Causes and Consequences of Oil Price Shocks: A VECM-Based Decomposition Analysis

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Introduction

- Significant oil price movements over the last decade and half
  - Latest oil price collapse in the second half of 2014
  - Renewed discussions of the causes and economic impacts

- Underlying causes of oil price movements important to:
  - Estimating the economic implications
  - Designing policy responses that avoid mistakes
  - Help stakeholders gauge potential future market conditions

- Studies of the recent oil price collapse just beginning to emerge:
  - Current study applies an econometric model of the US economy
  - Performs historical decomposition analysis up to the first quarter of 2015
Model Specification

• Structural vector error correction approach:

\[ \Delta X_t = \mu_t + \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t \]  
\[ \varepsilon_t = B\eta_t \]  

\( X_t = \text{Vector of } N \text{ endogenous variables for period } t \text{ (} t = 1...T \text{ periods);} \)
\( \mu_t = \text{Deterministic terms;} \)
\( \varepsilon = \text{Matrix of reduced-form residuals (shocks) with a non-singular covariance matrix } \Sigma_{\varepsilon}; \)
\( \eta = \text{Matrix of structural residuals with a diagonal covariance matrix } \Sigma_{\eta}; \)
\( B = \text{Contemporaneous impacts of shocks} \)
\( \Pi = \text{Matrix of long run parameters} \)
\( \Gamma_i \text{ (} i = 1...p \text{ lags) = Model parameter vectors of length } N. \)

• Implementation

• Quarterly model (1973:1 – 2015:1): 10 variables
• Tests indicated \( p = 4 \) lags and 3 cointegration vectors
• Johasen’s procedure used for long-run identification
• Order-independent procedure used for short-run identification
• See Oladosu G.A. (2015) for a more detailed description*

Data and Sources

- U.S. Energy Information Administration
- St. Louis Federal Reserve Database (FRED)
- Interpolated annual to quarterly data
  - 1973-1983
  - Non-US oil demand
  - Non-US OECD stock

*Variables in logs* (except federal funds and inflation rates)
Normalized IRF of oil prices: elasticities

- Impulse response functions (IRF): effects of a unit shock over time
- Mean impacts and 68% confidence interval
  - **Positive**: Own-shocks; global demand; inflation rate; federal funds rate
  - **Negative**: OPEC prod.-cap. ratio; exchange rate; OECD stock; real M1
  - **Changing signs**: real U.S. GDP; non-OPEC production
  - Real U.S. GDP shock represents a technology shock
Normalized IRF of real U.S. GDP: elasticities

- Impulse response functions (IRF): effects of a unit shock over time
- Mean impacts and 68% confidence interval
  - **Positive**: Own-shocks; non-OPEC production; demand; real exchange rate
  - **Negative**: Oil price; OPEC prod.-cap. ratio; real M1 money
  - **Changing signs**: OECD Stock; federal funds rate; inflation rate;
Dates of significant global events identified with bars:

- Timing of oil price shocks imply that it reflects many of these events
Model-based vs. other measures of oil price shocks

- All agree on the 1973 oil price shock
- Model-based shocks between 2003 and 2010 are small
  - Fundamentals accounted for oil price changes during the period
Historical economic/financial shocks

- Shocks do not match dates of major global events closely
  - Inflation rate is the only nominal variable in this model
  - Largest federal funds rate shock was in early 1980s
  - Monetary shocks in 2009 and 2011
  - Together these shocks capture global economic outlook/policy changes
Historical Decomposition: oil price (2001:2013)

- Difference between actual data and baseline forecast
  - Baseline is model forecast based on information up to 2000:4
  - Major drivers over this period: Global demand (+); real M1 money (+/-); real GDP (+); OPEC production-capacity ratio (+)
  - Other contributions: Own-shocks (-/+); inflation rate (+/-);

- Difference between actual data and baseline forecast
  - Baseline is model forecast based on information up to 2000:4
  - Largest contribution is negative own-shock (technology)
  - Other negative contributions: real exchange rate; inflation rate; non-OPEC production (small)

- Difference between actual data and baseline forecast
  - Baseline is model forecast based on information up to 2013:4

- Contributions to change in real WTI price:
  - Own-shocks (changing market sentiments: --)
  - Inflation rate shock (changing global economic outlook: -)

- Contributions to real U.S. GDP:
  - Own-shocks (--), real M1 supply (-); inflation rate (-); oil price (+)
CONCLUSIONS

- Recent oil price movements appear to be driven mainly by:
  - Oil market-specific and global economic outlook changes
  - OPEC production-capacity ratio has only a small effect
- Oil price recovery depends on:
  - Global economic outlook
  - Return of tight oil market sentiments
- Increasing U.S. production capacity
  - Restrains tight oil market sentiments
  - Reduces upside oil price risk
  - Geopolitical events (?)
  - Oil and gas investments (?)
- Global economic outlook
  - Quick global recovery ➔ upside risk for oil prices
  - Slow recovery or deteriorating outlook ➔ downside risk for oil prices
Additional Slides

- Difference between actual data and baseline forecast
  - Baseline is model forecast based on information up to 1973:4
  - Major drivers over this period: Own-shocks (+/-); global oil demand (-); non-OPEC production (+);
  - Other significant contributions: Real M1 (+/-); federal funds rate (-/+)

- Other contributions:
  - Real GDP (2005$trillion)

- **Difference between actual data and baseline forecast**
  - Baseline is model forecast with information up to 1973:4
  - Largest contribution is positive own-shock (technology)
  - Other contributions: real exchange rate (-); non-OPEC production (+); global demand (-); real WTI (-/+)

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**Legend:**
- Federal Funds Rate
- Non-OPEC Oil Production (mbpd)
- Real Exchange Rate (2005:1=1)
- Real WTI Price ($/bbl)
- Inflation Rate
- OECD Petroleum Stock (mbpd)
- Real GDP (2005$trillion)
- Total
- Global Oil Demand (mbpd)
- OPEC Production to Capacity Ratio
- Real M1 Money (2005$trillion)