Oil Price Uncertainty in a Small Open Economy

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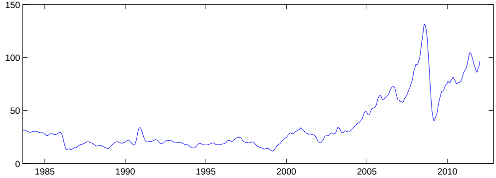
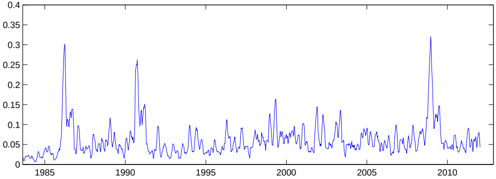
Oil price volatility is high and it varies over time...



(a) Mean



(b) Coefficient of Variation

Notes: Weekly WTI crude oil prices (90-day moving windows). Data source is Bloomberg.

High volatility creates instability and undermines confidence

- Statement by Gordon Brown and Nicolas Sarkozy on WSJ July 8, 2009

  "For two years the price of oil has been dangerously volatile...First it rose by more than $80 a barrel, then fell rapidly by more than $100, before doubling to its current level of around $70....such erratic price movement in one of the world's most crucial commodities is a growing cause for alarm...The risk is that a new period of instability [in oil prices] could undermine confidence just as we are pushing for recovery..."

- OPEC Chief El-Badri on January 31, 2012

  "Volatility is bad for investment. If there is conflict [in Iran] we really cannot invest, there will be clouds all over the investment projects."

Literature on oil price volatility

Empirical: Ferderer (1996), Guo and Kliesen (2005) and Elder and Serletis (2010)

- Negative effect of higher oil price volatility on investment and output growth
- Oil price volatility can partly account for the asymmetric relationship between output growth and oil price changes.

Theoretical:

- Bernanke (1983) and Pindyck (1991)
  - uncertainty about oil prices induce firms to postpone investment decisions
- Plante and Traum (2011)
  - investment can increase in response to oil price volatility due to higher precautionary savings channeled towards domestic capital in a closed economy RBC model

What we do in this paper

- analyze the effects of oil price volatility shocks in an oil-importing small open economy
- show the importance of the degree of financial market integration for the effects of oil price shocks
- compare the implications of level and volatility shocks
- discuss the role of volatility shocks in accounting for the asymmetry puzzle

Main features of the model

- Small open economy RBC model similar to Mendoza (1995)
- Trade in a single international bond subject to portfolio adjustment costs
  - The scale of portfolio adjustment costs captures the degree of financial market integration
- Tradable and non-tradable good sectors
- Oil in consumption and production as in Kim and Loungani (1992) and Blanchard and Gali (2007)
- Stochastic volatility in real oil prices and sectoral TFP shocks modeled as in Benigno et al. (2010)

Households

Final good consumption, C_t, is composed of tradable, C_t^T, and non-tradable goods, C_t^N:

$$C_t = \left[\gamma^{\frac{1}{\kappa}} \left(C_t^T\right)^{\frac{\kappa-1}{\kappa}} + (1-\gamma)^{\frac{1}{\kappa}} \left(C_t^N\right)^{\frac{\kappa-1}{\kappa}}\right]^{\frac{\kappa}{\kappa-1}} \tag{1}$$

Oil enters the tradable consumption good:

$$C_t^T = \left[\nu^{\frac{1}{\xi}} \left(C_t^Q\right)^{\frac{\xi-1}{\xi}} + (1-\nu)^{\frac{1}{\xi}} \left(C_t^O\right)^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}} \tag{2}$$

Households choose C_t, h_t, K_{t+1} and B_{t+1} to maximize lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\eta}}{1+\eta}\right), \tag{3}$$

subject to

$$I_t + \frac{\Phi^K}{2}(K_{t+1}-K_t)^2 + C_t^T + \frac{P_t^N}{P_t^T} C_t^N + B_{t+1} = w_t h_t + r_t K_t + RB_t - \frac{\Phi^B}{2}(B_{t+1}-B_t)^2, \tag{4}$$

$$I_t = K_{t+1} - (1-\delta)K_t \tag{5}$$

Firms

Tradable and non-tradable sector firms operate in perfectly competitive markets and require capital, labor and imported oil for production.

$$Y_t^i = \left[a_i^{\frac{1}{\theta}} \left(A_t^i (h_t^i)^{\alpha^i} (K_t^i)^{1-\alpha^i} \right)^{\frac{\theta-1}{\theta}} + (1-a_i)^{\frac{1}{\theta}} \left(O_t^i \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \; i = T, N.$$

Each period, they choose h_t^i, K_t^i and O_t^i to maximize profit

$$\Pi_t^i = \frac{P_t^i}{P_t^T} Y_t^i - w_t h_t^i - r_t K_t^i - \frac{P_t^O}{P_t^T} O_t^i, \; i = T, N.$$

Shocks to real oil prices

- The stochastic process for real oil prices:

$$log\left(\frac{P^O_{t+1}}{P_{t+1}}\right) = \rho^P log\left(\frac{P^O_t}{P_t}\right) + \mu_{P,t}\epsilon_{t+1}, \tag{6}$$

- The variance of oil prices can stochastically change over time for a given level of prices:

$$\mu^2_{P,t+1} = (1-\rho^{\mu_P})\bar{\mu}^2_P + \rho^{\mu_P}\mu^2_{P,t} + \psi^2_P\zeta_{P,t+1}, \tag{7}$$

  where $\zeta_{P,t}$ is i.i.d. with zero mean and unit variance.
- We solve the model using the methodology developed by Benigno et al. (2010)
  - It is sufficient to consider a second-order approximation around the steady-state to have a distinct and separate role for volatility shocks.
  - Assumption: Exogenous state variables follow conditionally linear stochastic processes

Calibration

Standard parameters

- $\beta = 0.99$, constant discount factor
- $\sigma = 2$, coefficient of constant relative risk aversion
- $\eta = 5$, inverse of the Frisch elasticity of labor supply
- $\kappa = 0.41$, elasticity of substitution (eos) between traded and non-traded goods
- $\alpha^T = 0.67$, labor share in tradable sector value added
- $\alpha^N = 0.99$, labor share in non-tradable sector value added
- $\gamma = 0.43$, weight on tradable goods in total consumption
- $\delta = 0.025$, depreciation rate of capital
- $\Phi^K = 0.028$, capital adjustment cost parameter
- $B/Y = -0.25$, foreign bonds as a ratio of GDP
- $\Phi^B = 0.01, 1000$, portfolio adjustment cost parameter

Calibration-2

Parameters regarding oil use

- $\xi = 0.25$, eos between oil and non-oil goods in tradable consumption
- $\theta = \phi = 0.40$, eos between oil and non-oil goods in production
- $1 - \nu = 0.08$, weight on oil in tradable goods consumption
- $1 - a_T = 1 - a_N = 0.05$, weight on oil in production

Parameters regarding the shock processes

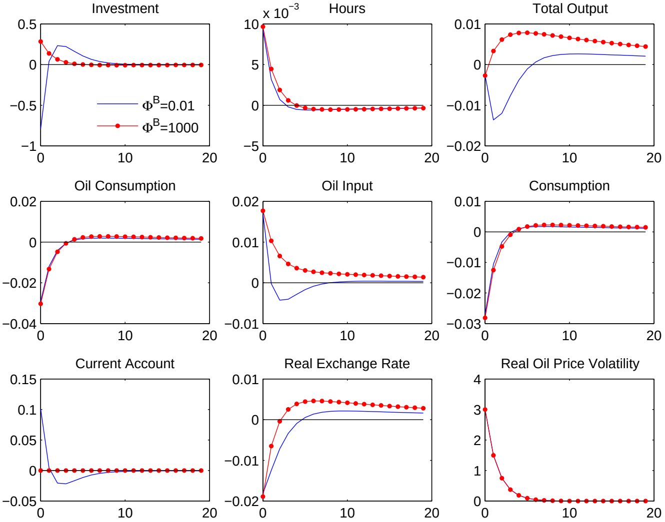
- $\rho^T = \rho^N = 0.90$, persistence of TFP level shocks
- $\rho^P = 0.95$, persistence of oil level shocks
- $\rho^{\mu_T} = \rho^{\mu_N} = \rho^{\mu_P} = 0.50$, persistence of volatility shocks
- $\bar{\mu}_T^2 = \bar{\mu}_N^2 = \bar{\mu}_P^2 = 0.009^2$, variance of level shocks
- $\psi_T^2 = \psi_N^2 = \psi_P^2 = (0.009/10)^2$, variance of volatility shocks

The Effect of Uncertainty on Physical Investment: Intuition

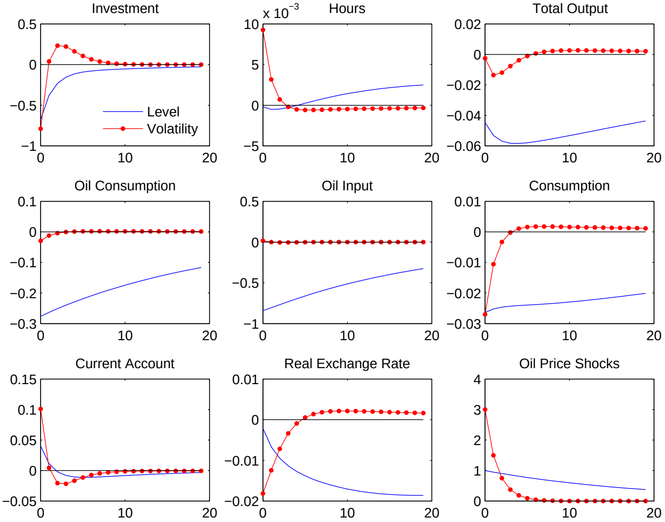
- Households can save either by accumulating capital, K_{t+1}, or by buying international bonds, B_{t+1}
- An increase in oil price volatility leads to
  1. higher labor income risk
     $\Rightarrow$ precautionary saving effect ($K_{t+1} \uparrow$, $B_{t+1} \uparrow$)
  2. more risky returns to domestic savings (physical capital)
     $\Rightarrow$ precautionary saving effect ($K_{t+1} \uparrow$, $B_{t+1} \uparrow$) and substitution effect ($K_{t+1} \downarrow$, $B_{t+1} \uparrow$)
- The overall impact on K_{t+1} depends on which effect dominates: precautionary saving or substitution effect?

IRFs to Three S.D. Increase in Oil Price Volatility-Normalized

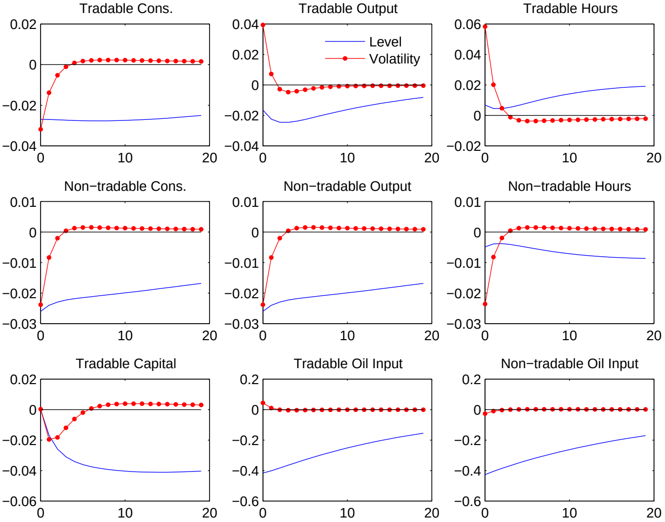
Sectoral effects



Comparing level and volatility shocks



Comparing level and volatility shocks: sectoral effects



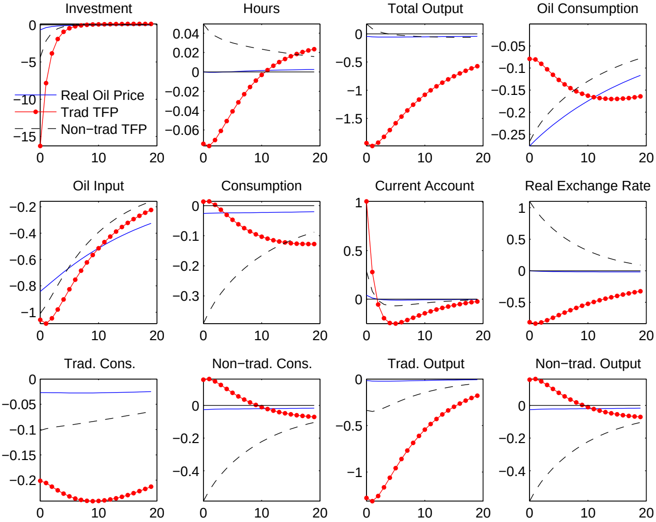
Addressing the asymmetry puzzle

- Empirical literature documents the asymmetric effects of oil price changes: increases are associated with a slowdown in growth but decreases do not necessarily lead to higher growth.
  - Mork (1989), Mork et al. (1994), Ferderer (1996)...
- Our model suggests that considering level shocks alongside volatility shocks can account for this asymmetry.
- If increases and decreases in oil prices are associated with higher uncertainty,
  - adverse effects of an increase in oil prices are exacerbated while
  - favorable effects of a decrease are mitigated.

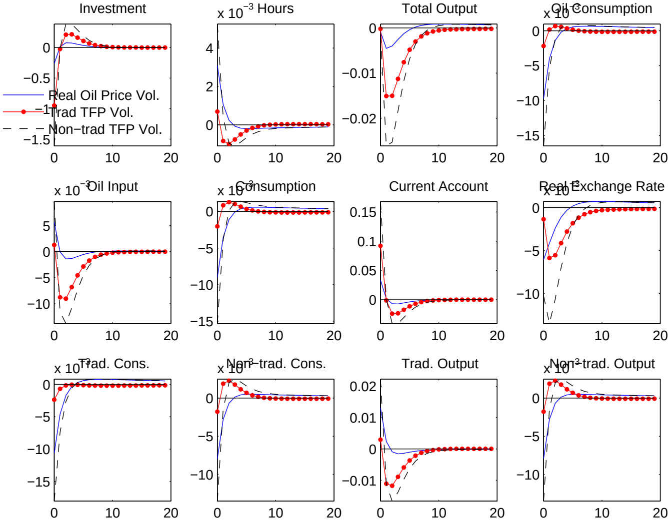
Oil price shocks versus TFP shocks

- Adverse oil price level shocks affect investment, tradable consumption and output in a similar way compared to adverse TFP level shocks
- The main difference is that TFP level shocks have different sectoral effects than oil price level shocks
- Shocks to the volatility of oil prices and sectoral TFP's have very similar implications as they all imply an increase in income uncertainty and mainly work through the precautionary saving channel

Comparing *level* shocks to real oil prices and sectoral TFP's



Comparing *volatility* shocks to real oil prices and sectoral TFP's



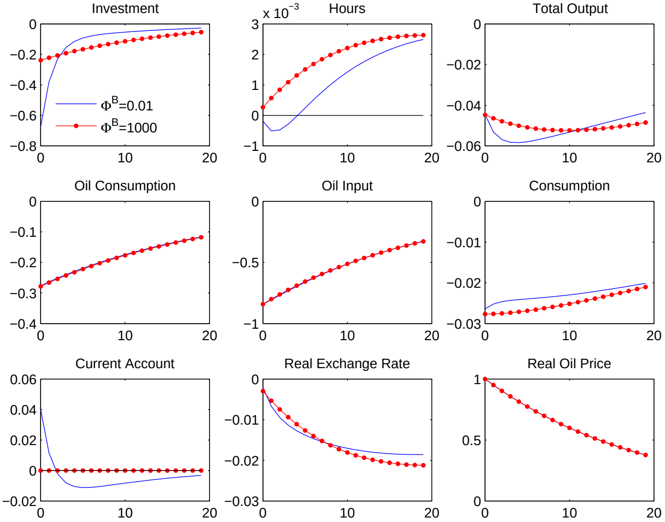
Summary

- We analyze the effects of oil price volatility shocks in an oil-importing small open economy.
- Whether or not domestic agents have access to foreign savings is important for the response of investment and economic activity to volatility shocks.
- In the case of financial autarky, precautionary savings resulting from higher uncertainty are channeled towards domestic capital. This implies an increase in investment and output which is at odds with the empirical evidence.
- The availability of internationally traded bonds as an extra asset can overturn this result.
- The co-existence of level and volatility shocks can generate an asymmetry in the way the economy responds to increases and decreases in oil prices in line with the empirical evidence.

APPENDIX

IRFs to a One S.D. Adverse Oil Price Level Shock-Normalized

Sectoral effects



IRFs to a One S.D. Adverse Oil Price Level Shock-Normalized

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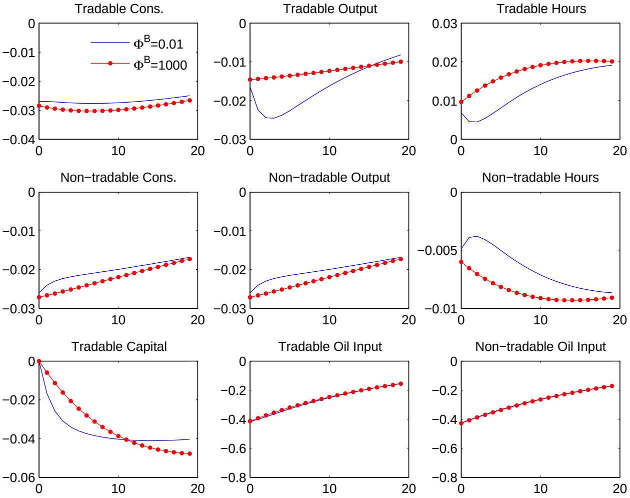

IRFs to Three S.D. Increase in Oil Price Volatility-Normalized

Sectoral effects

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