On the Sources and Consequences of Oil Price Fluctuations: The Role of Storage

Deren Unalmis (CBRT), Ibrahim Unalmis (CBRT),
and D. Filiz Unsal (IMF)

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Motivation

- 1970s: Oil price shocks were believed to have a dramatic impact on the economy.
  —— Most U.S. postwar recessions are caused by oil price increases (Hamilton, 1983,1996).

- This view has recently been challenged (Bernanke et al., 1997, Barsky and Kilian, 2002)
  —— The linear relation between oil prices and economic activity has diminished since 1973 (Hooker, 1996).

Motivation

- 2000s: Inflation was low and growth remained high and stable, despite high oil prices.
  —— This disconnect can be accounted for by more flexible labor markets and lower oil intensity in production (Blanchard and Gali, 2010).

- Recently, greater focus on the origins of oil price shocks (Guerrieri, 2005, Baumeister and Peersman, 2009, Lippi and Nobili, 2009, Unalmis et al., 2009).
  —— Kilian (2009) distinguishes "oil supply shocks", "aggregate demand shocks", and "precautionary/speculative demand shocks". The latter refers to a change in the demand for oil without a change in the expected oil production or economic activity.

Related Literature

- Increased interest in the empirical relevance of expectations and its role in speculative oil demand (Kilian, 2008, 2009, Kilian and Murphy, 2010, and Kilian, 2010).

- However, recent theoretical contributions neglect the role of (speculative) storage on oil price movements.

- This is the first paper in the literature that explicitly incorporates oil (commodity) storage in a general equilibrium, New Keynesian framework.

In this paper

- We construct a sticky-price DSGE model in which oil is used in consumption, production and can also be stored.
- We investigate the implications of various shocks for the oil market (price, storage of oil).
  — These shocks include total factor productivity (TFP), labor productivity, fiscal and monetary policy.
- We also investigate the macroeconomic effects of shocks that originate in the oil market.
  — Oil supply and speculative demand.
- We estimate the model for the U.S. economy with Bayesian methods.
  — We compare versions of the model with and without storage.

Results

- Oil price changes are mainly driven by productivity shocks, but oil supply shocks and speculative oil demand shocks also play a role.
  —— TFP shocks were especially prominent in the 2000s. Oil supply and speculative demand shocks were less of a factor.
  —— Ignoring storage causes a sizable upward bias in the estimated contribution of oil supply shocks to oil price volatility.
- The role of storage is ambiguous.
  —— It makes oil prices more responsive to a productivity shock, and less responsive to an oil supply shock.
  —— The reason for this is a new transmission channel that works via the impact of interest rate changes on storage activity.

The Model

- A canonical NK model with "bells and whistles".

  —— The economy is populated by households, production firms, a government, a monetary authority, and speculative storers.

  —— Empirically relevant features: habit formation, inflation indexation, and investment adjustment costs.

  —— Staggered prices in the non-oil sector.

  —— Government follows a balanced budget; finances its expenditures by lump-sum taxation.

  —— Monetary policy is described by a Taylor rule.
- Oil is consumed directly and also used as an input in production.

The Model

- Speculative Oil Storers

—— Speculative oil storage based on competitive storage model a la Williams and Wright (1982, 1984, 1991) and Deaton and Laroque (1992, 1994).
—— Competitive oil storers—*competitive speculators*—carry forward oil as out-of-ground oil inventories.
—— They buy oil from the producers and decide how much to sell or store through an intertemporal arbitrage condition.

The Model

- Speculative Oil Storers

— The profit per unit stored is the difference between future (expected, discounted) and current price, net of storage costs and waste:

$$\frac{aE_t(P_{o,t+1})}{R_t} - P_{o,t}(1 + \Upsilon(S_t)) \text{ where } \Upsilon(S_t(z)) = \kappa + \frac{\Psi}{2}S_t(z)$$

— Whenever expected oil price appreciation exceeds the marginal storage cost, speculators increase their stockholding until arbitrage is restored.

— The log-linearized storage demand equation is:

$$s_t = \Theta(E_t\{\widehat{p_{o,t+1}}\} - \widehat{p_{o,t}} - (r_t - \pi_{t+1})) + sd_t$$

The Model

- Oil Market Equilibrium

—— The total quantity demanded by households and firms is equal to the new production, plus old inventories net of depreciation, minus new inventories:

$$O_{c,t} + O_{y,t} = O_{s,t} + aS_{t-1} - S_t$$

—— An increase in the expected price of oil raises storage, which in turn creates excess demand and drives current prices up.
—— Oil supply is assumed to follow an exogenous process.

Estimation

- Bayesian estimation of most parameters of the model (An and Schorfheide, 2007) for the US economy. Others are calibrated.

- 7 observables: output (per capita) growth, investment (per capita) growth, CPI inflation, interest rate, real price of oil and oil storage (per capita) growth.

- Sample period: 1982:1-2007:4.

Variance Decomposition (1982:1-2007:4)

Benchmark

	quarter	ε_{tfp}	ε_{l}	ε_{g}	ε_{mp}	ε_{os}	ε_{sd}
Real Price of Oil	4	32.49	28.37	9.73	3.48	14.87	11.06
	8	24.06	47.15	5.88	2.16	12.74	8.01
	12	17.99	60.72	4.12	1.54	9.91	5.73
	50	6.02	87.04	1.30	0.49	3.26	1.89

No Storage

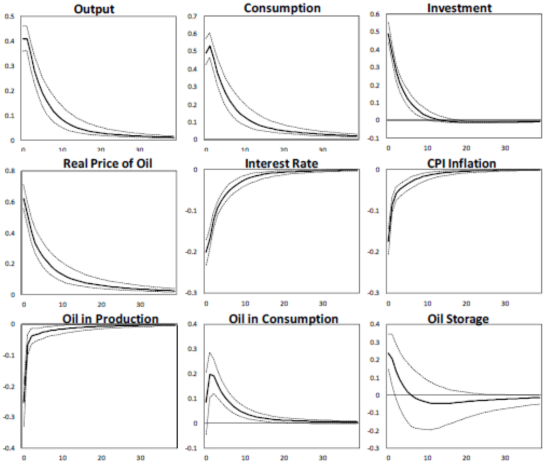
	quarter	ε_{tfp}	ε_{l}	ε_{g}	ε_{mp}	ε_{os}
Real Price of Oil	4	25.25	24.76	11.07	2.89	36.03
	8	18.01	38.69	8.95	1.54	32.82
	12	13.12	50.47	6.95	1.03	28.44
	50	3.50	83.32	2.05	0.25	10.87

Variance Decomposition (2000:1-2007:4)

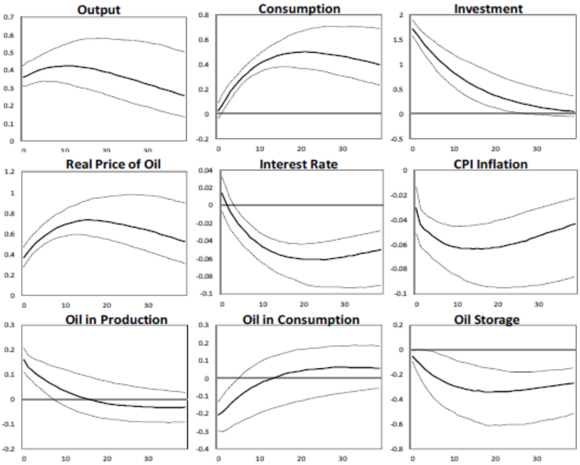
Benchmark							
	quarter	ε_{tfp}	ε_{l}	ε_{g}	ε_{mp}	ε_{os}	ε_{sd}
Real Price of Oil	4	51.73	23.88	4.92	6.29	5.65	3.52
	8	39.38	43.29	3.10	6.71	4.92	2.59
	12	29.80	57.48	2.20	4.84	3.83	1.85
	50	9.49	86.84	0.66	1.45	1.18	0.59

No Storage						
	quarter	ε_{tfp}	ε_{l}	ε_{g}	ε_{mp}	ε_{os}
Real Price of Oil	4	51.91	13.00	9.77	1.83	23.50
	8	44.76	27.18	8.08	1.09	18.89
	12	36.70	41.23	6.48	0.78	14.80
	50	12.49	80.50	2.19	0.23	4.59

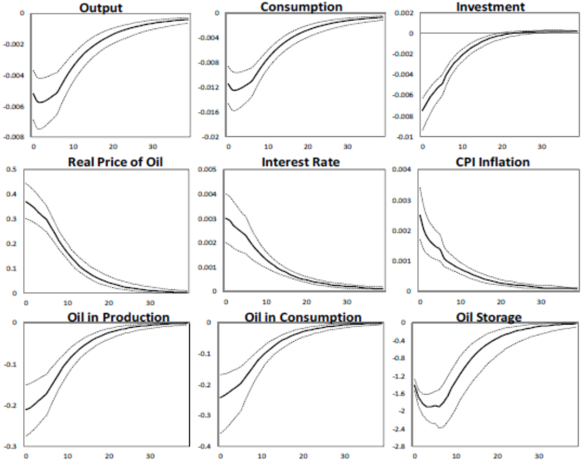
Positive TFP Shock



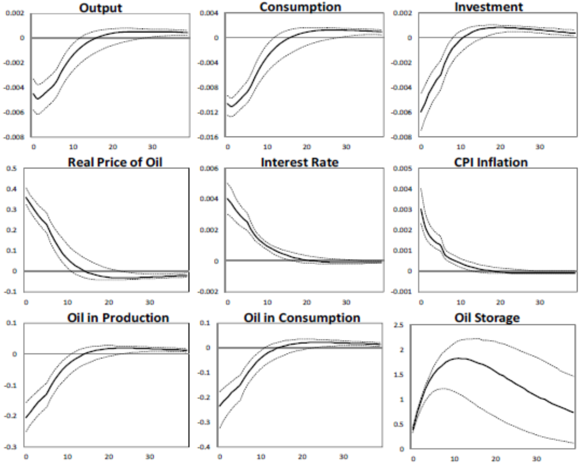
Positive Labor Productivity Shock



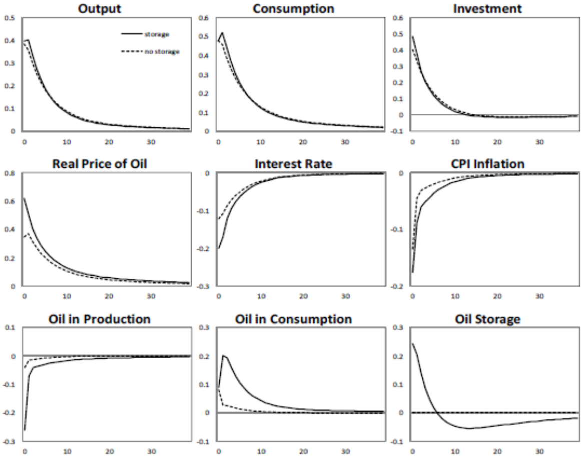
Negative Oil Supply Shock



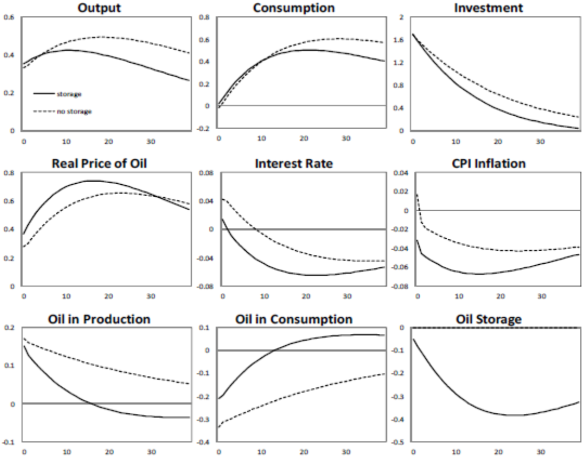
Positive Storage Demand Shock



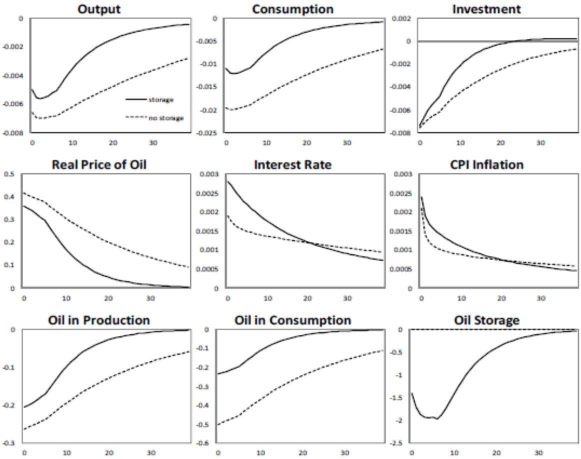
Positive TFP Shock: With and Without Storage



Positive Labor Productivity Shock: With and Without Storage



Negative Oil Supply Shock:With and Without Storage



Conclusion

- Distinguishing "oil demand shocks" from "oil supply shocks" is simplistic. Different demand-side shocks could have different transmission channels and consequences.
  —— Productivity shocks are increasingly the most important driver of oil prices changes. The role of oil supply shocks and speculative oil demand shocks decreased in 2000s.

- Policymakers should incorporate oil inventories data and speculative demand shocks into their policy analysis.
  —— Incorporating storage provides a new transmission channel via endogenous responses of storage to interest rate changes.
  —— Ignoring speculative oil shocks results in overstating the importance of oil supply shocks.