Supplementary Material for Oil Price Elasticities and Oil Price Fluctuations

Dario Caldara* Michele Cavallo† Matteo Iacoviello‡

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*Federal Reserve Board.

†Federal Reserve Board.

‡Corresponding author: Division of International Finance, Federal Reserve Board, 20th and C St. NW, 20551, Washington, DC United States. E-mail: matteo.iacoviello@frb.gov

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.[1] 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.

[1] See https://www.eia.gov/totalenergy/data/monthly/pdf/sec14.pdf.

Table A.1: Summary Data on Advanced Economies' Industrial Production

Country	Share of Global GDP, Percent	Share of Global Oil Production, Percent	Share of Global Oil Consumption, Percent	Sample
United States	21.70	11.62	20.60	1985-2015
Japan	6.70	0.00	4.92	1985-2015
Germany	4.88	0.00	2.62	1985-2015
France	3.65	0.00	1.81	1985-2015
United Kingdom	3.54	1.00	1.66	1985-2015
Italy	2.77	0.13	1.37	1985-2015
Canada	2.40	4.62	2.59	1985-2015
Spain	1.77	0.00	1.30	1985-2015
Netherlands	1.13	0.00	0.98	2000-2015
Sweden	0.75	0.00	0.33	2000-2015
Norway	0.68	2.12	0.26	1985-2015
Belgium	0.68	0.00	0.69	1985-2015
Austria	0.56	0.00	0.29	1985-2015
Denmark	0.45	0.21	0.17	2000-2015
Finland	0.35	0.00	0.21	1995-2015
Greece	0.31	0.00	0.32	1995-2015
Ireland	0.31	0.00	0.15	1985-2015
Portugal	0.29	0.00	0.26	2005-2015
Luxembourg	0.08			1985-2015
AFE total	52.99	19.70	40.52	

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

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

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.[2]

The following equations summarize the restrictions imposed on the parameters in matrix **A**:

$$\Delta q_t = u_{S,t}, \tag{A.1}$$

$$\Delta q_t = \eta_A rea_t + \eta_D p_t + u_{D,t}, \tag{A.2}$$

$$rea_t = \nu_Q \Delta q_t + u_{REA,t}, \tag{A.3}$$

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, rea_t. The parameter η_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
24-Month Ahead – Kilian (2009) Model

Shock	Oil Supply	Oil Demand	Rea
Oil Prices	1.5	69.6	28.9
	[1.4; 8.2]	[53.5; 81.4]	[15.0; 43.4]
Oil Production[a]	95.1	0.8	4.2
	[83.1; 94.0]	[1.6; 6.9]	[3.2; 12.6]
Rea	1.7	7.9	90.5
	[1.1; 9.4]	[4.1; 18.3]	[76.5; 93.1]

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.

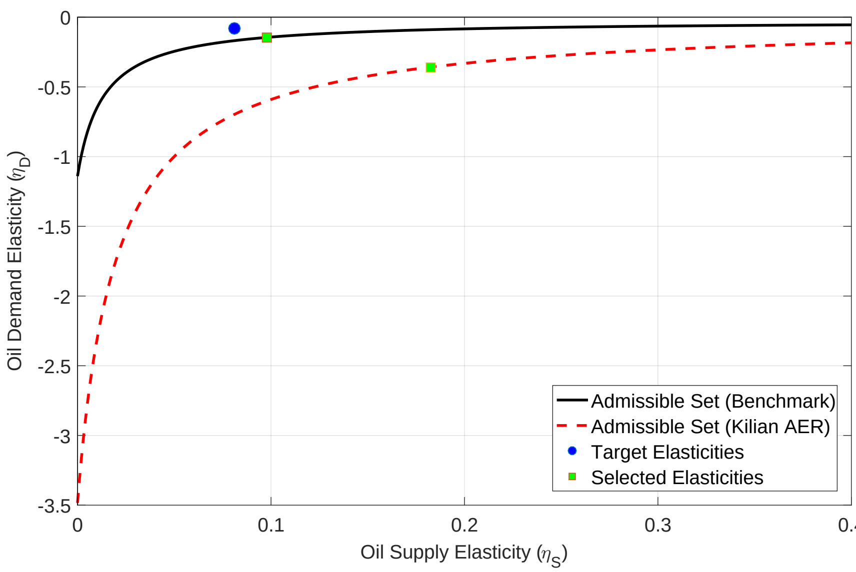
Table A.3 presents the 24-months ahead forecast error variance decomposition of Kilian's model. Of note, supply shocks account for a very small fraction of the fluctuations in oil prices, while oil

[2] 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.[3]

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.[4]

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

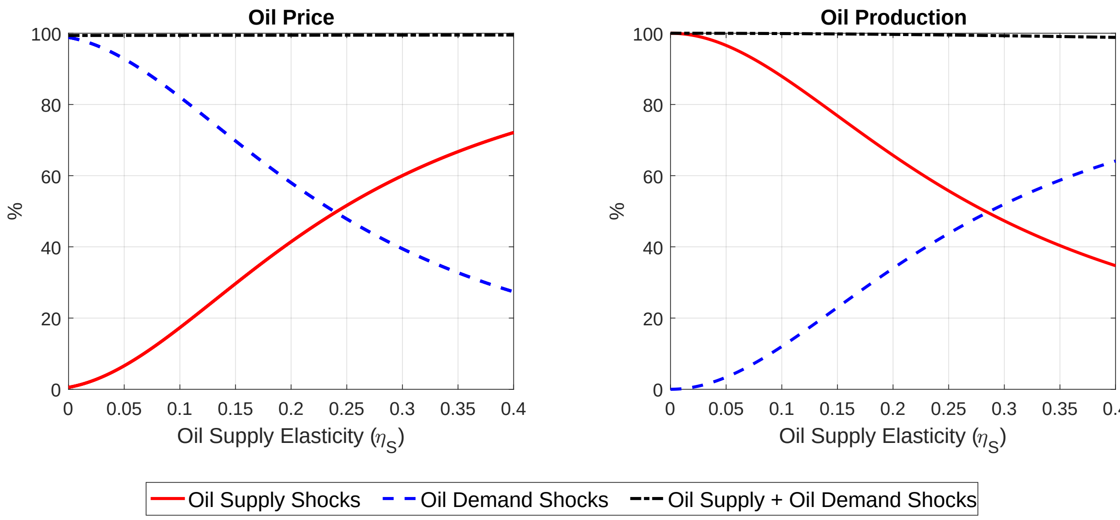
Figure A.2 plots the share of the forecast error variance at horizon zero for oil prices (left panel) and for oil production (right panel) that is attributable to oil shocks, as a function of the oil supply elasticity η_S for the Kilian (2009) model. Setting $\eta_S = 0$, almost all of the forecast error 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.

[3]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.

[4]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.[5] 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 (2017) and extend our baseline model to include oil inventories. Define the change in inventories (ΔI) as the difference between oil production (Q) and oil consumption (C):

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

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:

$$\begin{aligned}
q_t &= \eta_S p_t + u_{s,t}, & \text{(A.5)}\\
q_t - \Delta i_t &= \eta_A ya_t + \eta_E ye_t + \eta_D p_t + u_{d,t}, & \text{(A.6)}\\
ya_t &= \nu_Q q_t + u_{ya,t}, & \text{(A.7)}\\
ye_t &= \mu_Q q_t + \mu_A ya_t + u_{ye,t}, & \text{(A.8)}\\
m_t &= \psi_Q q_t + \psi_A ya_t + \psi_E ye_t + \psi_P p_t + u_{m,t}, & \text{(A.9)}\\
\Delta i_t &= \phi_Q q_t + \phi_A ya_t + \psi_E ye_t + \phi_P p_t + \phi_M m_t + u_{i,t}. & \text{(A.10)}
\end{aligned}$$

There are three differences compared to our baseline model described in the main text. First, the inclusion of inventories in the VAR changes the dynamics of the model and consequently the estimation of the reduced-form residuals ε_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 (2017), except that we do not allow for measurement error in inventories.

We find that the estimated 6-variable VAR 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

[5] 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
Six-variable Model with Inventories: 24-Month Ahead

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

Note: The entries in the table denote the estimated share 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.

demand, with a secondary role played by oil-specific demand shocks and a negligible role played by the remaining shocks.

The key properties of the six-variable VAR model with oil inventories do not change when we replace our three activity indicators (ya, ye, and m) with Kilian (2009)'s indicator of real activity, thus considering a 4-variable VAR with q, p, rea, and Δi. In this case—abstracting from lags—the structural model becomes:

$$q_t = \eta_S p_t + u_{s,t}, \quad (A.11)$$

$$q_t - \Delta i_t = \eta_R rea_t + \eta_D p_t + u_{d,t}, \quad (A.12)$$

$$rea_t = \nu_Q q_t + u_{rea,t}, \quad (A.13)$$

$$\Delta i_t = \phi_Q q_t + \phi_{REA} rea_t + \phi_P p_t + u_{i,t}. \quad (A.14)$$

Using this specification, shocks to oil supply and shocks to global demand account for 46 and 35 percent of the 24-month ahead forecast error variance of oil prices, respectively.

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** :

$$q_t = \eta_S p_t + u_{S,t}, \quad (A.15)$$

$$q_t = \eta_A ya_t + \eta_E ye_t + \eta_D p_t + u_{D,t}, \quad (A.16)$$

$$ya_t = \nu_Q q_t + u_{A,t}, \quad (A.17)$$

$$ye_t = \mu_Q q_t + \mu_A ya_t + u_{E,t}. \quad (A.18)$$

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.

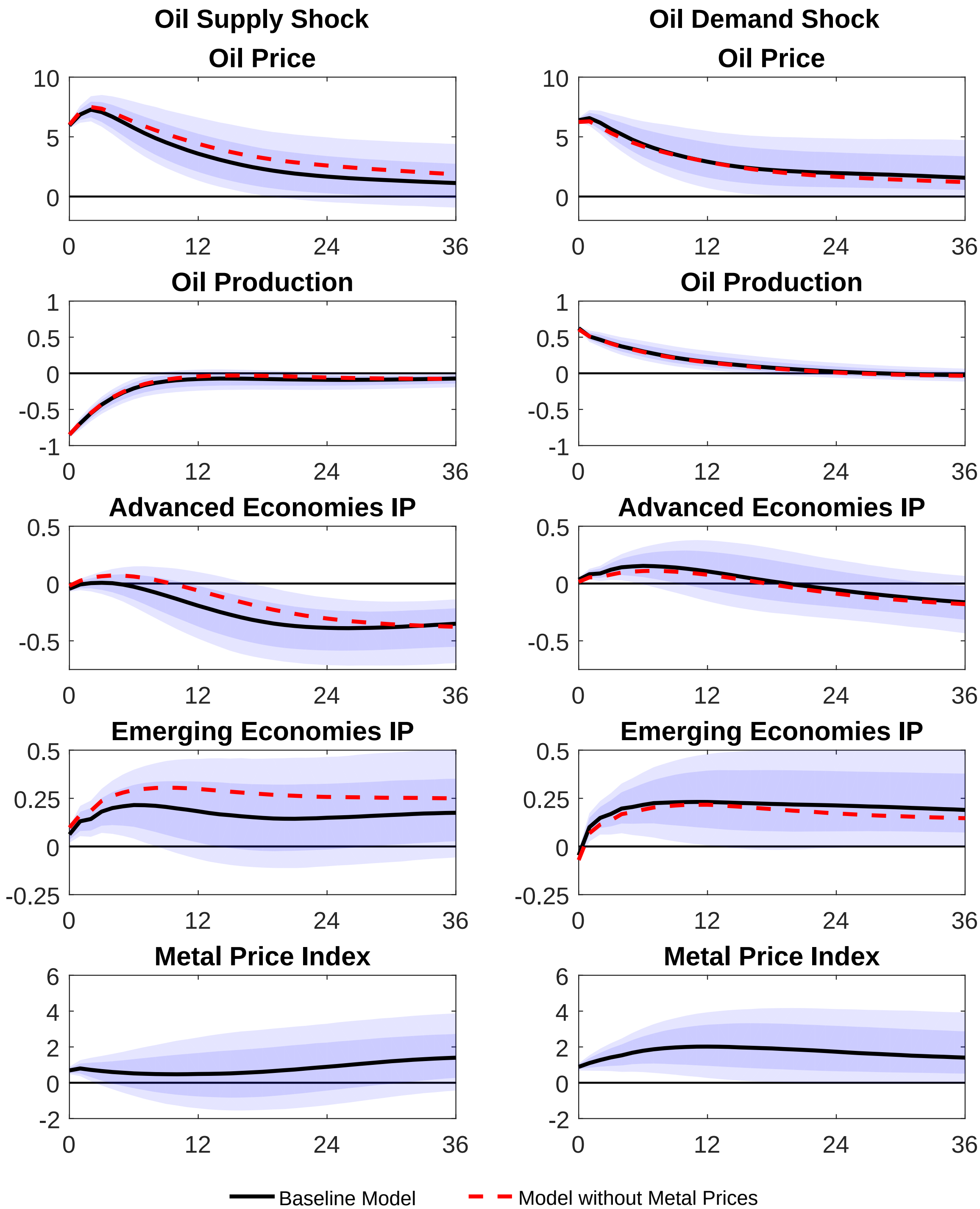
Figure A.3 compares impulse responses to oil market shocks estimated under the baseline model and under a model that excludes metal prices. The responses of all variables to the two oil market shocks are nearly identical.

Table A.5: Forecast Error Variance Decomposition
24-Month Ahead – Model without Metal Prices

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

Note: The entries in the table denote the estimated share 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.

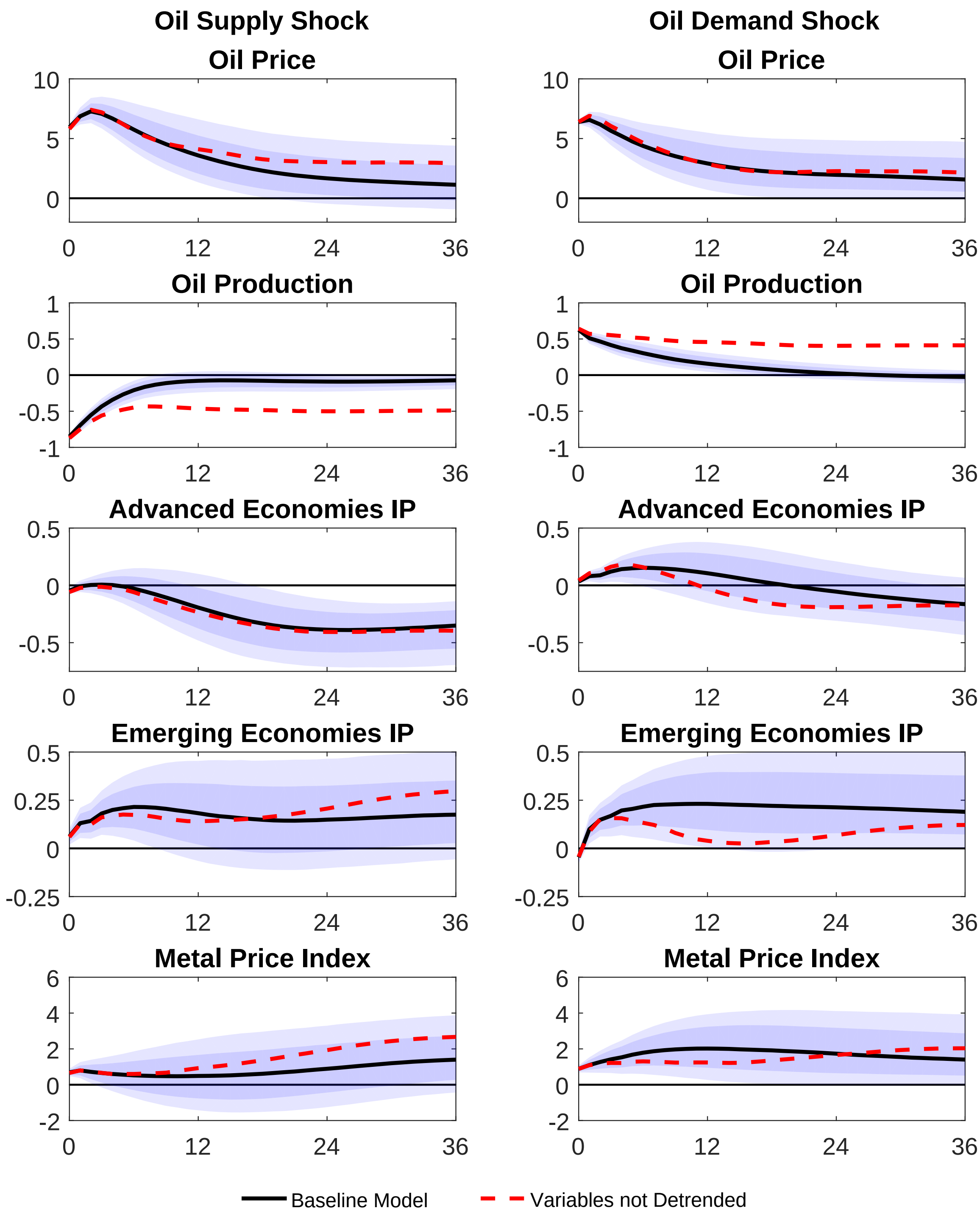
Figure A.4 reports impulse responses to the oil supply and the oil demand shock. When the data are not detrended, the impulse responses—most notably those for oil production—are more persistent, and in some cases do not revert to the baseline after the initial impulse. However, nearly all median responses 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

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

Note: The entries in the table denote the estimated share 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 of the main text: the oil price shock in the "oil price exogenous" approach, and the oil-specific demand shock in the "inelastic production" approach.[6] 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.

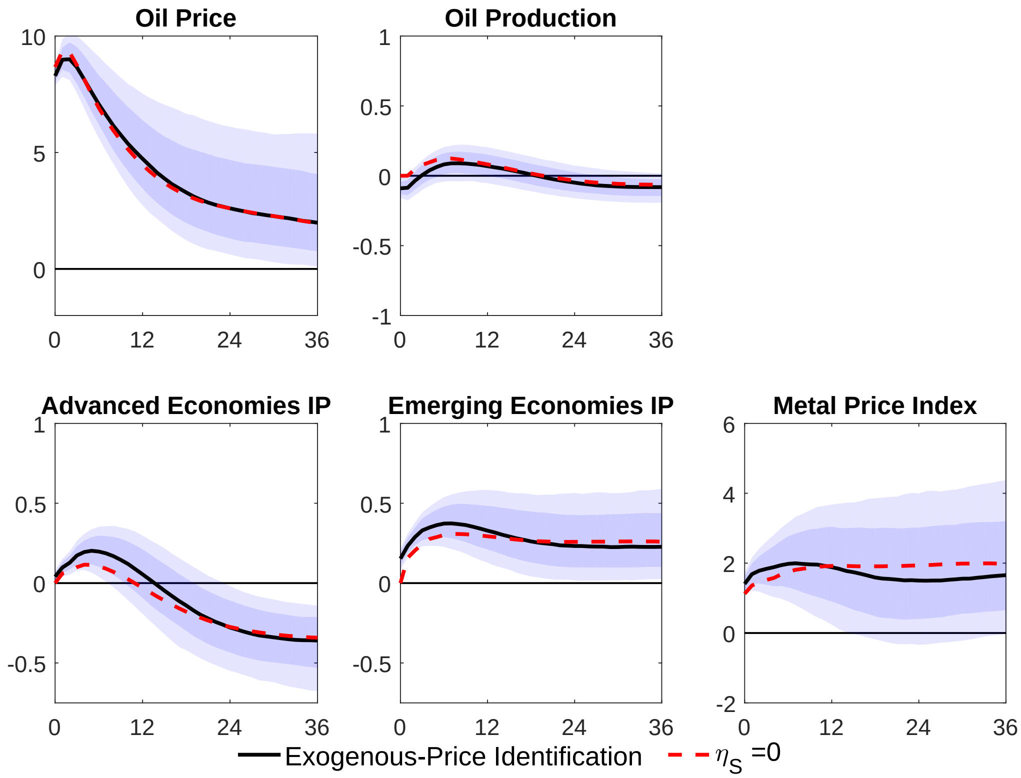
Why? The "inelastic" production approach allows prices to contemporaneously respond to movements in other variables.[7] However, this response is estimated to be small, owing to the low correlation between oil prices and other variables and to the zero restrictions imposed by the VAR. Hence, prices are 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 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.

[6] 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).

[7] 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

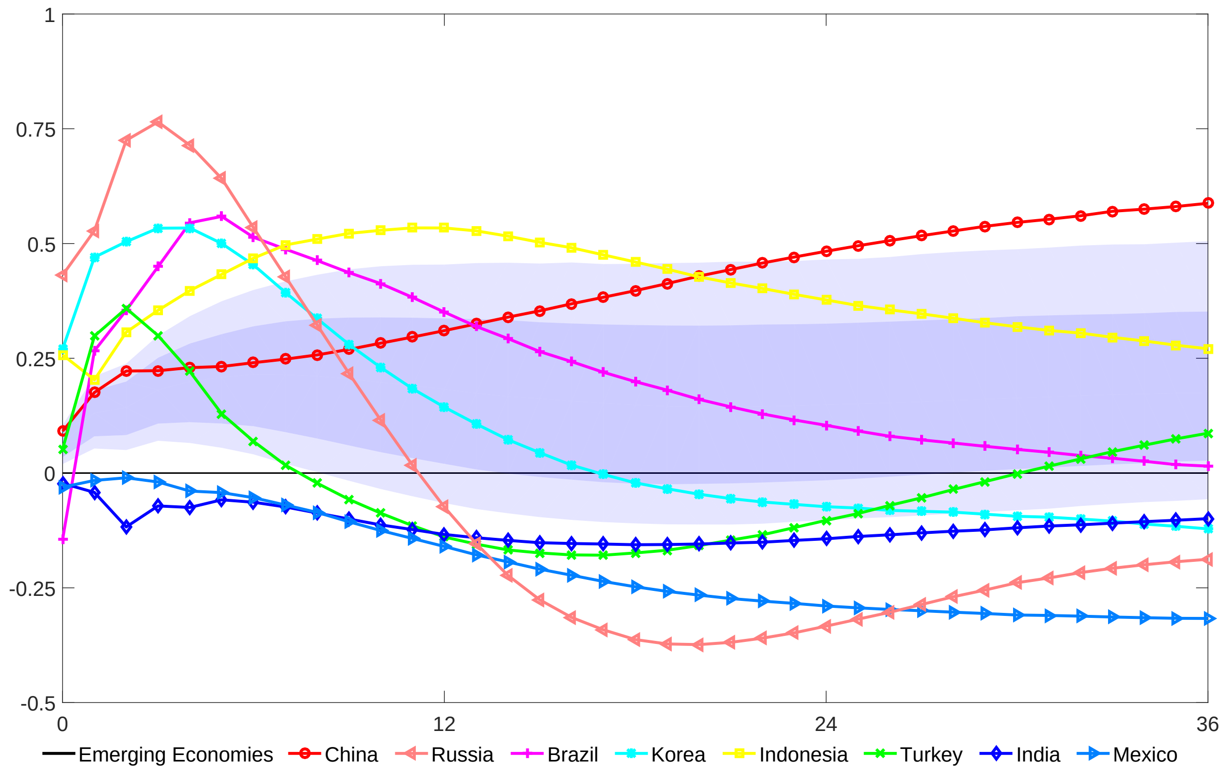


Note: The solid lines depict median responses of the specified variable to a one standard-deviation oil shock identified by ordering oil prices first in a Cholesky decomposition; the red-dashed lines depict median responses to a one standard-deviation oil demand shock identified by imposing $\eta_S = 0$; 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 of the main text. 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).[8] 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).[9] 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.[10] 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.

Sources: Oil Daily, December 4, December 5, December 11, December 18, December 19, December 26, and December 27, 1984; January 2, January 8, January 9, January 11, January 14, January 15, January 18, January 23, January 24, January 25, January 29, and February 7, 1985.

[8] 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.

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

[10] 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.

Sources: Oil Daily, November 3, November 13, November 18, December 9, December 16, December 17, December 18, December 22, December 23, December 29, 1986, and January 14, 1987.

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.

Sources: Oil Daily, March 9, March 10, March 11, March 12, March 17, 1987.

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, September17 , 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.

Sources: Oil Daily, December 9, December 15, December 16, 1987, January 4, January 5, January 6, 1988.

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.

Sources: IEA Oil Market Reports, December 11, 2000, and January 19, 2001.

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.

Sources: IEA Oil Market Reports, December 11, 2002, and January 17, 2003.

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.

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