on their own lag and a constant. The solid red, black dashed, and blue dotted lines represent alternative configurations of the oil demand and the oil supply curves that are consistent with the data.
Figure 2: Oil Demand and Supply Elasticities Implied by the VAR Model: 
Baseline VAR Specification

Note: The solid line plots the relationship between the price elasticity of oil supply and oil demand implied by the 
baseline structural VAR model described in Section 2. The blue circle corresponds to the elasticities estimated in 
Section 3 ($\eta_S^* = 0.081, \eta_D^* = -0.080$). The green square corresponds to the elasticities selected by our identification 
scheme ($\eta_S = 0.10, \eta_D = -0.14$). See Section 2 for additional information.
Figure 3: **Forecast Error Variance Decomposition – Impact Horizon**

**Baseline VAR Specification**

Note: Fraction of forecast error variance in oil price (left panel) and oil production (right panel) at horizon zero explained by oil supply shocks (solid red line), oil demand shocks (dashed blue line), and the sum of oil supply and oil-specific demand shocks (dashed-dotted black line).
Figure 4: Aggregate Series of Oil Supply Shocks

NOTE: Time-series comparison between the oil shocks series in this paper based on identified shocks from the narrative analysis and Kilian’s (2008) measure of oil supply shocks. The inset panel is a scatter plot of the observations corresponding to months in which our oil supply shocks measure takes non-zero values.
Figure 5: Impulse Responses to Oil Market Shocks

Note: The solid lines in the left column depict median responses of the specified variable to a one standard-deviation oil supply shock, while those in the right column depict median responses to a one standard-deviation oil demand shock. The light shaded bands represent the 90 percent pointwise credible sets and the dark shaded bands represent the 68 percent pointwise credible sets. All variables are expressed in log changes (multiplied by 100).
Figure 6: Impulse Responses to Global Activity Shocks

Note: The solid lines in the left column depict median responses of the specified variable to a one standard-deviation shock to advanced economies’ activity; those in the middle column depict median responses to a one standard-deviation shock to emerging economies’ activity, and those in the right column depict median responses to a one standard-deviation metal price shock; The light shaded bands represent the 90 percent pointwise credible sets and the dark shaded bands represent the 68 percent pointwise credible sets. All variables are expressed in log changes (multiplied by 100).
Figure 7: Historical Decomposition

(a) The Gulf War

(b) The Asian Financial Crisis

(c) The Global Financial Crisis

(d) The 2014–15 Oil Price Slump

Note: The shaded regions in each panel depict the historical contributions of oil supply (red), oil demand (orange), advanced economies (dark blue), emerging economies (light blue), and metal price (green) shocks to the specified variable, while the solid lines depict the actual series. All variables are expressed in log changes (multiplied by 100) from the initial period of the episode.
## Table 1: Large Country-Specific Drops in Crude Oil Production

<table>
<thead>
<tr>
<th>Date</th>
<th>Country</th>
<th>Event</th>
<th>Exogenous?</th>
<th>% of Global Oil Prod.</th>
<th>% of Domestic Oil Prod.</th>
<th>Narrow Crit.[a]</th>
<th>Broad Crit.[b]</th>
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<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td>Nigeria</td>
<td>OPEC</td>
<td></td>
<td>-0.67</td>
<td>-24.15</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jan 1986</td>
<td>Nigeria</td>
<td>OPEC</td>
<td></td>
<td>-0.79</td>
<td>-27.28</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 1986</td>
<td>Norway</td>
<td>Strike</td>
<td>✓</td>
<td>-0.97</td>
<td>-62.36</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 1986</td>
<td>Qatar</td>
<td>NV A</td>
<td></td>
<td>-0.28</td>
<td>-48.46</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jul 1986</td>
<td>Egypt</td>
<td>OPEC</td>
<td></td>
<td>-0.26</td>
<td>-20.13</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 1986</td>
<td>Nigeria</td>
<td>OPEC</td>
<td></td>
<td>-0.79</td>
<td>-26.35</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 1986</td>
<td>Saudi Arabia</td>
<td>OPEC</td>
<td></td>
<td>-2.64</td>
<td>-25.09</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Oct 1986</td>
<td>Egypt</td>
<td>OPEC</td>
<td></td>
<td>-0.21</td>
<td>-12.71</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jan 1987</td>
<td>Saudi Arabia</td>
<td>OPEC</td>
<td></td>
<td>-2.06</td>
<td>-22.46</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mar 1987</td>
<td>Ecuador</td>
<td>Earthquake</td>
<td>✓</td>
<td>-0.40</td>
<td>-82.56</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 1987</td>
<td>Iran</td>
<td>War</td>
<td>✓</td>
<td>-0.97</td>
<td>-22.24</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jan 1988</td>
<td>U.A.E.</td>
<td>OPEC</td>
<td></td>
<td>-0.81</td>
<td>-28.63</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jan 1989</td>
<td>Saudi Arabia</td>
<td>OPEC</td>
<td></td>
<td>-2.82</td>
<td>-26.10</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aug 1990</td>
<td>Iraq</td>
<td>War</td>
<td>✓</td>
<td>-4.03</td>
<td>-70.59</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aug 1990</td>
<td>Kuwait</td>
<td>War</td>
<td></td>
<td>-2.90</td>
<td>-94.59</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aug 1990</td>
<td>U.A.E.</td>
<td>Geopolitics</td>
<td>✓</td>
<td>-0.66</td>
<td>-19.51</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>May 1992</td>
<td>Russia</td>
<td>Anticipated</td>
<td></td>
<td>-0.86</td>
<td>-6.32</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jun 1997</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>✓</td>
<td>-1.07</td>
<td>-54.33</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dec 2000</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>✓</td>
<td>-2.07</td>
<td>-51.87</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jun 2001</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>✓</td>
<td>-2.61</td>
<td>-61.96</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 2002</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>✓</td>
<td>-1.95</td>
<td>-51.69</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dec 2002</td>
<td>Venezuela</td>
<td>Geopolitics</td>
<td>✓</td>
<td>-2.83</td>
<td>-65.68</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 2003</td>
<td>Iraq</td>
<td>War</td>
<td>✓</td>
<td>-1.88</td>
<td>-96.14</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 2005</td>
<td>U.S.A.</td>
<td>Hurricane</td>
<td>✓</td>
<td>-1.33</td>
<td>-18.94</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 2008</td>
<td>U.S.A.</td>
<td>Hurricane</td>
<td>✓</td>
<td>-1.39</td>
<td>-20.51</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mar 2011</td>
<td>Libya</td>
<td>Civil War</td>
<td>✓</td>
<td>-1.38</td>
<td>-77.61</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Note:** The entries in the table list large drops in oil production identified by using the criteria described below.

\[a\] Narrow criterion: Domestic oil production in month $t$ drops by more than 2 percent of global oil production.

\[b\] Broad criterion: Domestic oil production in month $t$ drops by: (1) more than 0.66 percent of global oil production, and (2) more than 19.5 percent and (3) more than 4 standard deviations; OR domestic oil production relative to a 6-month moving average drops by more than 5 standard deviations.
Table 2: Exogenous Drops in Oil Production Included in the Instruments

<table>
<thead>
<tr>
<th>Date</th>
<th>Country</th>
<th>Event</th>
<th>% of global Oil Prod.</th>
<th>Narrow Instrument[a]</th>
<th>Broad Instrument[b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 1985</td>
<td>Iran</td>
<td>Iran-Iraq War</td>
<td>-1.03</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 1986</td>
<td>Norway</td>
<td>Strike</td>
<td>-0.97</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mar 1987</td>
<td>Ecuador</td>
<td>Earthquake</td>
<td>-0.40</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 1987</td>
<td>Iran</td>
<td>Iran-Iraq War</td>
<td>-0.97</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aug 1990</td>
<td>Iraq+Kuwait+U.A.E.</td>
<td>Gulf War</td>
<td>-7.59</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Oct 1995</td>
<td>Mexico</td>
<td>Hurricanes</td>
<td>-1.37</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jun 1997</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>-1.07</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dec 2000</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>-2.07</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jun 2001</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>-2.61</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 2002</td>
<td>Iraq</td>
<td>Geopolitics</td>
<td>-1.95</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dec 2002</td>
<td>Venezuela</td>
<td>Political Unrest</td>
<td>-2.83</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Apr 2003</td>
<td>Iraq</td>
<td>Iraq War</td>
<td>-1.88</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 2005</td>
<td>U.S.A.</td>
<td>Hurricane</td>
<td>-1.33</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sep 2008</td>
<td>U.S.A.</td>
<td>Hurricane</td>
<td>-1.39</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mar 2011</td>
<td>Libya</td>
<td>Civil War</td>
<td>-1.38</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Note: The entries in the table list the episodes of large drops in oil production that comprise the narrow and broad instruments. See text for additional details.

\[a\] Narrow instrument: Drops in oil production that satisfy the narrow criterion discussed in Table 1 and are classified as oil supply shocks in the narrative analysis.

\[b\] Broad instrument: Drops in oil production that satisfy the broad criterion discussed in Table 1 and are classified as oil supply shocks in the narrative analysis.
Table 3: Panel Estimates of the Price Elasticity of Crude Oil Supply and Demand

<table>
<thead>
<tr>
<th></th>
<th>1. OLS</th>
<th>2. Narrow IV</th>
<th>3. Broad IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A.) Price elasticity of crude oil supply</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_S$</td>
<td>0.021</td>
<td>0.054</td>
<td>0.081</td>
</tr>
<tr>
<td>[0.017]</td>
<td>[0.019]</td>
<td>[0.037]</td>
<td></td>
</tr>
<tr>
<td>First-stage F stat.</td>
<td>-</td>
<td>16.25</td>
<td>16.61</td>
</tr>
<tr>
<td>Total Obs.</td>
<td>7719</td>
<td>77</td>
<td>293</td>
</tr>
<tr>
<td>Countries</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Unique Episodes</td>
<td>372</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>(B.) Price elasticity of crude oil demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_D$</td>
<td>-0.017</td>
<td>-0.031</td>
<td>-0.080</td>
</tr>
<tr>
<td>[0.036]</td>
<td>[0.037]</td>
<td>[0.079]</td>
<td></td>
</tr>
<tr>
<td>First-stage F stat.</td>
<td>-</td>
<td>16.25</td>
<td>16.61</td>
</tr>
<tr>
<td>Total Obs.</td>
<td>2976</td>
<td>32</td>
<td>118</td>
</tr>
<tr>
<td>Countries</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Unique Episodes</td>
<td>372</td>
<td>4</td>
<td>15</td>
</tr>
</tbody>
</table>

Note: The dependent variables in each specification are $\Delta q_{S,i,t}$ (panel A) and $\Delta q_{D,i,t}$ (panel B), the monthly change in the production and consumption, respectively, of crude oil in country $i$. The entries in the rows of the table corresponding to $\eta_S$ and $\eta_D$ denote the estimates of the coefficients associated with the monthly change in the real price of crude oil. The second column reports OLS estimates, while columns 3 and 4 show the IV estimates using the narrow and broad instruments described in Table 2 and in the text. Standard errors—clustered by time and country—are reported in brackets. All specifications include country fixed effects. The OLS specifications include month-of-the-year dummies. The OLS and Broad IV specifications in panel B include current and lagged log changes in country $i$’s industrial production, in advanced economies’ aggregate industrial production, and in emerging economies’ aggregate industrial production.
### Table 4: Forecast Error Variance Decomposition of Selected Variables
24-Month Ahead

<table>
<thead>
<tr>
<th>Shock</th>
<th>Oil Supply</th>
<th>Oil Demand</th>
<th>AE Activity</th>
<th>EE Activity</th>
<th>Metal Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Prices</td>
<td>36.6</td>
<td>26.5</td>
<td>2.5</td>
<td>13.1</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>[24.3; 46.7]</td>
<td>[16.6; 36.2]</td>
<td>[1.7; 7.7]</td>
<td>[5.9; 22.8]</td>
<td>[9.9; 32.8]</td>
</tr>
<tr>
<td>Oil Production</td>
<td>42.6</td>
<td>36.0</td>
<td>9.8</td>
<td>4.1</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>[32.1; 49.5]</td>
<td>[25.8; 42.2]</td>
<td>[4.7; 17.5]</td>
<td>[2.8; 9.3]</td>
<td>[3.9; 15.5]</td>
</tr>
<tr>
<td>AE Activity</td>
<td>8.1</td>
<td>1.4</td>
<td>64.2</td>
<td>7.6</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td>[2.4; 18.1]</td>
<td>[0.9; 6.8]</td>
<td>[48.0; 70.9]</td>
<td>[5.1; 13.3]</td>
<td>[8.7; 29.9]</td>
</tr>
<tr>
<td>EE Activity</td>
<td>5.1</td>
<td>7.5</td>
<td>10.4</td>
<td>48.7</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>[1.5; 13.6]</td>
<td>[2.0; 16.5]</td>
<td>[7.0; 16.6]</td>
<td>[34.1; 59.0]</td>
<td>[14.9; 39.6]</td>
</tr>
</tbody>
</table>

**Note:** The entries in the table denote the posterior median estimate of the portion of the forecast error variance of a specified variable at the 24-month horizon that is attributable to five structural shocks. The 16th and 84th percentiles of the posterior distributions are reported in bracket. See subsection 4.2 for details.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Sample</th>
<th>Identification: oil price elasticities</th>
<th>Share of oil prices explained by oil supply shocks</th>
<th>Share of oil prices explained by global demand shocks[^a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>( q, p, ya, ye, m )</td>
<td>1985-2015</td>
<td>( \eta_S = 0.10, \eta_D = -0.14 )</td>
<td>36.6</td>
<td>36.9</td>
</tr>
<tr>
<td>( q, p, ya, ye, m )</td>
<td>1985-2015</td>
<td>( \eta_S = 0.00, \eta_D = -1.14 )</td>
<td>1.8</td>
<td>38.7</td>
</tr>
<tr>
<td>( q, ya, ye, m, \Delta i )</td>
<td>1985-2015</td>
<td>( \eta_S = 0.09, \eta_D = -0.13 )</td>
<td>34.2</td>
<td>38.8</td>
</tr>
<tr>
<td>( q, p, ya, ye )</td>
<td>1985-2015</td>
<td>( \eta_S = 0.10, \eta_D = -0.15 )</td>
<td>46.9</td>
<td>27.8</td>
</tr>
<tr>
<td>( q, p, rea )</td>
<td>1985-2015</td>
<td>( \eta_S = 0.10, \eta_D = -0.15 )</td>
<td>45.5</td>
<td>33.5</td>
</tr>
<tr>
<td>( \Delta q, p, rea )</td>
<td>1973-2007</td>
<td>( \eta_S = 0.00, \eta_D = -3.48 )</td>
<td>1.5</td>
<td>28.9</td>
</tr>
<tr>
<td>( \Delta q, p, rea )</td>
<td>1973-2007</td>
<td>( \eta_S = 0.18, \eta_D = -0.36 )</td>
<td>23.3</td>
<td>29.3</td>
</tr>
</tbody>
</table>

Note: The first row displays selected results from the forecast error variance decomposition for the baseline, 5-variable VAR model with an oil supply elasticity of 0.10 and an oil demand elasticity of \(-0.14\). The other rows show the variance decomposition for alternative specifications of our VAR that change the sample, the number of variables, or the identification scheme.

[^a]: For each VAR, global demand shocks combine the shocks to all activity indicators.
Appendices

A  The Data

Industrial Production. We construct a monthly index of industrial production (IP) for advanced economies and emerging economies by aggregating country-level data. We take monthly, seasonally adjusted, total IP excluding the construction industries. For countries where this series is not available, we use monthly, seasonally adjusted, manufacturing industrial production. The initial unbalanced dataset runs from 1960:M1 to 2015:M12 for advanced economies and from 1963:M1 to 2015:M12 for emerging economies. To construct the indexes, we first compute the growth rate of IP for each individual country. For both advanced and emerging economies, we then aggregate the country-specific growth rates by calculating annual weights based on gross domestic production (GDP) in current U.S. dollars from the World Bank’s Global Development Indicators. Next, we obtain the level of industrial production by cumulating the resulting monthly growth series. Both indexes are normalized to take the value of 100 in January 2007. Although the IP data potentially start in the 1960s, we set 1985 as the starting date because 1985:M1 is the earliest observation when our sample includes enough emerging economies so that they account, using today’s GDP weights, for at least 25 percent of emerging economies’ GDP.

Table A.1 lists the countries included in the advanced economies index, while Table A.2 lists the countries included in the emerging economies index. For each country we report the weight in the total index as of 2013 as well as the sample availability. For advanced economies, since 1985—the first observation we use in the estimation—data are available for all countries except Finland, Greece, and Portugal, which are countries with a small weight in the overall index. Data availability is more scattered for emerging economies. From 1985 to the mid–1990s, the emerging economies index is driven mostly by India, Korea, and Mexico. Data for Russia, the third largest country in the panel, become available in 1993, while data for China are available since 1997.

The countries in the sample account, in 2013, for 87 percent of global GDP in current dollars, with 53 percentage points and 34 percentage points of GDP accruing to advanced and emerging economies, respectively. Because of the lack of monthly IP data, the largest economies missing from the sample are Australia, Saudi Arabia, Switzerland, Nigeria, Iran, and the United Arab Emirates, which together account for about 6 percent of global GDP.

The advanced economies in the sample account for 20 percent of global oil production and 41 percent of global oil consumption—the oil production and oil consumption data in Tables A.1 and A.2 refer to 2013 and come from the BP Statistical Review of World Energy. The emerging economies in the sample account for 34 percent of global oil production and 39 percent of global oil consumption. (As a consequence, the missing countries account for 13 percent of global GDP, 46 percent of global oil production, and 20 percent of global oil consumption)

Metal Prices. Metal prices are measured from the IMF Metal Price Index, linearly log detrended and expressed in real terms dividing by the U.S. consumer price index (CPI). The metal price index (code: PMETA) is available at https://www.imf.org/external/np/res/commod/index.aspx.

Oil Market Variables. The real price of oil is the monthly average of the West Texas Intermediate, linearly log detrended and expressed in real terms dividing by the U.S. CPI index. Data on crude production and consumption are from the International Petroleum section of the Monthly Energy
Review published by the U.S. Energy Information Administration (EIA). The data are available at https://www.eia.gov/totalenergy/data/monthly/#international. In that section, Table 11.1a tabulates data on production in OPEC members, Table 11.1b tabulates data on production for non-OPEC countries and world, while Table 11.2 tabulates data for petroleum consumption in eight OECD countries. Petroleum consumption is defined as total petroleum products supplied. For the U.S., as indicated in the Glossary of the EIA’s Monthly Energy Review, petroleum products supplied—including natural gas plant liquids and crude oil burned as fuel—approximately represents consumption of petroleum products because it measures the disappearance of these products from primary sources, i.e., refineries, natural gas-processing plants, blending plants, pipelines, and bulk terminals. For each petroleum product, product supplied in any given period is computed as field production, plus refinery production, plus imports, plus unaccounted-for crude oil minus stock change, minus crude oil losses, minus refinery inputs, and minus exports.\textsuperscript{26} In turn, petroleum products include products obtained from the processing of crude oil (including lease condensate), natural gas, and other hydrocarbon compounds.

For the country-panel regressions reported in Section 3, we use oil production data from 1985m1 through 2015m12 for the following 21 countries: Algeria, Angola, Canada, China, Ecuador, Egypt, Indonesia, Iran, Iraq, Kuwait, Libya, Mexico, Nigeria, Norway, Qatar, Russia, Saudi Arabia, United Arab Emirates, United Kingdom, United States, and Venezuela. Data for Russia start in 1992m1. We exclude Gabon, a small producer, due to concerns about data quality. There are eight other missing observations in the regressions involving percent changes in oil production for the following country-month pairs: Ecuador-1987m5, Iraq-1991m3, Iraq-1991m4, Kuwait-1991m3, Kuwait-1991m4, Kuwait-1991m5, Kuwait-1991m6, Libya-2011m9. For these eight observations, the level of oil production in that country in the previous month was zero, thus implying that the percent change in oil production is not defined.

We use oil consumption data for the following eight countries: France, Germany, Italy, United Kingdom, Canada, Japan, South Korea, and the United States.

There are no data on global crude oil inventories. Hence, as standard in the literature, we proxy for global oil inventories by using data on total U.S. oil inventories scaled by the ratio of OECD petroleum stocks over U.S. petroleum stocks.

\textsuperscript{26}See https://www.eia.gov/totalenergy/data/monthly/pdf/sec14.pdf.
Table A.1: Summary Data on Advanced Economies’ Industrial Production

<table>
<thead>
<tr>
<th>Country</th>
<th>Share of Global GDP, Percent</th>
<th>Share of Global Oil Production, Percent</th>
<th>Share of Global Oil Consumption, Percent</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>6.70</td>
<td>0.00</td>
<td>4.92</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Germany</td>
<td>4.88</td>
<td>0.00</td>
<td>2.62</td>
<td>1985-2015</td>
</tr>
<tr>
<td>France</td>
<td>3.65</td>
<td>0.00</td>
<td>1.81</td>
<td>1985-2015</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3.54</td>
<td>1.00</td>
<td>1.66</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Italy</td>
<td>2.77</td>
<td>0.13</td>
<td>1.37</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Canada</td>
<td>2.40</td>
<td>4.62</td>
<td>2.59</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Spain</td>
<td>1.77</td>
<td>0.00</td>
<td>1.30</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1.13</td>
<td>0.00</td>
<td>0.98</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.75</td>
<td>0.00</td>
<td>0.33</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Norway</td>
<td>0.68</td>
<td>2.12</td>
<td>0.26</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.68</td>
<td>0.00</td>
<td>0.69</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Austria</td>
<td>0.56</td>
<td>0.00</td>
<td>0.29</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.45</td>
<td>0.21</td>
<td>0.17</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Finland</td>
<td>0.35</td>
<td>0.00</td>
<td>0.21</td>
<td>1995-2015</td>
</tr>
<tr>
<td>Greece</td>
<td>0.31</td>
<td>0.00</td>
<td>0.32</td>
<td>1995-2015</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.31</td>
<td>0.00</td>
<td>0.15</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.29</td>
<td>0.00</td>
<td>0.26</td>
<td>2005-2015</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.08</td>
<td></td>
<td></td>
<td>1985-2015</td>
</tr>
<tr>
<td>AFE total</td>
<td>52.99</td>
<td>19.70</td>
<td>40.52</td>
<td></td>
</tr>
</tbody>
</table>

Note: The entries in the table list the countries used in the calculation of the industrial production index in advanced economies. The underlying country indexes refer to total industrial production excluding construction. Data for Japan are on manufacturing industrial production.
## Table A.2: Summary Data on Emerging Economies’ Industrial Production

<table>
<thead>
<tr>
<th>Country</th>
<th>Share of Global GDP, Percent</th>
<th>Share of Global Oil Production, Percent</th>
<th>Share of Global Oil Consumption, Percent</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>12.49</td>
<td>4.87</td>
<td>11.66</td>
<td>1997-2015</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.21</td>
<td>2.44</td>
<td>3.37</td>
<td>2002-2015</td>
</tr>
<tr>
<td>Russia</td>
<td>2.90</td>
<td>12.45</td>
<td>3.42</td>
<td>1993-2015</td>
</tr>
<tr>
<td>India</td>
<td>2.41</td>
<td>1.05</td>
<td>4.05</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Korea</td>
<td>1.70</td>
<td>0.00</td>
<td>2.67</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Mexico</td>
<td>1.64</td>
<td>3.32</td>
<td>2.19</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.24</td>
<td>0.00</td>
<td>0.76</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.19</td>
<td>1.02</td>
<td>1.78</td>
<td>1993-2015</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.72</td>
<td>0.74</td>
<td>0.73</td>
<td>1994-2015</td>
</tr>
<tr>
<td>Poland</td>
<td>0.68</td>
<td>0.00</td>
<td>0.57</td>
<td>1996-2015</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.55</td>
<td>0.52</td>
<td>1.42</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.49</td>
<td>1.16</td>
<td>0.32</td>
<td>1990-2015</td>
</tr>
<tr>
<td>Venezuela</td>
<td>0.48</td>
<td>3.09</td>
<td>0.89</td>
<td>1997-2013</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.48</td>
<td>0.00</td>
<td>0.63</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.42</td>
<td>0.72</td>
<td>0.87</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.39</td>
<td>0.00</td>
<td>1.33</td>
<td>1985-2015</td>
</tr>
<tr>
<td>Israel</td>
<td>0.38</td>
<td>0.00</td>
<td>0.26</td>
<td>1990-2015</td>
</tr>
<tr>
<td>Chile</td>
<td>0.36</td>
<td>0.00</td>
<td>0.39</td>
<td>1991-2015</td>
</tr>
<tr>
<td>Philippines</td>
<td>0.35</td>
<td>0.00</td>
<td>0.35</td>
<td>1998-2015</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>0.31</td>
<td>1.99</td>
<td>0.30</td>
<td>1999-2015</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>0.27</td>
<td>0.00</td>
<td>0.20</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Peru</td>
<td>0.26</td>
<td>0.13</td>
<td>0.25</td>
<td>1990-2015</td>
</tr>
<tr>
<td>Romania</td>
<td>0.25</td>
<td>0.10</td>
<td>0.19</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.24</td>
<td>0.00</td>
<td>0.28</td>
<td>2002-2015</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.18</td>
<td>0.00</td>
<td>0.14</td>
<td>1993-2015</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>0.13</td>
<td></td>
<td></td>
<td>1998-2015</td>
</tr>
<tr>
<td>Croatia</td>
<td>0.08</td>
<td></td>
<td></td>
<td>2000-2015</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0.07</td>
<td>0.00</td>
<td>0.08</td>
<td>2000-2015</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.06</td>
<td></td>
<td></td>
<td>1998-2015</td>
</tr>
<tr>
<td>Lithuania</td>
<td>0.06</td>
<td>0.00</td>
<td>0.06</td>
<td>1995-2015</td>
</tr>
<tr>
<td>Jordan</td>
<td>0.04</td>
<td></td>
<td></td>
<td>2002-2015</td>
</tr>
<tr>
<td>Latvia</td>
<td>0.04</td>
<td></td>
<td></td>
<td>2000-2015</td>
</tr>
<tr>
<td>Estonia</td>
<td>0.03</td>
<td></td>
<td></td>
<td>2000-2015</td>
</tr>
<tr>
<td><strong>EME total</strong></td>
<td><strong>34.10</strong></td>
<td><strong>33.60</strong></td>
<td><strong>39.15</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The entries in the table list the countries used in the calculation of the industrial production index in emerging economies. The underlying country indexes refer to total industrial production excluding construction. Data for Chile, Colombia, Indonesia, Israel, Peru, Philippines, Singapore, South Africa, Thailand, and Venezuela refer to manufacturing industrial production. Data for Mexico are for total industrial production including construction.
B Alternative Specifications of the VAR

B.1 Kilian’s 3-equation VAR Model

In this section, we compare selected results under our baseline model specification to those obtained estimating the VAR model in Kilian (2009). The two major differences compared to our baseline specification of the reduced-form models are in the choice of sample—which goes from 1973 to 2007 in Kilian (2009)—and in the choice of global activity indicators: Kilian (2009) uses an indicator based on dry cargo ocean freight rates, designed to capture shifts in the demand for industrial commodities and, similarly to the metal price index, to capture expected changes in global activity.\(^{27}\)

The following equations summarize the restrictions imposed on the parameters in matrix \(A\):

\[
\Delta q_t = u_{S,t}, \quad (A.1) \\
\Delta q_t = \eta_A \text{rea}_t + \eta_D p_t + u_{D,t}, \quad (A.2) \\
\text{rea}_t = \nu Q \Delta q_t + u_{\text{REA},t}, \quad (A.3)
\]

Equation (A.1) describes the oil supply schedule, where log production enters in first differences. In Kilian (2009), the short-run price elasticity of supply is assumed to be to zero. Equation (A.2) describes the oil demand schedule: oil demand is allowed to respond contemporaneously to the real activity index, \(\text{rea}_t\). The parameter \(\eta_D\) denotes the short-run price elasticity of demand. Finally, Equation (A.3) characterizes global demand, which can respond within the period to oil production.

Table A.3: Forecast Error Variance Decomposition

<table>
<thead>
<tr>
<th>Shock</th>
<th>Oil Supply</th>
<th>Oil Demand</th>
<th>Rea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Prices</td>
<td>1.5</td>
<td>69.6</td>
<td>28.9</td>
</tr>
<tr>
<td></td>
<td>[1.4; 8.2]</td>
<td>[53.5; 81.4]</td>
<td>[15.0; 43.4]</td>
</tr>
<tr>
<td>Oil Production(^\text{a})</td>
<td>95.1</td>
<td>0.8</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>[83.1; 94.0]</td>
<td>[1.6; 6.9]</td>
<td>[3.2; 12.6]</td>
</tr>
<tr>
<td>Rea</td>
<td>1.7</td>
<td>7.9</td>
<td>90.5</td>
</tr>
<tr>
<td></td>
<td>[1.1; 9.4]</td>
<td>[4.1; 18.3]</td>
<td>[76.5; 93.1]</td>
</tr>
</tbody>
</table>

Note: The entries in the table denote the estimate of the portion of the forecast error variance of a specified variable at the 24-month horizon that is attributable to the three structural shocks in Kilian’s model. The 16th and 84th percentiles of the posterior distributions are reported in bracket.

\(^{a}\) Oil production is the cumulative sum of the change in oil production.

Table A.3 presents the 24-months ahead forecast error variance decomposition of Kilian’s model. Of note, supply shocks account for a very small fraction of the fluctuations in oil prices, while oil

\(^{27}\) Results for Kilian (2009) are based on the original database available in the supplemental material on the American Economic Review website. We convert the series of annualized changes in oil production into month-on-month changes, by dividing the original series by 12. This transformation allows us to compute monthly oil elasticities. The oil price series is based on the refiner acquisition cost of imported crude oil.
demand shocks account for about 70 percent of the volatility in oil prices.28

Figure A.1 compares the implications of our VAR for the admissible demand and supply elasticities with those entailed by the VAR model of Kilian (2009). When one uses Kilian’s variables and sample period—from 1973 through 2007—any given supply elasticity implies an admissible demand elasticity which is larger, in absolute value, than in our specification. For instance, given a supply elasticity equal to zero, the value used in Kilian (2009), our VAR estimates are consistent with a demand elasticity of about \(-1\), while Kilian’s VAR is consistent with a demand elasticity of about \(-3.5\).29

\[ \text{Oil Demand Elasticity} = -0.081, \text{Oil Supply Elasticity} = 0.080. \]

Figure A.1: Oil Demand and Supply Elasticities Implied by the VAR Model: Comparison with Kilian (2009) Model

Note: The black solid line plots the relationship between the price elasticity of oil supply and oil demand implied by the benchmark structural VAR model described in Section 2; the red dashed line plots the relationship implied by the Kilian (2009) model. The blue circle corresponds to the elasticities estimated in Section 3 \((\eta_S = 0.081, \eta_D = -0.080)\). The green squares correspond to the elasticities selected by our identification scheme applied to the two models.

Figure A.2 plots the share of the forecast error variance at horizon zero for oil prices (left panel) and for oil production (right panel) that is attributable to oil shocks, as a function of the oil supply elasticity \(\eta_S\) for the Kilian (2009) model. Setting \(\eta_S = 0\), almost all of the forecast error variance of oil prices, about 99 percent, is explained by the oil-specific demand shock. Moreover, as in our baseline model, small but positive values of the oil supply elasticity significantly alter the relative importance of oil-specific supply and demand shocks in accounting for fluctuations in the price of oil.

Overall, the key findings documented for our baseline model, namely the relationship between oil supply and demand elasticities and the importance of these elasticities to understand oil price fluctuations, are consistent with standard VARs of the oil market, and do not depend on details of the specification of the VAR model used in the paper.

28 As in the main text, the point estimates reported in the table are computed at the OLS estimates of the reduced-form parameters. For oil production, the OLS estimates are outside the 68 credible set. The median contribution to oil production of oil supply, oil demand and rea shocks are 89.8, 3.1, and 6.1, respectively.

29 This difference is by and large due to the different sample period: when Kilian’s model is estimated on data from 1985 to 2007, the relationship between elasticities is nearly identical to our baseline model.
Figure A.2: Forecast Error Variance Decomposition – Impact Horizon
Kilian (2009) Model

Note: Fraction of forecast error variance in oil price (left panel) and oil production (right panel) at horizon zero explained by oil supply shocks (solid red line), oil demand shocks (dashed blue line), and the sum of oil supply and oil-specific demand shocks (dashed-dotted black line) implied by the Kilian (2009) model.
B.2 VAR Model with Oil Inventories

Our baseline specification abstracts from inventories, by assuming that oil production is fully absorbed by consumption in every period. The total stock of oil inventories are, across countries, a small multiple of the flow of global oil production within a month, thus making it hard to conjecture that changes in inventories can dampen oil price movements caused by large gaps between production and consumption at monthly frequency. For instance, U.S. crude oil stocks are less than twice monthly U.S. crude oil production. However, inventories could in principle quickly move to absorb differences between oil production and oil consumption, in turn affecting the dynamics of the oil market. To account for this possibility, we follow Kilian and Murphy (2014) and Baumeister and Hamilton (2015) and extend our model of the oil market presented in Section 2 to include oil inventories. Define the change in inventories $\Delta I_t$ as the difference between oil production $Q_t$ and oil consumption $C_t$:

$$\Delta I_t = Q_t - C_t.$$  \tag{A.4}

Recall that our benchmark VAR includes $q_t = 100 \log(Q_t/\bar{Q}_t)$, where $\bar{Q}_t$ is the trend level of production constructed assuming a constant growth rate. Given this scaling, we can express detrended oil consumption as $c_t = q_t - \Delta i_t$, where $\Delta i_t = 100 \Delta I_t/\bar{Q}_t$. This leads—abstracting from lags—to the following structural model:

$$q_t = \eta S p_t + u_{s,t},$$ \tag{A.5}

$$q_t - \Delta i_t = \eta A y a_t + \eta E ye_t + \eta D q_t + u_{d,t},$$ \tag{A.6}

$$y a_t = \nu Q q_t + u_{ya,t},$$ \tag{A.7}

$$y e_t = \mu T q_t + \mu A y a_t + u_{ye,t},$$ \tag{A.8}

$$m_t = \psi T q_t + \psi A y a + \psi E ye_t + \psi P pt + u_{m,t},$$ \tag{A.9}

$$\Delta i_t = \phi Q q_t + \phi A y a_t + \phi E ye_t + \phi P pt + \phi M m_t + u_{i,t}.$$ \tag{A.10}

There are three differences compared to our baseline model described in Equations (5)–(9). First, the inclusion of inventories in the VAR changes the dynamics of the model and consequently the estimation of the reduced-form residuals $\varepsilon_t$. Second, inventories enter the oil demand curve described by Equation (A.6). Third, Equation (A.10) describes how inventories react to movements in oil-market and macroeconomic variables. The disturbance $u_{i,t}$ denotes inventory-demand shocks that, in concert with oil-specific demand shocks $u_{d,t}$, drive oil demand holding macroeconomic conditions unchanged. The proposed model of inventories follows closely Baumeister and Hamilton (2015), except that we do not allow for measurement error in inventories.

We find that the estimated model with inventories admits a set of demand and supply elasticities that are very similar to the baseline model. Accordingly, the estimated oil supply and demand elasticities are 0.09 and $-0.13$, respectively, and are nearly identical to those of the baseline model. Table A.4 shows the two-year-ahead forecast error variance decomposition for this model. As shown in the first two rows of Table A.4, the contribution of inventory-demand shocks to the forecast error variance of oil prices and production is small. In addition, the contribution of oil supply shocks and oil demand shocks (the sum of oil-specific demand and inventory demand shocks) to fluctuations in oil prices and oil production is similar to the baseline model. Finally, as shown in the third row of Table A.4, fluctuations in oil inventories are mostly driven by shocks to inventory demand, with a

---

In 2015, average stocks of crude oil excluding the Strategic Petroleum Reserve were 481 million barrels (Source: US Department of Energy). Average monthly crude oil production was about 285 million barrels (Source: Oil and Gas Journal).
Table A.4: Forecast Error Variance Decomposition of Selected Variables Model with Oil Inventories: 24-Month Ahead

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Prices</td>
<td>34.2</td>
<td>20.7</td>
<td>6.3</td>
<td>2.6</td>
<td>13.6</td>
<td>22.7</td>
</tr>
<tr>
<td></td>
<td>[22.3; 43.9]</td>
<td>[12.2; 29.2]</td>
<td>[3.1; 10.3]</td>
<td>[1.7; 8.0]</td>
<td>[5.8; 23.2]</td>
<td>[11.2; 34.0]</td>
</tr>
<tr>
<td>Oil Production</td>
<td>43.7</td>
<td>32.1</td>
<td>3.3</td>
<td>9.3</td>
<td>3.9</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>[32.6; 50.1]</td>
<td>[22.6; 37.5]</td>
<td>[2.4; 5.7]</td>
<td>[4.4; 17.0]</td>
<td>[2.6; 9.0]</td>
<td>[3.8; 15.8]</td>
</tr>
<tr>
<td>Oil Inventories</td>
<td>4.8</td>
<td>26.1</td>
<td>64.8</td>
<td>0.8</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>[3.7; 6.8]</td>
<td>[23.0; 27.7]</td>
<td>[58.9; 65.0]</td>
<td>[1.3; 3.1]</td>
<td>[1.2; 3.2]</td>
<td>[2.3; 5.0]</td>
</tr>
<tr>
<td>AE Activity</td>
<td>8.4</td>
<td>1.2</td>
<td>0.2</td>
<td>63.6</td>
<td>7.6</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>[2.5; 18.0]</td>
<td>[0.7; 6.0]</td>
<td>[0.2; 2.3]</td>
<td>[46.8; 70.0]</td>
<td>[5.0; 13.2]</td>
<td>[8.9; 30.3]</td>
</tr>
<tr>
<td>EE Activity</td>
<td>4.5</td>
<td>6.3</td>
<td>0.5</td>
<td>10.4</td>
<td>49.3</td>
<td>29.1</td>
</tr>
<tr>
<td></td>
<td>[1.5; 12.6]</td>
<td>[1.7; 14.0]</td>
<td>[0.2; 2.9]</td>
<td>[7.0; 16.7]</td>
<td>[34.2; 58.4]</td>
<td>[15.8; 40.1]</td>
</tr>
</tbody>
</table>

Note: The entries in the table denote the posterior median estimate of the portion of the forecast error variance of a specified variable at the 24-month horizon that is attributable to the structural shocks. The 16th and 84th percentiles of the posterior distributions are reported in brackets.

secondary role played by oil-specific demand shocks and a negligible role played by the remaining shocks.
B.3 VAR Model without Metal Prices

The following four equations describe the joint modeling of the oil–market and the global–activity blocks in a version of the VAR model estimated without metal prices, and summarize the restrictions we impose on the parameters of the corresponding matrix $A$:

\[
q_t = \eta_S p_t + u_{S,t}, \quad (A.11)
\]
\[
q_t = \eta_A y a_t + \eta_E y e_t + \eta_D p_t + u_{D,t}, \quad (A.12)
\]
\[
y a_t = \nu_Q q_t + u_{A,t}, \quad (A.13)
\]
\[
y e_t = \mu_Q q_t + \mu_A y a_t + u_{E,t}. \quad (A.14)
\]

Table A.5 reports the forecast error variance decomposition at the 2-year horizon for the model without metal prices. Removing metal prices slightly reduces the importance of global activity shocks in accounting for fluctuations in oil prices: the combined contribution of activity shocks to oil price variance drops from 37 to 28 percent, whereas the contribution of oil supply shocks in driving oil prices rises from 37 to 47 percent.

Figure A.3 compares impulse responses to oil market shocks estimated under the baseline model and under a model that excludes metal prices. The responses of all variables to the two oil market shocks are nearly identical.

<table>
<thead>
<tr>
<th>Shock</th>
<th>Oil Supply</th>
<th>Oil Demand</th>
<th>AE Activity</th>
<th>EE Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Prices</td>
<td>46.9</td>
<td>25.3</td>
<td>5.7</td>
<td>22.1</td>
</tr>
<tr>
<td></td>
<td>[33.1; 58.3]</td>
<td>[15.7; 36.0]</td>
<td>[2.8; 12.9]</td>
<td>[12.1; 32.8]</td>
</tr>
<tr>
<td>Oil Production</td>
<td>41.5</td>
<td>35.6</td>
<td>15.8</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>[32.4; 49.4]</td>
<td>[25.9; 43.5]</td>
<td>[8.7; 25.5]</td>
<td>[4.2; 13.3]</td>
</tr>
<tr>
<td>AE Activity</td>
<td>3.5</td>
<td>0.9</td>
<td>85.4</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>[1.7; 11.5]</td>
<td>[0.7; 6.6]</td>
<td>[71.6; 87.1]</td>
<td>[6.7; 16.7]</td>
</tr>
<tr>
<td>EE Activity</td>
<td>12.4</td>
<td>6.1</td>
<td>17.8</td>
<td>63.7</td>
</tr>
<tr>
<td></td>
<td>[4.3; 24.7]</td>
<td>[1.4; 15.1]</td>
<td>[11.6; 26.3]</td>
<td>[48.4; 72.2]</td>
</tr>
</tbody>
</table>

Note: The entries in the table denote the posterior median estimate of the portion of the forecast error variance of a specified variable at the 24-month horizon that is attributable to the structural shocks under the model that excludes the metal price index. The 16th and 84th percentiles of the posterior distributions are reported in bracket.
Figure A.3: Impulse Responses to Oil Market Shocks
VAR without Metal Prices

Note: The lines in the left column depict median responses of the specified variable to a one standard-deviation oil supply shock estimated under the baseline model (black solid) and under a model that excludes metal prices (red dashed), while those in the right column depict median responses to a one standard-deviation oil demand shock; The light shaded bands represent the 90 percent pointwise credible sets and the dark shaded bands represent the 68 percent pointwise credible sets from the baseline model. All variables are expressed in log changes (multiplied by 100).
B.4 VAR Model with Non-detrended Variables

In our baseline specification we linearly detrend the variables prior to estimation. We estimate a variant of the model that includes all variables in log levels without detrending.

Table A.6 reports the forecast error variance decomposition at a 2-year horizon. The key finding of our paper, namely that oil supply shocks are an important driver of oil price fluctuations, is unchanged under this model specification. The importance of oil market shocks to account for variations in IP, already small in the baseline model, becomes slightly smaller.

Figure A.4 reports impulse responses to the oil supply and the oil demand shock. When the data are not detrended, the impulse responses—most notably those for oil production—are more persistent, and in some cases do not revert to the baseline after the initial impulse. However, nearly all median responses estimated under the non-stationary VAR are within the 90 percent credible sets of the baseline VAR model. The one-year response of emerging economies IP to an oil demand shock is smaller than in the baseline but, already in the baseline model, the importance of oil demand shocks for real activity is very limited.

Table A.6: Forecast Error Variance Decomposition of Selected Variables
24-Month Ahead – Non-Detrended Variables

<table>
<thead>
<tr>
<th>Shock</th>
<th>Oil Supply</th>
<th>Oil Demand</th>
<th>AE Activity</th>
<th>EE Activity</th>
<th>Metal Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Prices</td>
<td>41.7</td>
<td>28.9</td>
<td>3.2</td>
<td>10.5</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>[29.6; 50.8]</td>
<td>[19.7; 36.3]</td>
<td>[2.3; 9.0]</td>
<td>[4.9; 17.1]</td>
<td>[7.2; 27.0]</td>
</tr>
<tr>
<td>Oil Production</td>
<td>47.2</td>
<td>39.7</td>
<td>5.5</td>
<td>6.2</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>[31.5; 58.7]</td>
<td>[25.7; 50.7]</td>
<td>[1.9; 13.3]</td>
<td>[2.2; 12.1]</td>
<td>[1.4; 6.7]</td>
</tr>
<tr>
<td>AE Activity</td>
<td>5.5</td>
<td>1.6</td>
<td>69.6</td>
<td>7.8</td>
<td>15.6</td>
</tr>
<tr>
<td></td>
<td>[1.2; 13.7]</td>
<td>[1.1; 5.8]</td>
<td>[53.6; 77.9]</td>
<td>[3.4; 13.8]</td>
<td>[6.8; 26.9]</td>
</tr>
<tr>
<td>EE Activity</td>
<td>2.9</td>
<td>0.9</td>
<td>11.9</td>
<td>73.5</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>[0.9; 10.0]</td>
<td>[0.7; 5.0]</td>
<td>[7.2; 19.7]</td>
<td>[57.9; 77.8]</td>
<td>[4.01; 20.8]</td>
</tr>
</tbody>
</table>

Note: The entries in the table denote the posterior median estimate of the portion of the forecast error variance of a specified variable at the 24-month horizon that is attributable to five structural shocks under the model estimated using data that have not been linearly detrended. The 16th and 84th percentiles of the posterior distributions are reported in bracket.
Figure A.4: Impulse Responses to Oil Market Shocks: Results with Non-Detrended Variables

Note: The lines in the left column depict median responses of the specified variable to a one standard-deviation oil supply shock estimated under the baseline model (black solid) and under a model where all variables enter in log-levels and not linearly detrended (red dashed), while those in the right column depict median responses to a one standard-deviation oil demand shock; The light shaded bands represent the 90 percent pointwise credible sets and the dark shaded bands represent the 68 percent pointwise credible sets from the baseline model. All variables are expressed in log changes (multiplied by 100).
C Revisiting the “Oil Exogenous” Assumption

Stock and Watson (2016) distinguish between two research waves in the VAR literature on oil. The first research wave adopts the “oil price exogenous” approach. This approach, initially used to study the 1970s oil shocks, assumes that oil prices are predetermined, and interprets innovations in prices as the outcome of oil supply shocks. In the context of a structural VAR, this approach orders oil prices first in a Cholesky decomposition, and finds that oil supply shocks are important drivers of oil prices. Examples of papers adopting this approach are Shapiro and Watson (1988), Rotemberg and Woodford (1996), and Blanchard and Galí (2010). Blanchard and Galí (2010) identify an oil shock that explains about 80 percent of oil prices, and interpret the shock as being mostly driven by oil supply factors.

The second research wave, influentially promoted by Kilian (2009), assumes that the short-run oil supply elasticity is zero—“inelastic production” approach. Additionally, and unlike the “oil exogenous” approach, this line of research explicitly allows for oil prices to contemporaneously respond to movements in oil production and in global demand. In the context of a structural VAR, this approach orders oil production first—and oil prices last—in a Cholesky decomposition, and finds that oil-specific demand shocks are important drivers of oil prices.

Figure A.5 compares the impulse responses to the key drivers of oil prices in the two approaches, using the five-variable VAR described in Section 2: the oil price shock in the “oil price exogenous” approach, and the oil-specific demand shock in the “inelastic production” approach. The upshot of this comparison is that the two shocks induce near-identical responses in oil prices, oil production, and global activity variables.

Key to understanding this result is the observation that the identified oil price shocks in the “oil price exogenous” approach are similar to the identified oil-specific demand shock in the “inelastic production” approach. Hence, the two structural equations used to recover these shocks are also similar.

Why? The “inelastic” production approach allows prices to contemporaneously respond to movements in other variables. However, this response is estimated to be small, owing to the low correlation between oil prices and other variables and to the zero restrictions imposed by the VAR. Hence, prices are mostly driven by their own shocks, even in the inelastic production approach. The main difference is obviously one of interpretation: the “oil price exogenous” approach views these shocks as deriving from shifts in supply. The “inelastic production” approach views these shocks as deriving from shifts in demand.

The structural VAR implied by our identification strategy falls between these two polar cases: by allowing for sufficiently upward-sloping supply curves and for sufficiently downward-sloping demand curves, we find that both oil supply shocks and oil-specific demand shocks jointly affect oil prices and production.

31 For the “oil price exogenous” approach, we identify the oil price shock by ordering oil prices first in a Cholesky decomposition. For the “inelastic production” approach, we set \( \eta_S = 0 \) in equation (5).

32 To see why prices respond contemporaneously to other variables, one can use equation (6) and invert it to express it as an inverse demand function.
Figure A.5: Impulse Responses to Oil Demand and to Exogenous Oil Price Shocks

**Note:** The solid lines depict median responses of the specified variable to a one standard-deviation oil shock identified by ordering oil prices first in a Cholesky decomposition; the red-dashed lines depict median responses to a one standard-deviation oil demand shock identified by imposing $\eta_S = 0$; The light shaded bands represent the 90 percent pointwise credible sets and the dark shaded bands represent the 68 percent pointwise credible sets. All variables are expressed in log changes (multiplied by 100).
D Impulse Responses of the Largest Emerging Economies to an Oil Supply Shock

We compute the impulse response to an oil supply shock of country-specific IP for the eight largest emerging economies included in our emerging economies IP index, by adding the country-specific IP indexes to our baseline VAR one at a time. The responses are indicative of a broad-based increase in industrial production following a negative oil supply shock, with the only exceptions of Mexico and India.

Figure A.6: COUNTRY-SPECIFIC IMPULSE RESPONSES TO THE OIL SUPPLY SHOCK

Note: All variables are expressed in log changes (multiplied by 100).
E Narrative Analysis of Large Drops in Oil Production

This appendix provides a narrative analysis of the episodes characterized by large drops in oil production as listed in Tables 1 and 2. These episodes are identified using the criteria described in the main body of the paper and reported in the notes of the tables. We use this narrative analysis to classify the episodes as either endogenous or exogenous.

The structure of the sections relative to each episode is as follows. We start by reporting the corresponding change in domestic crude production. Data on crude production is from the International Petroleum section of the Monthly Energy Review published by the U.S. Energy Information Administration (EIA).33 We express the levels of and the changes in domestic production either in million barrels per day (mbd) or in thousand barrels per day (kbd), as appropriate. Next, we report the nature of the events as classified in the fourth column of Table 1 and we add a brief description of the episode. We then provide a lengthier description of each episode to justify the corresponding classification.

As backbones of our narrative description we use two sources. For the episodes from 1991 onward, we rely on information from the Oil Market Report (OMR) of the International Energy Agency (IEA).34 To complement the information from the Oil Market Report, we also use the Oil Daily published by the Energy Intelligence Group. For the episodes prior to 1991, we rely exclusively on the Oil Daily.35 Finally, at the end of each section we report the list of the publications that we used to characterize the related episode.

January 1985 Iran

Change in production: -558 kbd (-22.32% of domestic production, from 2.500 mbd in December 1984 to 1.942 mbd in January 1985)

Nature of the event:

**Exogenous**: War.

Narrative description:

At the beginning of 1985, Iranian oil production fell by more than 500 kbd to about 1.9 mbd, significantly below Iran’s agreed OPEC output quota of 2.3 mbd. The fall occurred amid intensified attacks by Iraqi warplanes on oil tankers entering an Iraqi-imposed war zone, barred to shipping, to load crude at Iran’s main oil terminal on Kharg Island in the northeast Persian Gulf. Iraq and Iran had been at war since September 1980. The aim of the attacks was to cripple Iranian oil exports by continuing the blockade of Kharg Island and other Iranian ports with the goal of inducing Iran to cease the war with Iraq. Attacks by Iraqi jets had already resumed in early December 1984, breaking a long period of quiet that had lasted since mid-October 1984, and became more frequent during January 1985. Because of the frequent Iraqi raids on tankers loading at its ports, Iran’s output and exports came to be erratic, as it became difficult to charter vessels to Iran’s oil terminals.


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33 The data are available at https://www.eia.gov/totalenergy/data/monthly/#international. In that section, Table 11.1a is for OPEC members, while Table 11.1b is for non-OPEC countries.

34 Electronic copies of the Oil Market Report are available only starting in 1990 at https://www.iea.org/oilmarketreport/reports/.

35 Microfilms of the various issues of the Oil Daily from 1985 to 1999 were obtained from the Research Library of the Federal Reserve Bank of Dallas.
May 1985 Saudi Arabia

Change in production:

-880 kbd (-25.36% of domestic production, from 3.470 mbd in April 1985 to 2.590 mbd in May 1985)

Nature of the event:

**Endogenous**: Support OPEC prices amid price and quota violations by other cartel members.

Narrative description:

The drop in Saudi Arabia’s output in May 1985 appears to have been driven by its willingness to keep overall OPEC output below the established ceiling amid widespread violations of the agreed quotas and the resulting production increases by several other member countries. For the first five months of 1985, Saudi output averaged only about 3.5 mbd. Saudi Arabia’s quota under the OPEC agreement prevailing at that time was a little less than 4.4 mbd, compared to its peak production four years earlier of about 10 mbd. The Oil Daily reported that the production cut to as little as 2.6 mbd in May may have resulted from Saudi efforts to support the market in the face of unofficial price cutting and breaches of quotas by other OPEC members. The Oil Daily further speculated that these numbers as well as OPEC’s own estimates might have been used as evidence at the OPEC ministerial conference on June 30 in case the Saudis, as expected, had tried to curb widespread price-cutting and overproduction by other members. As also reported by the IEA in its May 1985 Oil Market Report, Saudi Arabia was willing to curb its own production in an effort to keep total OPEC output below its overall ceiling of 16 mbd. During a meeting of the OPEC ministerial executive council in early June 1985, a message from King Fahd of Saudi Arabia was delivered, saying that his country would no longer bear the burden of absorbing other members’ overproduction.

Sources: Oil Daily, June 5 and June 10, 1985.

June 1985 Nigeria

Change in production:

-356 kbd (-24.15% of domestic production, from 1.474 mbd in May 1985 to 1.118 mbd in June 1985)

Nature of the event:

**Endogenous**: Bringing output in line with OPEC price and quota structure to support prices.

Narrative description:

In July, industry sources in the U.S. said that Nigeria’s crude oil production was seen to be near 1.1 mbd, the same level as in June. This level marked a significant cutback in production from the 1.626 mbd output in April and a continuation of the decline which was noted when May production was cut back to 1.474 mbd. The Oil Daily reported that Nigeria was worried about the outcome of the July 22 OPEC meeting and was doing its part. In addition, in the lead-up prior to OPEC meetings, Nigerian production had been frequently cut back as a mark of solidarity. During 1985:Q1, estimates of Nigerian oil production ranged as high as 1.7 mbd, but sales began to fall after official prices were raised in February to bring Nigeria into line with a revised OPEC price structure.

Sources: Oil Daily, July 19 and August 12, 1985.

January 1986 Nigeria

Change in production:
-449 kbd (-27.29% of domestic production, from 1.646 mbd in December 1985 to 1.197 mbd in January 1986)

Nature of the event:

**Endogenous:** Drop in output along with those of other OPEC producers to shore up prices.

Narrative description:

In March 1986, the Oil Daily reported that combined crude output from OPEC countries declined from almost 18 mbd in November and December 1985 to around 17 mbd in January 1986 and to slightly lower levels in February. Over the first two months of 1986, crude output levels in Iran, Iraq, Libya, and Nigeria were below those seen in 1985:Q4 levels.

Sources: Oil Daily, March 10, 1986.

**April 1986 Norway**

Change in production: -537 kbd (-62.37% of domestic production, from 861 kbd in March 1986 to 324 kbd in April 1986)

Nature of the event:

**Exogenous:** Strike of offshore catering workers followed by employers’ lockout of production workers

Narrative description:

In early April 1986, negotiations broke off between Norway’s Catering Employees Association (CAF) union representing offshore caterers working on North Sea’s oil fields and employers representatives. Members of the CAF union voted for strike action when employers rejected their demand for a 28 percent wage increase that would have granted them parity with other oil production workers, with the union representing production workers saying that they favored wage harmonization. On April 6, about 670 offshore catering workers went on strike. Employers retaliated immediately by locking out about 3,000 North Sea production workers of all affiliated offshore unions, thus leading to the shut down of Norway’s 900 kbd crude oil production. A few days after the start of the dispute, Norwegian state oil company, Statoil, said it had warned its customers that deliveries might have been suspended, and that a force majeure contract clause on crude shipments might have been declared. On April 25, 1986, offshore caterers called off their strike, after Norway’s government asked Parliament to enact legislation to make arbitration between the two sides compulsory, thus banning the strike. Labor Minister Arne Rettedal, told the press that the dispute could not be allowed to continue, on concerns that it was threatening safety on the North Sea’s fields. With production workers returning to the platforms on the Statfjord field during the weekend of April 26-27, more than two-thirds of Norwegian production were back on stream by April 29.

Sources: Oil Daily, April 3, April 7, April 8, April 9, April 10, April 15, April 18, April 21, April 23, April 24, April 25, and April 28, 1986.

**April 1986 Qatar**

Change in production:

-157 kbd (-48.46% of domestic production, from 324 kbd in March 1986 to 167 kbd in April 1986)

Nature of the event:

**Likely Endogenous:** No information available

Narrative description:
We found no material that could help explain the observed production decrease. Since Qatar is an OPEC member, we classified this event as being likely endogenous.

**July 1986 Egypt**

Change in production:

-150 kbd (-20.13% of domestic production, from 745 kbd in June 1986 to 595 kbd in July 1986)

Nature of the event:

**Endogenous**: Transitory alignment with OPEC’s intention to reduce output and support prices.

Narrative description:

Even though we could not find information directly explaining the production drop for Egypt in July 1986, several articles form the Oil Daily suggest that it might have been related to its willingness to go along with OPEC’s strategy to curb production and prop up sagging global oil prices. To achieve this goal, Saudi Arabian oil minister Sheik Ahmed Zaki Yamani led for several months an OPEC’s campaign to enlist other non-OPEC producers to cooperate in controlling output and stabilizing prices, warning that prices could collapse further if non-OPEC producers did not cooperate. As early as February 1986, the Oil Daily reported that Egypt, an important non-OPEC producer, had said it was willing to cut its production temporarily by 100 to 150 kbd. During the same month, the Egyptian oil minister Abdel-Hadi Kandil and his Mexican and Venezuelan counterparts held talks in Cairo about shoring up prices and agreed on several proposals to stabilize the oil market planning to present these to other OPEC and non-OPEC producers. In March, the Vice Chairman of Egyptian General Petroleum Corporation, Hammad Ayoub, said that Egypt was willing to attend any meeting of oil producing countries that might help stabilize the oil market. Subsequently, Egypt was one of the non-member countries that participated in a joint meeting in Geneva of OPEC and non-OPEC producers that followed OPEC’s own ministerial conference with the aim of negotiating on output levels that could support prices. At that meeting, Egypt was one of the non-OPEC producers who expressed the willingness to cooperate in reducing production and to help stabilize prices. Despite OPEC’s failure to reach an agreement, in early April Egyptian oil minister Kandil said that “the possibility of cooperation is still there if all are sincere” and that OPEC had to show other producers its good intentions and double its efforts to fix prices at $20 a barrel. Ahead of the ministerial OPEC conference to be held at the end of June 1986 in the island of Brioni in Yugoslavia, it was reported that Egypt was one of the non-OPEC producers which expressed the willingness to consider cooperation with OPEC to cut production. At that meeting, ten of OPEC’s 13 members, including Saudi Arabia, reached an agreement to restrain production, with the agreement—described by Iraqi oil minister Qassem Ahmed Taqi as a “gentlemen’s agreement”—covering a four-week period until the ministers’ next meeting at the end of July 1986 in Geneva. Some members pointed to discussions held with non-OPEC producers such as Mexico, Egypt, and Norway as signs that cooperation with these competitors was becoming a real possibility. In light of this information, it is presumable that Egypt reduced its output to follow through with the strategy implied by the “gentlemen’s agreement.” However, while some OPEC and non-OPEC producers began to hold the line on production in July, Saudi Arabia’s crude production continued to swell, rising from about 5.1 mbd in June to 5.7 mbd in July, well above its OPEC quota at that time of 4.353 mbd. Thus, the failure of Saudi Arabia to fall in line with the “gentlemen’s agreement” might help explain why Egypt raised back its production in August 1986.

Sources: February 3, February 6, February 10, February 11, February 26, February 28, March 4, March 11, March 12, March 14, March 18, March 21, April 2, May 20, May 28, June 20, June 25, July 1, July 2, July 17, July 31, August 7, August 12, 1986.
**September 1986 Saudi Arabia**

Change in production:
-1.558 mbd (-25.09% of domestic production, from 6.209 mbd in August 1986 to 4.651 mbd in September 1986)

Nature of the event:
- **Endogenous**: Bringing output in line with OPEC quota to boost prices.

Narrative description:

In early August 1986, at the end of its ministerial meeting in Geneva, OPEC announced to have reached a surprise agreement, originally proposed by Iran, according to which 11 of its 13 member countries—excluding Iraq and Ecuador—would have returned to their former output quotas established in October 1984 in a bid to achieve the targeted production cutback and force up sagging prices. In December 1985, in an attempt to recapture its “fair share” of the global oil market from outside producers, OPEC had abandoned production and price controls. As a result, from late 1985 until the summer of 1986, oil prices had plummeted from an average of $28 to about $10 a barrel. The new plan, which was supposed to come into effect at the beginning of September 1986 and last for at least two months, was aimed at curbing OPEC’s production by nearly 4 mbd, from approximately 20 mbd back to an estimated 16.7 mbd. A report by the semi-official U.A.E. newspaper Al-Ittihad on August 4 claimed that Saudi Arabian oil minister Sheikh Ahmed Zaki Yamani had already obtained his government’s approval to support the return to production levels similar to those accepted in October 1984. Subsequently, the Oil Daily reported that in mid-September Yamani told Norwegian oil minister Arne Oeien that oil output in the first week of September 1986 was 3.7 mbd, and also that, according to Gulf oil industry sources, Saudi Arabia’s production may have been lower than its OPEC quota of 4.353 mbd during the second week of September. Finally, the Oil Daily stated that OPEC’s crude oil output averaged about 16.5 mbd in mid-September 1986, thus under the 16.8 mbd production ceiling agreed to by the group, and 4 mbd lower than the average 20.5 mbd produced in August, with the steepest cutbacks coming from Saudi Arabia and Iran.

Sources: Oil Daily, August 5, August 12, September 23, September 25, 1986.

**September 1986 Nigeria**

Change in production:
-464 kbd (-26.35% of domestic production, from 1.761 mbd in August 1986 to 1.297 mbd in September 1986)

Nature of the event:
- **Endogenous**: Bringing output in line with OPEC quota to boost prices.

Narrative description:

The drop in crude output during September 1986 reflected Nigeria’s attempt to keep production within the limit of its quota. During August 1986, the Oil Daily reported that Nigeria would make a 25 percent cut in oil production beginning September 1, as revealed by the Nigerian National Petroleum Company. Cuts of this magnitude were deemed necessary to bring Nigeria into line with its OPEC quota of 1.3 mbd, as the country had been producing about 1.7 mbd. The cut in production by Nigeria was among the news from OPEC that its members were taking the individual steps required to reduce its output down by about 4 mbd beginning September 1, when a temporary accord reached in early August in Geneva would have come into force. The information received came
after Nigeria’s oil minister and OPEC conference President was reported by Nigerian state television as saying that Nigeria would reduce its production from September 1.

Sources: Oil Daily, August 14, 1986.

**October 1986 Egypt**

Change in production:

-115 kbd (-12.7% of domestic production, from 905 kbd in September 1986 to 790 kbd in October 1986)

Nature of the event:

**Endogenous**: Cooperation with OPEC’s agreement to bring output in line with quota system to boost prices.

Narrative description:

We could not find information directly addressing the production drop that occurred in October 1986. A couple of articles published in the Oil Daily during the summer of 1986 indicate that the drop might have been related to Egypt’s willingness to cooperate with OPEC and curb production in an effort to boost prices. As early as the end of July 1986, the Oil Daily reported OPEC President Rilwanu Lukman saying—amid the negotiations at OPEC’s Geneva meeting initially aimed at achieving voluntary production cutbacks—that all but one non-OPEC producers had agreed to cooperate with the cartel’s efforts to shore up sagging prices. Subsequently, in early August 1986 OPEC oil ministers, after agreeing to curb production, turned their attention to similar cutbacks by non-OPEC producers. The Oil Daily cited reports indicating that five non-OPEC nations had pledged output cuts totaling 500 to 700 kbd as part of OPEC’s efforts to achieve market stability, with Egypt identified among these non-OPEC producers.

Sources: Oil Daily, July 31, August 6, 1986.

**January 1987 Saudi Arabia**

Change in production:

-1.160 mbd (-22.46% of domestic production, from 5.164 mbd in December 1986 to 4.004 mbd in January 1987)

Nature of the event:

**Endogenous**: Shift in strategic emphasis by Saudi Arabia from targeting market share to targeting higher prices.

Narrative description:

The January 1987 output drop reflected a shift in Saudi Arabia’s strategy from keeping production at elevated levels and targeting market share to restraining production and achieving higher prices. The shift began with the ousting at the end of October 1986 of Saudi Arabia’s oil minister Sheikh Zaki Ahmed Yamani, who had been advocating the market share strategy, and culminated with the OPEC’s pact to cut output and return to fixed prices, which was reached at the December 1986 meeting in Geneva and which had the key backing of Saudi Arabia. Saudi Arabia shifted its policy stance after less than a year of increased production that pushed prices down to as low as $9 a barrel in July 1986. After the ousting of Yamani, acting Saudi Arabian oil minister Hisham Nazer led an emergency meeting of key OPEC ministers in Quito in mid-November 1986 to discuss boosting crude prices. The December agreement, reached after 10 days of disputing, called for an across-the-board
cut of more than 7 percent in OPEC production for the first half of 1987, thus implying an output reduction of more than 1 mbd, from the temporary output ceiling of 17.0 mbd expiring at the end of 1986 to 15.8 mbd. The agreement also contemplated the return to a fixed price structure fully effective February 1, based on a target average of $18 a barrel. In mid-January 1987, the Oil Daily reported that Saudi Arabia had been pumping an average of about 3.6 mbd during the first half of the same month, significantly below its quota allocated under the OPEC’s agreement.


March 1987 Ecuador

Change in production:

-218 kbd (-82.58% of domestic production, from 264 kbd in February 1987 to 46 kbd in March 1987)

Nature of the event:

Exogenous: Earthquakes disrupted oil production and transportation equipment.

Narrative description:

On March 5, 1987, two devastating earthquakes in northeastern Ecuador crippled its oil industry, causing damage to pumping and crude transport installations and leading to a halt in crude output. The earthquakes resulted in severe damage to the Trans-Ecuadorian pipeline, the country’s main crude transportation facility, carrying crude oil from the jungle oilfields in the northeast to the Balao marine terminal near Esmeraldas on the Pacific coast. Most of the disruption occurred where the pipeline route follows the banks of the Coca river, in the proximity of the Reventador Volcano, near the epicenter of the quake, which Ecuadorian seismologists said registered six on the 12-point international Mercalli scale. Along this section, about 24 miles of pipeline were destroyed and had to be reconstructed. One pumping station on the pipeline at El Salado, near the confluence of the Salado and Coca rivers, was badly damaged by a landslide triggered by the earthquakes. An 180-meter section of the pipeline attached to a highway bridge over the Aguarico river—also close to the volcano—collapsed. Ecuador’s three refineries continued functioning, but had no access to crude supplies because of the ruptured pipeline. The state oil firm Corporacion Estatal Petrolera Ecuatoriana (CEPE) notified foreign customers that it was declaring force majeure on its crude exports due to the tremor. The earthquakes led to suspension of crude exports for five months, the period required for the completion of repairs to the pipeline and pumping stations.


September 1987 Iran

Change in production:

-569 kbd (-22.24% of domestic production, from 2.558 mbd in August 1987 to 1.989 mbd in September 1987)

Nature of the event:

Exogenous: Iraq air strikes damaged oil installations.

Narrative description:

The fall in Iranian output during September 1987 to just a little less than 2 mbd and below its quota of 2.369 mbd reflected the disruptions caused by Iraqi attacks on Iran’s oil tankers and
installations. At the end of August 1987, Iraqi warplanes hit four Iran oil tankers in the Persian Gulf, attacked Iran’s Raksh offshore oil field, and raided oil and industrial plants in Iranian territory. The attack ended a break of more than six weeks in Iraqi air strikes on Iranian oil installations.

Sources: Oil Daily, September 1, September 17, October 6, and November 4, 1987.

January 1988 U.A.E.

Change in production:

-471 kbd (-28.63% of domestic production, from 1.645 mbd in December 1987 to 1.174 mbd in January 1988)

Nature of the event:

**Endogenous**: Compliance with OPEC’s resolve to curb overproduction that glutted the market and weakened oil prices.

Narrative description:

The drop in U.A.E. output at the beginning of 1988 reflected its compliance with OPEC’s resolve to curb the quota violations and the resulting excess production that glutted the oil market since the summer of 1987, leading to a steep fall in prices. Between July and November 1987, OPEC as a whole produced, on average, more than 19 mbd, while the established output ceiling set in June for the second half of 1987 was 16.6 mbd. The U.A.E. was among the member countries that were violating their quotas. Over the same period, it produced, on average, about 1.85 mbd, nearly twice as much as its assigned national quota of 948 kbd. In mid-December 1987, after several days of negotiations in Vienna, OPEC ministers decided to extend into the first half of 1988 the same terms of the price and quota system prevailing for the second half of 1987. The agreement was signed by 12 of the 13 member countries, with the exclusion of Iraq which was given no quota. It stipulated that the production levels of all member countries would have been 15.06 mbd during the first half of 1988, distributed into national production levels in the same manner as laid out in the previous agreement, with the exception of Iraq, whose earlier quota was 1.54 mbd. Since the conclusion of the OPEC meeting, the U.A.E. announced output cuts effective January 1, 1988. In early January 1988, the Oil Daily cited oil industry sources reporting that Abu Dhabi, the largest producer in the U.A.E., had decided to cut output and had hence ordered operating companies to reduce production by about 400 kbd.


January 1989 Saudi Arabia

Change in production:

-1.737 kbd (-26.10% of domestic production, from 6.655 mbd in December 1988 to 4.918 mbd in January 1989)

Nature of the event:

**Endogenous**: Bringing output in line with renewed OPEC quota structure to boost prices.

Narrative description:

The reduction in Saudi Arabia’s output during January 1989 reflected its attempt to bring production in line with a new OPEC agreement signed in late November 1988 in Vienna and aimed at boosting prices. At that meeting, OPEC’ 13 members agreed to set overall production at 18.5 mbd,
effective January 1 and valid for the first half of 1989, with the new output ceiling 4 mbd lower than the total 22.5 mbd produced on average during October and November 1988. Under the new agreement, Saudi Arabia’s output quota was temporarily set at 4.524 mbd, 2 mbd below the Kingdom’s production in November 1988, but a bit higher than the previously assigned quota of 4.353 mbd. During the second half of December 1988, the Oil Daily cited a report that Saudi Arabia had cut its commitment to a major Japanese buyer for January 1989 by 40 percent. This development was interpreted as indicating that the OPEC member country was seriously attempting to cut back production based on the new agreement.

Sources: Oil Daily, November 29, November 30, December 5, December 6, December 7, December 22, 1988, January 11, January 18, 1989.

August 1990 U.A.E.

Change in production:

-399.5 kbd (-19.51% of domestic production, from 2.047 mbd in July 1990 to 1.648 mbd in August 1990)

Nature of the event:

Exogenous: Strong political pressure on U.A.E. to cut production.

Narrative description:

The decrease in U.A.E. production registered during August 1990 appeared to be driven by the return of the oil-producing country within the OPEC quota system. At a November 1989 meeting, OPEC agreed on an output ceiling of 22.1 mbd. The U.A.E. was effectively excluded from the agreement after it refused to recognize its allocated quota of about 1.1 mbd. Since then, U.A.E. output had averaged about 2 mbd, a major factor in the ongoing OPEC overproduction which had led to a sharp drop in global oil prices. The decision by the U.A.E to limit their crude oil output starting in August 1990 followed on the heels of an unprecedented high-profile barrage of strong political intimidation conducted by Iraqi President Saddam Hussein and his top officials as well as diplomatic campaigns with relatively softer tones pursued by other OPEC members such as Iran and Saudi Arabia.

These initiatives were aimed at coercing the U.A.E., along with Kuwait—the other member country targeted as quota-buster—to get in line with OPEC quota compliance and thus adopt production policies that would secure considerably higher oil prices. Around mid-June 1990, Iran’s oil minister, Gholamreza Aqazadeh, criticized both the U.A.E. and Kuwait for exceeding their OPEC quotas, while a statement by Saudi Arabia’s King Fahd called again for other OPEC members to adhere to the May 2 agreement cutting back OPEC production. During the second half of the same month, Iraqi oil minister Issaam al-Chalabi delivered a blistering attack on U.A.E. overproduction, blaming the Gulf country for being the only member still violating the May 2 emergency OPEC accord. A few days later, he blasted the U.A.E and Kuwait for quota-busting and reserved special scorn for the U.A.E. saying that the Emirates had rejected OPEC offers for quota parity with Kuwait at 1.5 mbd by asking for even more than Kuwait’s quota.

According to the Oil Daily, Chalabi’s two strong statements were taken to reflect President Saddam Hussein’s increasing exasperation with Iraqi revenue downturns caused by OPEC overproduction. In particular, his use of the term “intentional harm” brought to mind the report that, at the Baghdad summit the previous month, Saddam Hussein was said to have mentioned that at least one Arab Gulf state was waging economic warfare against the interests of Iraq. At around the same time, Iraqi Deputy Prime Minister Saadoun Hammadi, responsible for economic affairs, paid a visit
to U.A.E.’s President Sheikh Zaid al-Nuhayan, delivering a message from President Saddam Hussein that explained the problems that Iraq faced with overproduction driving oil prices down. After the meeting, Hammadi said that Sheikh Zaid had shown “understanding of Iraq’s position.”

On the initiative of the government of Saudi Arabia, the oil ministers of the U.A.E., Qatar, Kuwait, Iraq, and Saudi Arabia met in Jeddah on July 10 and 11 for discussions about the situation in the oil markets and the deterioration in oil prices that had been harming the interests of member countries. The ministers agreed that priority should have been given to restoring health to oil prices and that it was to be achieved through strict, practical, and immediate commitment by all OPEC members to the production ceiling set out in the November 1989 accord, which was to be maintained until prices had risen to an acceptable level. At that high-level meeting, the U.A.E looked set to rejoin the OPEC quota fold, and the U.A.E. President Sheik Zayed bin Sultan al-Nahyan pledged to cut their overproduction to 1.5 mbd as part of efforts by OPEC to stabilize global oil prices. On July 13, the Oil Daily noted how reports that Sheikh Zayed had signaled his acceptance of 1.5 mbd as a quota for the Emirates—implying a major cutback for Abu Dhabi—showed the importance that the Middle East’s highest political authorities had attached to getting oil prices up. The pledged figure was about 400 to 500 kbd below what the U.A.E. had consistently claimed and produced. The agreement, which was to be formalized only when OPEC ministers would meet in Geneva on July 25, would freeze the official quotas of all other OPEC members. A couple of days after the Jeddah meeting, U.A.E. oil minister Mana Said Otaiba met in Abu Dhabi with his Iranian counterpart. Briefing reporters on the results of the visit, he confirmed that the U.A.E. had accepted an oil quota of 1.5 mbd. Otaiba also said that the U.A.E., which was at that time estimated to be producing as much as 2 mbd, had cut its output to the new quota level immediately.

A few days after the Jeddah meeting, Abu Dhabi National Oil Company (ADNOC) informally told buyers of its crude that it intended to reduce production by about 400 kbd for an indefinite period beginning August 1, 1990. Abu Dhabi had been producing at levels of around 1.5 mbd, the bulk of U.A.E.’s crude output. On July 17, President Saddam Hussein launched a verbal attack against some Persian Gulf states charging that they had conspired with the U.S. to depress global oil prices through overproduction. In a speech apparently referring to Kuwait and the U.A.E., Hussein accused certain Gulf Arab states of stabbing Iraq “in the back with a poisoned dagger” by helping send crude oil prices tumbling. He threatened that “if words fail to protect Iraqis, something effective must be done to return things to their natural course and return usurped rights to their owners.” Subsequently, Iraq’s Foreign Minister Tareq Aziz charged that “the attempt by the governments of Kuwait and the U.A.E. to flood the oil market with extra crude is a premeditated and deliberate plan to weaken Iraq and undermine its economy and security.” Finally, following through with the pledge made earlier that month at the Jeddah meeting to cut the overproduction, it was agreed at the OPEC meeting in late July 1990, that the output quota for the U.A.E. would be 1.5 mbd.

Sources: Oil Daily, June 19, June 20, June 26, June 28, June 29, July 3, July 9, July 11, July 12, July 13, July 16, July 17, July 18, July 19, July 20, July 23, July 25, and July 30, 1990.

**August 1990 Iraq**

Change in production:

-2.438 kbd (-70.59% of domestic production, from 3.454 mbd in July 1990 to 1.016 mbd in August 1990)

Nature of the event:

**Exogenous:** Production drop caused by the embargo on Iraqi and Kuwait oil in reaction to the Gulf War.
Narrative description:

The drop in Iraqi production was the result of the embargo imposed on Iraq after it invaded Kuwait in early August 1990 with an estimated 100,000 battle-hardened troops to oust the ruling emir and set up what most observers said was a puppet government. Immediately after the invasion, U.S. President Bush issued an executive order banning virtually all trade with Iraq, including Iraqi oil imports and exports. In just a few days, Iraq’s vital oil exports were cut by nearly 50 percent as a result of U.S.-led efforts to boycott Iraqi crude oil. Nearly 90 percent of Iraq’s oil exports went through pipelines through Turkey and Saudi Arabia. Iraqi authorities told Turkey’s BOTAS pipeline company that one of the two pipelines which carried Iraqi crude oil through Turkey would be closed “for reasons of marketing.” In addition to cutting flow through the one pipeline, Iraq reduced the flow through the other line by 56 percent. In a key development of the global crisis that began when Iraq sent its armed forces into Kuwait, the U.N. Security Council passed a resolution calling for a complete economic embargo on all goods, including oil, military and civilian equipment, of all Iraqi imports and exports. Iraqi exports stopped when Baghdad was denied the use of its major outlets. The pipelines through Turkey and Saudi Arabia, as well as the tanker route through the Gulf had all been closed. Turkey banned the loading of Iraqi oil at its Mediterranean oil tankers docks, ending Iraqi exports through the BOTAS pipeline which carried Iraqi oil from its Kirkuk and Mosul fields to the Turkish port of Ceyhan. The decision came after a Turkish government cabinet meeting which decided immediately to implement the U.N. Security Council resolution.

Sources: Oil Daily, August 3, August 7, August 8, August 9, September 5, 1990.

**August 1990 Kuwait**

Change in production:

-1.757 kbd (-94.59% of domestic production, from 1.858 mbd in July 1990 to 100 kbd in August 1990)

Nature of the event:

**Exogenous**: Production drop caused by the embargo on Iraqi and Kuwait oil in reaction to the First Persian Gulf War.

Narrative description:

As with the event described just above involving Iraq, the drop in Kuwait production was also the result of the total economic and military embargo imposed on Iraq and Kuwait after the troops of Baghdad invaded Kuwait in early August 1990. One week after the invasion, Iraq responded to the rapidly growing opposition to its military moves by announcing that it had annexed Kuwait at the request of the provisional government installed after the takeover of its smaller Persian Gulf neighbor.

Sources: IEA Oil Market Report, October 1, 1990 and Oil Daily, August 8, 1990.

**May 1992 Russia**

Change in production:

-519 kbd (-6.32% of domestic production, from 8.212 mbd in April 1992 to 7.693 mbd in May 1992)

Nature of the event:

**Endogenous (Anticipated)**: Continued decline in crude oil output.
Narrative description:

The June 1992 OMR of the IEA reported that in April of the same year Russian production continued the 12-13 percent annual pace of decline already recorded in 1992:Q1. The year-on-year rate of decline in Russia reflected the severe decline in some of the largest mature fields in western Siberia, continuing to exceed that in the non-Russian republics of the former Soviet Union as a whole. In the July 1992 OMR, the IEA noted that discrepancies and inconsistencies abounded among available estimates of oil production in both Russia and the former USSR for the months of April and May. The report also noted that no official or unofficial sources of data on production, measured as deliveries into the main pipeline system showed a smooth month-on-month decline during the first part of 1992. The IEA conjectured that producer associations might have used any logistical flexibility available to them to take advantage of price movements on the domestic market as well as the effect of the export license review in January and February. Based on partial monthly data, the annual decline in oil output production in Russia in the first four months was almost 13 percent.

Sources: IEA Oil Market Reports, June 5 and July 7, 1992.

**October 1995 Mexico**

Change in production:

-862 kbd (-30.37% of domestic production, from 2.839 mbd in September 1995 to 1.977 mbd in October 1995)

Nature of the event:

**Exogenous**: Damages on oil infrastructure caused by Hurricane Roxanne.

Narrative description:

During mid-October 1995, Hurricane Roxanne left a trail of devastation over Mexico, affecting in particular the southwestern portion of the Gulf of Mexico. State oil monopoly Petroleos Mexicanos (Pemex) reported that Roxanne cut substantially its oil production, with most of the production cuts in the Campeche Bay, beneath which lies the Cantarell giant oil field complex. The hurricane forced Pemex to shut in about 85 percent of production from Campeche bay, which accounted for nearly 70 percent of Mexico’s 2.7 million barrels per day of crude output. Pemex also declared force majeure on its 1.25 million barrels per day of exports due to the protracted closure of ports at Dos Bocas, Cayorcas and Pajripos. In late October, Pemex said that crude output in its key Campeche Bay production area was back to 75 percent of its normal level but that it would also fail to deliver almost 15 million barrel of crude scheduled for the whole month of October due to force majeure following damage from Hurricane Roxanne. In early November, Tradewind Petroleum Services assessed that in October Hurricane Roxanne led to the shut in of nearly 30 million barrels of crude oil, and that, before returning to normal, Pemex would have lost 35 million to 40 million barrels of production, a notably higher figure than earlier estimates.

Sources: Oil Daily, October 13, 16, 18, 19, and 26, and November 6, 8, and 13, 1995. IEA Oil Market Report, November 8 and December 7, 1995.

**June 1997 Iraq**

Change in production:

-700 kbd (-54.33% of domestic production, from 1.290 mbd in May 1997 to 589 kbd in June 1987)

Nature of the event:

**Exogenous**: Unanticipated completion of the first phase of the “oil-for-food” program.
Narrative description:

In June 1997 Iraq exports dropped by about 800 kbd, due to the early and unanticipated completion of the first phase of the Iraqi “oil-for-food” program in late May. Earlier strength in prices resulted in revenues for the second 90-day period of the program slightly exceeding the $1 billion revenue target, so that two cargoes scheduled to be loaded at the Persian Gulf Mina-al-Bakr terminal had to be canceled. With no changes in terminal storage or pipeline fill, the end of the loadings were reflected in lower production starting at the end of May.

Sources: IEA Oil Market Reports, June 6, July 8, and August 8 1997.

December 2000 Iraq

Change in production:

-1.460 mbd (-51.87% of domestic production, from 2.815 mbd in November 2000 to 1.355 mbd in December 2000)

Nature of the event:

Exogenous: Suspension of exports under the “oil-for-food” program.

Narrative description:

On November 30, 2000, Iraq suspended its oil exports under phase 8 of the “oil-for-food” program, as the UN and the Baghdad government were not able to reach an agreement about the December price formulas for Iraqi export sales. Under the program, Iraq exports transited through the Mediterranean port of Ceyhan in Turkey and the Persian Gulf port of Mina al-Bakr in Iraq. As of the second half of November, overall exports were running at 2.3 mbd. The 180-day phase 9 of the program was authorized to begin on December 6 1991, but it remained suspended. Eventually, oil-for-food exports were interrupted for 12 days, but even though they resumed on December 13, overall Iraqi supply for the month fell by 1.6 mbd, as resumed exports remained low and sporadic. In fact, with little storage capacity at Mina al-Bakr, and the tanks at Ceyhan full since mid-December, oil fields in Iraq were partly or fully shut down.


June 2001 Iraq

Change in production:

-1.769 mbd (-61.96% of domestic production, from 2.854 mbd in May 2001 to 1.086 mbd in June 2001)

Nature of the event:

Exogenous: Disagreement with the U.N. Security Council over the terms of the “oil-for-food” program.

Narrative description:

Following the U.N. Security Council’s decision to extend the Iraqi “oil-for-food” program for one month instead of the normal six months, on June 4 Iraq halted exports under the program, taking 2.1 mbd of supply out of the market, further indicating that the suspension would have lasted for one month. The UN Security Council resolution on June 1 to extend the program by 30 days instead of 180 days was intended to give Council members time to review and negotiate a revised “smart” sanction plan proposed by the UK and the US, which would lift restrictions on civilian goods but tighten the control on military-related supplies and smuggling.
Sources: IEA Oil Market Reports, June 12 and July 13, 2001.

**April 2002 Iraq**

Change in production:

-1.300 mbd (-51.69% of domestic production, from 2.515 mbd in March 2002 to 1.215 mbd in April 2002)

Nature of the event:

**Exogenous**: Disagreement with the U.N. Security Council over the terms of the “oil-for-food” program.

Narrative description:

On 8 April, Iraq announced a 30-day suspension of its oil-for-food exports. Iraqi output, as a combination of the UN exports, border trade and domestic consumption, fell by 1.2 mbd, thus leading to the loss of 40 to 50 million barrels of crude. This move was sanctioned by Iraqi president Saddam Hussein, in support of Palestinians and designed to pressure supporters of Israel to push for an amicable peace solution. Saddam Hussein called for Islamic countries to unite to broaden the oil embargo. Iran and Libya announced tentative support for such a measure, but only if all Islamic Gulf states fully participated in it. About 1.8 mbd of Iraqi exports were lost from the market through early May. Iraq resumed exports under the UN program on May 8.

Sources: IEA Oil Market Reports, April 10 and May 13, 2002.

**December 2002 Venezuela**

Change in production:

-1.952 mbd (-65.68% of domestic production, from 2.972 mbd in November 2002 to 1.020 mbd in December 2002)

Nature of the event:

**Exogenous**: General national strike led to substantial fall in crude oil production.

Narrative description:

A general national strike began in Venezuela on December 2, resulting from protracted political conflict between President Chavez and his opponents. Opponents of the Chavez government were calling for a mid-term referendum on his leadership. Stoppages by workers, including port staff, pilots, shipping operatives, and employees of state oil company PDVSA did cut oil output substantially, causing force majeure to be declared on crude and products exports and crude runs at refineries within Venezuela to be reduced to minimum operating levels. Because of the strike, crude production in Venezuela during December 2002 fell by nearly 2 mbd. In addition, other liquids, including upgraded heavy crude production, fell by more than 500 kbd, bringing the overall Venezuelan production loss to about 74 million barrels.


**April 2003 Iraq**

Change in production:

-1.316 mbd (-96.14% of domestic production, from 1.369 mbd in March 2003 to 52.873 kbd in April 2003)

Nature of the event:
**Exogenous**: Supply disruptions following military actions of the Second Persian Gulf War.

Narrative description:

In April 2003, due to supply disruptions following military actions, Iraq production fell by 1.3 mbd. Limited pipeline exports of crude from northern fields to Syria and Turkey continued until around mid-April. In contrast, southern operations were thought to have ceased soon after the war began in March. US forces were reported to have closed the Iraq-Syria pipeline around April 15. With Ceyhan port storage full to capacity at the same time, and with coalition forces having captured northern facilities, crude production (and refining operations) there came to a complete halt soon after mid-month. After extinguishing a limited number of oil well fires, and having first sealed and checked production facilities for sabotage, southern area production was started up once more on April 23, while northern area production resumed around April 27. However, volumes remained limited.

Sources: IEA Oil Market Reports, April 10 and May 13, 2003.

**September 2005 U.S.A.**

Change in production:

-985 kbd (-18.94% of domestic production, from 5.198 mbd in August 2005 to 4.214 mbd in September 2005)

Nature of the event:

**Exogenous**: Adverse impact of Hurricanes Katrina and Rita.

Narrative description:

In September 2005, Hurricanes Katrina and Rita led to the loss of nearly 1.0 mbd, equivalent to nearly 80 percent of U.S. crude production from the Gulf of Mexico and to almost 20 percent of total U.S. crude production. Severe damage affected elements of upstream infrastructure, with production recovery being further hampered by inoperable pipelines, processing plants, terminals and refineries. From late August 2005, the cumulative loss of crude supply was about 50 million barrels. Louisiana authorities also reported 165 kbd of oil production shut-in within the state’s onshore and shallow offshore boundaries. Damage to pipelines and onshore processing facilities as well as workplace displacement represented the real impediment to supply recovery. The US Minerals Management Service (MMS) reported at the end of September that Katrina did more damage to sub-sea pipelines than originally thought. Pipeline and processing constraints kept crude oil production shut-in for longer than would otherwise been the case. The October IEA OMR estimated that in addition to the crude oil losses, a further loss of 180 kbd of NGL may have been incurred.

Sources: IEA Oil Market Report, October 11, 2005.

**September 2008 U.S.A.**

Change in production:

-1.026 mbd (-20.51% of domestic production, from 5.006 mbd in August 2008 to 3.979 mbd in September 2008)

Nature of the event:

**Exogenous**: Adverse production impact of Hurricanes Gustav and Ike.

Narrative description:

In September 2008, heavy hurricane outages in the Gulf of Mexico had a major negative impact on U.S. production. As of early October 2008, over 40 percent of U.S. crude production in the Gulf
of Mexico remained off line amid shuttered pipeline links in the aftermath of Hurricanes Gustav and Ike. More specifically, 582 kbd of Outer Continental Shelf (OCS) crude production remained shut-in after the passing of Hurricanes Gustav and Ike, representing 45 percent and 39 percent, respectively, of pre-storm production levels. In addition, the IEA estimated that 150 to 200 kbd of regional shallow water and onshore crude and NGL production might also have been off line. As was the case after Hurricanes Katrina and Rita in 2005, the continued unavailability of offshore pipelines remained a key impediment to restoring production, more so than damaged production facilities per se. All told, the IEA assumed that oil outages averaged 1.4 mbd in September 2008, with cumulative total oil losses amounting to 45 million barrels by end-September.

Sources: IEA Oil Market Report, October 8, 2008.

**March 2011 Libya**

Change in production:

-1.040 mbd (-77.61% of domestic production, from 1.340 mbd in February 2011 to 300 kbd in March 2011)

Nature of the event:

**Exogenous**: Attacks on oil producing fields and infrastructure in retaliation of exports by opposition to Colonel Gaddafi.

Narrative description:

In March 2011, Libyan output fell by nearly 80 percent, plummeting by an average 1.34 mbd to only 300 kbd, following three separate attacks by Colonel Gaddafi’s government forces on oil producing fields and infrastructure in the rebel-controlled eastern region of the country. The attacks targeted oil infrastructure at the country’s largest field, Sarir, in the Sirte Basin, as well as oil fields in the Waha and Messla areas. The three fields were producing around 100 kbd, down sharply from the 420 kbd seen before hostilities erupted in late-February. The attacks were likely in retaliation for the opposition’s first export of crude to international markets. In fact, the attacks came on the heels of the first crude cargo exported by the opposition from Tobruk, but exports were suspended until security could be improved.

Sources: IEA Oil Market Report, April 12, 2011.