VAR Intro: Oil Demand and Supply Shocks (Kilian 2009)

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Common view: macroeconomic variables respond to oil prices, not vice versa

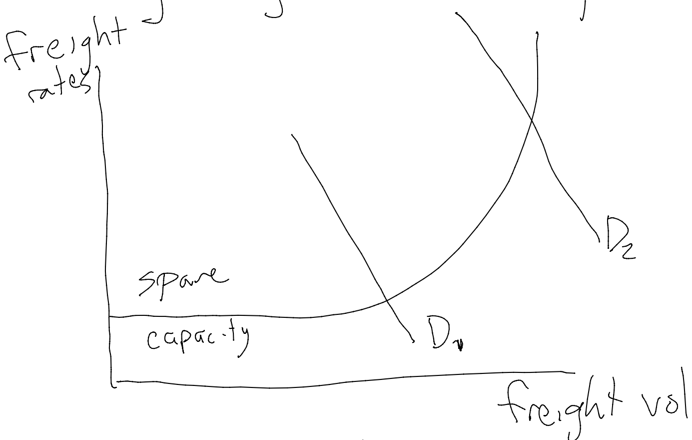
Problems with this:
- Macroeconomics might also drive oil markets
- Oil has its own global supply and demand shocks that affect the U.S economy AND the oil market (e.g., global aggregate demand).

Need to identify global crude oil demand and supply shocks separately

This paper:
- Use new measure of monthly global real economic activity: dry cargo ocean freight rates
- Decompose real oil price into
1. Crude oil supply shocks
2. Global industrial commodity demand shocks (aggregate demand)
3. Global crude oil-specific demand shocks - precautionary demand
    a. Related to convenience yield because of uncertainty over **real** demand or supply
    b. Driven by expectations (unobservable)

Findings:
- Supply shocks don't explain nearly all the variation in oil prices

Dry cargo ocean freight rates



deflates + detrend + log

rea_t

System equations

$$\Delta prod_t = \phi_{10} + \text{lags } \Delta prod_{t-s} + \text{lags } rea_{t-s} + \text{lags } rpo_{t-s} + \varepsilon_t^S$$

$$rea_t = \phi_{20} + \phi_{21}\Delta prod_t + \text{lags } \Delta prod_{t-s} + \text{lags } rea_{t-s} + \text{lags } rpo_{t-s} + \varepsilon_t^{AD}$$

$$rpo_t = \phi_{30} + \phi_{31}\Delta prod_t + \phi_{32} rea_t + \text{lags of } \Delta prod, rea, rpo + \varepsilon_t^{PD}$$

uncorrelated

Rewrite w/ current stuff on left

$$\Delta prod_t = \text{lags of all 3} + \varepsilon_t^S$$

$$-\phi_{21}\Delta prod_t + rea_t = \text{lags of all 3} + \varepsilon_t^{AD}$$

$$-\phi_{31}\Delta prod_t + -\phi_{32} rea_t + rpo_t = \text{lags of all 3} + \varepsilon_t^{PD}$$

$$\begin{bmatrix} 1 & 0 & 0 \\ -\phi_{21} & 1 & 0 \\ -\phi_{31} & -\phi_{32} & 1 \end{bmatrix} \begin{bmatrix} \Delta prod_t \\ rea_t \\ rpo_t \end{bmatrix} = \begin{bmatrix} \phi_{10} \\ \phi_{20} \\ \phi_{30} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \Delta prod_{t-1} \\ rea_{t-1} \\ rpo_{t-1} \end{bmatrix} + \dots + \underset{3\times3}{\underset{\sim}{A}_p} \cdot \underset{3\times1}{\underline{Z}_{t-p}} + \begin{bmatrix} \varepsilon_t^S \\ \varepsilon_t^{AD} \\ \varepsilon_t^{PD} \end{bmatrix}$$

$$\begin{bmatrix} \cdots \\ -\phi_{31} & -\phi_{32} & 1 \end{bmatrix} \begin{bmatrix} \cdots \\ rpo_t \end{bmatrix} = \begin{bmatrix} \cdots \\ \phi_{30} \end{bmatrix} + \begin{bmatrix} \cdots \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \cdots \\ rpo_{t-1} \end{bmatrix} + \cdots \underset{3\times 3}{\cdots_p} \underset{3\times 1}{\cdots_{t-p}} + \begin{bmatrix} \cdots \\ \varepsilon_t^{PD} \end{bmatrix}$$

$$\underset{3\times 3}{\underset{\sim}{A}_0} \qquad \underset{3\times 1}{\underline{z}_t} \qquad \underline{\alpha} \qquad \underset{3\times 3}{\underset{\sim}{A}_1} \qquad \underset{3\times 1}{\underline{z}_{t-1}}$$

structural matrix

$$\underset{\sim}{A}_0 \underline{z}_t = \underline{\alpha} + \sum_{s=1}^{p} \underset{\sim}{A}_s \underline{z}_{t-s} + \underline{\varepsilon}_t$$

structural vector autoregression (VAR)

$$\Longrightarrow \underset{3\times 1}{\underline{z}_t} = \underbrace{\underset{3\times 3}{\underset{\sim}{A}_0^{-1}} \underset{3\times 1}{\underline{\alpha}}} + \sum_{s=1}^{p} \underbrace{\underset{3\times 3}{\underset{\sim}{A}_0^{-1}} \underset{3\times 3}{\underset{\sim}{A}_s}} \underline{z}_{t-s} + \underline{e}_t \qquad \underline{e}_t = \underline{\underset{\sim}{A}_0^{-1} \underline{\varepsilon}_t}$$

reduced ~~form~~ VAR

structural shocks

$$\underline{\varepsilon}_t = \begin{bmatrix} \varepsilon_t^{S} \\ \varepsilon_t^{AD} \\ \varepsilon_t^{PD} \end{bmatrix}$$

uncorrelated w/ each other

$$\underset{\sim}{e}_t = \begin{bmatrix} e_t^{sprod} \\ e_t^{rea} \\ e_t^{rpo} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{S} \\ \varepsilon_t^{AD} \\ \varepsilon_t^{PD} \end{bmatrix}$$

structural shocks

reduced form shocks

$$\underset{\sim}{A}_0^{-1} \cdot \underline{\varepsilon}_t$$

correlated across equations

$$e_t^{sprod} = a_{11} \varepsilon_t^{S}$$

$$e_t^{rea} = a_{21} \underline{\varepsilon_t^{S}} + a_{22} \underline{\varepsilon_t^{AD}}$$

$$e_t^{rpo} = a_{31} \varepsilon_t^{S} + a_{32} \varepsilon_t^{AD} + a_{33} \varepsilon_t^{PD}$$

Ultimately we want

$$\frac{\partial rpo_{t+s}}{\partial \varepsilon_t^{AD}} \quad \text{for different values of } s$$

$$\frac{\partial rea_{t+s}}{\partial \varepsilon_t^{S}} \quad \text{" " " "}$$

Impulse Response Function (IRF)

$\partial rpo_{...}$

Impulse Response Function (IRF)

$$\frac{\partial rpo_{t+s}}{\partial e_t^{rea}}$$