Short-run Price-Inventory Dynamics in Crude Oil Market

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Research Questions
- What are the major contributors to the recent oil price swings?
- What is the role of speculation in oil price fluctuations?
- How would inventory data in addition to supply-demand help us better understand the oil price movements?

Contribution
- Study the inventory-price dynamics in an equilibrium model in which inventories, sales and prices are determined endogenously under rational expectation.
- Model speculation as a news shock
- Measure the contribution of different shocks to price and inventory movements empirically

Assumptions
- Competitive inventory-holding
  \[ P_t = \beta E_t[P_{t+1}] - E_t[MC_{t+1}] \]
- Net marginal cost of holding inventory
  \[ MC_{t+1} = P_t + \alpha \left( N_{t+1} - N_t \right) - \delta \Delta \left( N_{t+1} - N_t \right) - \beta \Delta \left( N_{t+1} - N_t \right) \]
- Demand
  \[ P_t = c \left( \frac{N_{t+1} - N_t}{\gamma} \right)^{-\delta} \]
- Supply \( Q_t \)
  \[ \log(Q_t) = \log(Q_{t-1}) + \log(\mu_t) \]
  \[ \log(\mu_t) = \bar{\mu} + \epsilon_t \sim N(0, \sigma_{\mu}^2) \]
- Relative Supply \( \frac{Q_t}{N_t} \)
  \[ \log \frac{Q_t}{N_t} = y_t + \eta_t \]
  \[ y_t = \rho y_{t-1} + \epsilon_t \]
  \[ \epsilon_t \sim N(0, \sigma_{\epsilon}^2) \]
  \[ \eta_t = \rho \eta_{t-1} + \epsilon_t \]
  \[ \epsilon_t \sim N(0, \sigma_{\eta}^2) \]
- Shocks
  \( y_t \): persistent shock; \( \eta_t \): temporary shock; \( \epsilon_t \): news shock

Model
- Rational expectation, equilibrium model
- Current and future shocks affect current and future world supply relative to demand which in turn determine inventory decision and the equilibrium price

Methodology and Data
- Linearize the equations around the deterministic steady state and solve the resulting linear rational expectations model as in Blanchard and Kahn (1980)
- Write the solved model in a state space form with the effective inventory and the exogenous shocks as the states
- Estimate using maximum likelihood method
- Monthly data on crude oil price, inventory, and oil supply from January 1988 to April 2011

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