



# The Dynamics of Global Crude Oil Production

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# Agenda

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## **1. Introduction**

## **2. Data and Methodology**

## **3. Results and Discussion**

## **4. Conclusions**

## **References**

# Motivation

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- **Crude oil production and prices are key economic variables, but understanding of their interaction over time and for different producers is incomplete**
- **We analyze the dynamic response of crude oil output to past prices and other important control variables**
- **Disentangle determinants of global oil production by major country groups and on individual country level**
  - **OPEC, OECD and non-OECD/non-OPEC production**
  - **Individual country analysis**

# State of the Literature

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- **Two major streams: models evaluating consequences of physical attributes/exhaustibility and tests of strategic producer behavior**
- **Physical attributes:**
  - **Hotelling (1931): resource exhaustibility**
  - **Hubbard (1956): oil depletion**
- **Strategic behavior:**
  - **Griffin (1985): empirical testing of popular hypotheses: Cartel behavior, competitive behavior, revenue targeting**
    - **No thorough dynamic analysis exists**
    - **Methodological challenges call into question validity of results**

# Agenda

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**1. Introduction**

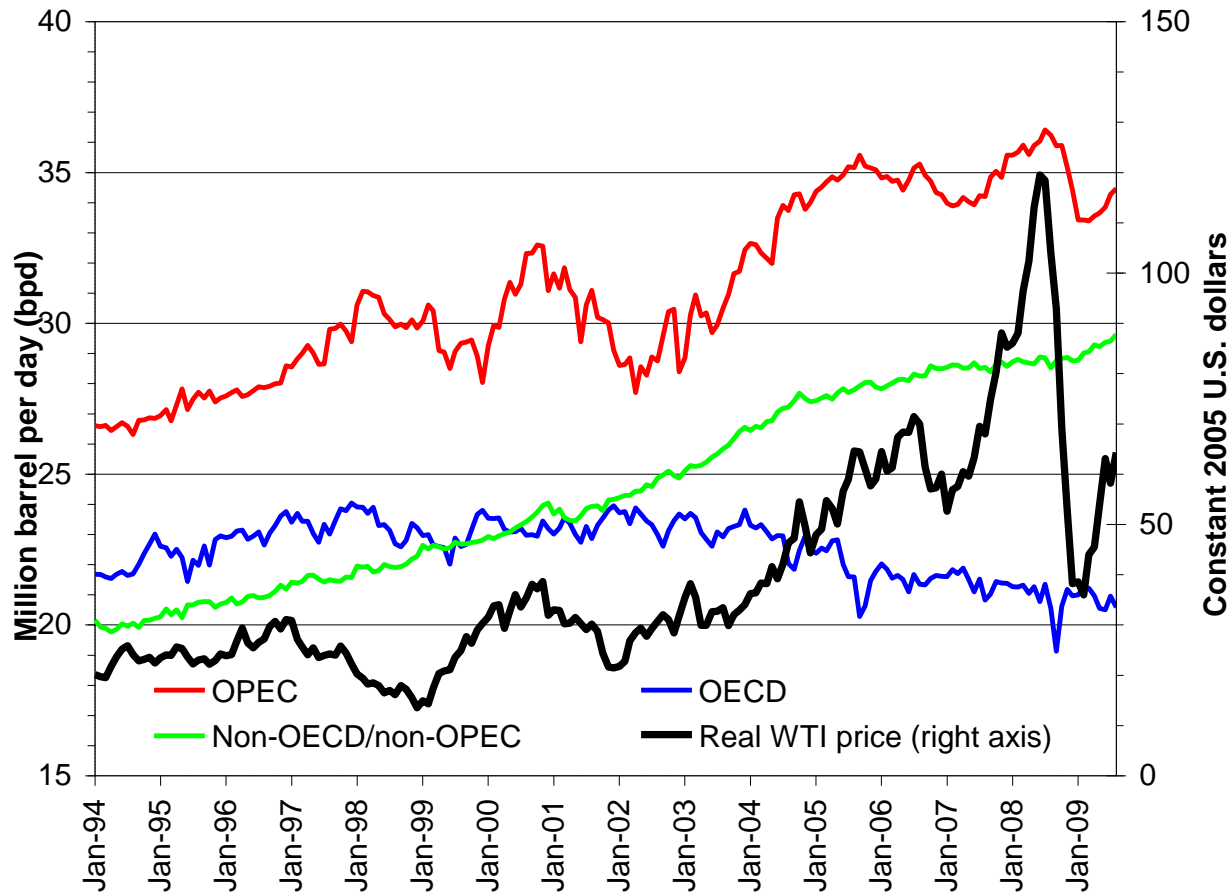
**2. Data and Methodology**

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# Descriptive Analysis: Graphical



**OECD: stable and slightly declining trend, with sharp movements**

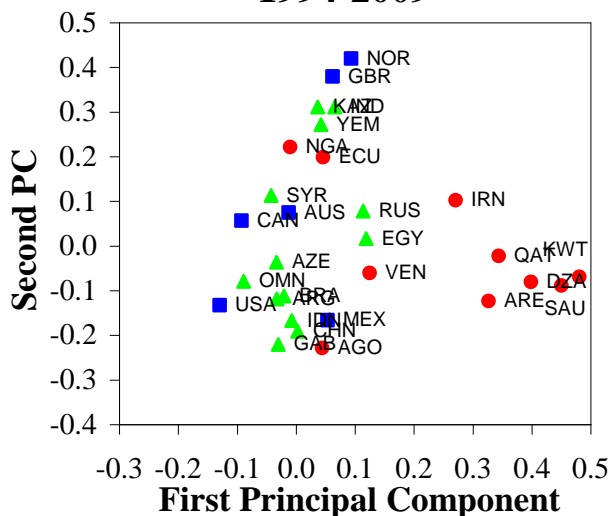
**OPEC: appears to mirror development in oil price, with a certain delay**

**Non-OECD/non-OPEC: smoothly increasing, broadly in line with trend in price**

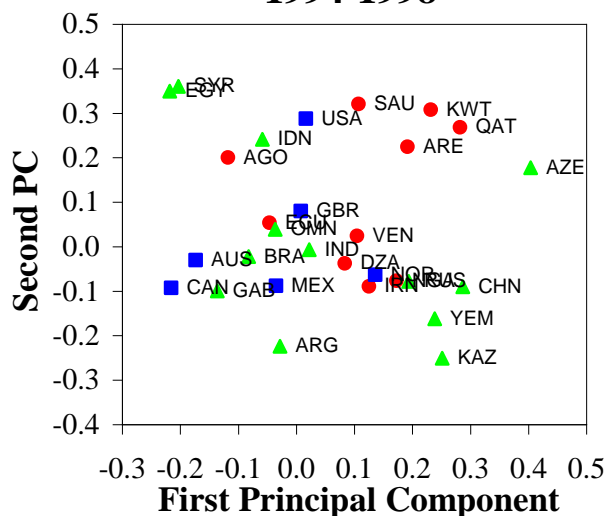
# Descriptive Analysis: Principal Components Analysis (PCA)

- PCA of oil production (first differences), various samples:

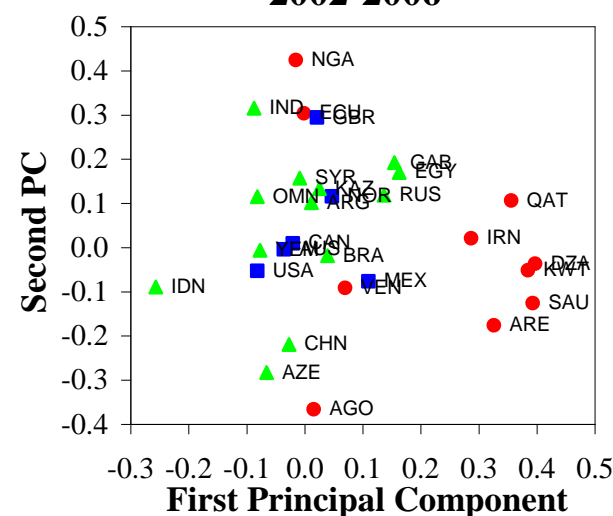
1994-2009



1994-1998



2002-2006



**Production behavior seems to differ according to:**

- Country groups
- Individual countries
- Time

# Hypotheses

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## **Hypothesis 1:**

**Crude oil output responds to prices and other control variables over a range of lags from the short to the long term.**

## **Hypothesis 2:**

**The response is heterogeneous among the three main groups of countries, OPEC, OECD and non-OECD/non-OPEC, as well as on the level of individual countries.**



# Methodology

- **Address stationarity issue by taking first differences of non-stationary variables**
- **Estimation strategy:**
  - **Determine effects of both global and local factors**
  - **Specify rich lag structure to analyze dynamics**

$$\Delta Q_{t,i} = \alpha_i + \sum_{j=1}^{11} \rho_j D_{t,j} + \lambda_i INST_{t,i} + \sum_{k=0}^K \beta_{k,i} \Delta P_{t-k} + \sum_{l=0}^L \gamma_{m,i} REAL_{t-m} + \sum_{m=1}^M \delta_{l,i} \Delta RIG_{t-l,i} \\ + \sum_{n=0}^N \varphi_{k,i} SD(\Delta P_t)_{t-k} + \sum_{p=0}^P \theta_{k,i} \Delta EX(USD)_{t-k} + \varepsilon_{t,i}$$

- **Optimize model structure using a data-driven algorithm based on the Bayesian Information Criterion (BIC)**

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# Role of Prices

	Oil supply		
	(1) OPEC	(2) OECD	(3) Non-OECD/non-OPEC
Real WTI Price, monthly average	-21.50 (0.171)	0.750 (0.925)	-0.963 (0.575)
Real WTI Price, monthly average (-1)	21.97** (0.031)	-10.46* (0.072)	-0.679 (0.791)
Real WTI Price, monthly average (-2)	26.14*** (0.001)	-20.32** (0.015)	-2.894 (0.521)
Real WTI Price, quarterly average (-1)	33.15 (0.517)	-111.5*** (0.000)	4.783 (0.497)
Real WTI Price, quarterly average (-2)		-69.26** (0.034)	9.495 (0.135)
Real WTI Price, quarterly average (-3)		-68.47* (0.074)	
Real WTI Price, yearly average (-1)	37.33 (0.856)	-123.9 (0.529)	
Real WTI Price, yearly average (-2)	-86.42 (0.722)	-152.0 (0.454)	174.2** (0.028)
Real WTI Price, yearly average (-3)	-471.6 (0.144)		174.1* (0.067)
Real WTI Price, yearly average (-4)	-683.0** (0.020)		36.63 (0.515)
Real WTI Price, yearly average (-5)			-1.560 (0.975)
Real WTI Price, yearly average (-6)			0.297 (0.994)
Real WTI Price, yearly average (-7)			
Real WTI Price, yearly average (-8)	-792.0*** (0.000)	-123.5 (0.547)	-20.87 (0.394)
Real WTI Price, yearly average (-9)	-300.6*** (0.000)	-90.74 (0.425)	
Observations	156	156	156

**Counter-cyclical price response**

**Pro-cyclical Price response**

**Pro-cyclical short-term response**

**Counter-cyclical longer term response**

Robust p-values in parentheses; \*, \*\*, \*\*\* indicate significance at the 10%, 5% and 1% level, respectively

# Role of Real Global Activity

	Oil supply		
	(1) OPEC	(2) OECD	(3) Non-OECD/non-OPEC
Kilian real activity, quarterly average	-19.87*** (0.003)	25.37*** (0.001)	3.394** (0.023)
Kilian real activity, quarterly average, (-1)	3.282 (0.623)	-16.31 (0.197)	0.581 (0.714)
Kilian real activity, quarterly average, (-2)	7.926* (0.076)	1.957 (0.876)	2.744 (0.245)
Kilian real activity, quarterly average, (-3)	23.88** (0.027)	-16.80*** (0.006)	1.447 (0.161)
Kilian real activity, yearly average, (-1)	30.72 (0.260)	-1.927 (0.847)	6.185 (0.101)
Kilian real activity, yearly average, (-2)	28.93** (0.020)	-1.340 (0.964)	-0.806 (0.877)
Kilian real activity, yearly average, (-3)	14.66 (0.409)	-13.55 (0.655)	8.078** (0.035)
Kilian real activity, yearly average, (-4)	-9.552 (0.312)	18.20** (0.027)	-1.861 (0.565)
Kilian real activity, yearly average, (-5)	-4.019 (0.729)	-18.99 (0.487)	3.670 (0.267)
Kilian real activity, yearly average, (-6)	13.62 (0.503)	-10.14 (0.865)	3.537 (0.716)
Kilian real activity, yearly average, (-7)	42.67** (0.020)	-27.83** (0.031)	14.81*** (0.001)
Kilian real activity, yearly average, (-8)	62.24*** (0.005)	39.68 (0.110)	4.362 (0.300)
Kilian real activity, yearly average, (-9)	14.99 (0.364)	-39.89 (0.376)	-2.171 (0.735)
Observations	156	156	156

Pro-cyclical demand effects

Robust p-values in parentheses; \*, \*\*, \*\*\* indicate significance at the 10%, 5% and 1% level, respectively

Mostly pro-cyclical global demand effects

Mostly counter-cyclical global demand effects

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# Conclusions

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- **Dynamic structure of our main model is important**
  - **We find significant responses across all lags**
    - **Static models may only capture part of the effect**
  - **In some cases the signs switch along the lag spectrum**
    - **Static models may be misleading since net effect may differ**
- **Substantial heterogeneity across both country groups (and individual countries)**
- **Next steps:**
  - **Model optimization**
  - **Multiple Equations, e.g. SVAR**



**Thank you for your attention!**

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# References

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- Alhajji, A.F., Huettner, D., 2000. OPEC and World Crude Oil Markets from 1973 to 1994: Cartel, Oligopoly or Competitive? *Energy Journal* 21 (3), 31–60.
- Dvir, E., Rogoff, K. S., 2009. Three Epochs of Oil. NBER Working Paper No. 14927.
- Griffin, J.M., 1985. OPEC Behavior: A Test of Alternative Hypotheses. *American Economic Review* 75 (5), 954–963.
- Hotelling, H., 1931. The Economics of Exhaustible Resources. *Journal of Political Economy* 39, 137-75.
- Hubbert, M. K., 1956. Nuclear Energy and the Fossil Fuels. American Petroleum Institute Drilling and Production Practice, Proceedings of Spring Meeting, San Antonio, 7-25.
- Kaufmann, D., Kraay, A., Mastruzzi, M., 2009. Governance Matters VIII: Governance Indicators for 1996-2008. World Bank Policy Research Working Paper No. 4978.
- Kaufmann, R.K, Bradford, A., Belanger, L.H., McLaughlin, J.P., Miki, Y., 2008. Determinants of OPEC Production: Implications for OPEC Behaviour, *Energy Economics* 30, 333-351.
- Kilian, L., 2009. Not all Oil Price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market. *American Economic Review* 99 (3), 1053-1069.
- MacAvoy, P., 1982. *Crude Oil Prices as Determined by OPEC and Market Fundamentals*. Cambridge: Ballinger.
- Organization of the Petroleum Exporting Countries, 2006. *OPEC Long-Term Strategy*, Vienna.
- Ringlund, G.B., Rosendahl, K.E., Skjerpen, T., 2008. Does Oil Rig Activity React to Price Changes? An Empirical Investigation. *Energy Economics* 30, 371-396.
- Ramcharran, H., 2002. Oil Production Responses to Price Changes: An Empirical Application of the Competitive Model to OPEC and Non-OPEC Countries. *Energy Economics* 24, 97–106.
- Smith, J.L., 2005. Inscrutable OPEC? Behavioral Tests of the Cartel Hypothesis. *The Energy Journal* 26 (1), 51–82.
- Teece, D., 1982. *OPEC Behavior: An Alternative View* in Griffin, J.M., *OPEC Behavior and World Oil Prices*, London: Allen & Unwin.
- World Bank, *Worldwide Governance Indicators*. Data and extensive documentation available at <http://info.worldbank.org/governance/wgi/index.asp>.
- Wurzel, E., Willard, L., Ollivaud, P., 2009. Recent Oil Price Movements – Forces and Policy Issues. OECD Economics Department Working Paper No. 737.