Investment-Uncertainty Relationship in Oil and Gas Industry

Maryam Ahmadi

Mehdi Sadeghzadeh

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- Investment is positively affected by uncertainty as long as the marginal productivity of capital is a convex function of prices.

  (Hartman [1972], Abel [1983], Stevens [1974] and Nickell [1980])

The Other strand: Option theory of investment

- Irreversibility and the possibility to delay are important characteristics of investment.
- The value of the investment includes the value of the waiting option.
- Investment project is adopted if the expected payoff is greater than the cost of investment plus the value of the waiting option.
- For sunk investment, an increase in uncertainty leads to an increase in the waiting value.
- Hence, investment is negatively affected by uncertainty.

(McDonald and Sigel [1986], Favero et al. [1992], Carruth et al. [1998], Bond and Cummins [2004], Sarkar [2000], Abel et al. [1996] and Caballero and Leahy [1991])

One important source of uncertainty is uncertainty about the output price (oil).

Increased oil price uncertainty raises the option value of waiting to invest and therefore firms postpone their investment decisions.

(Bernanke [1983], Misund and Mohn [2009] and Ratti and Yoon [2011])

Favero et al. [1992]: The effect of uncertainty on investment is a function of the expected price level.

Misund and Mohn [2009]: Tobin's Q is a poor investment indicator for the international oil and gas industry and uncertainty contribute significantly to the explanation of investment.

Hurn and Wright [1994]: The expected price of oil is important in influencing the appraisal duration but the variance of the oil price is not.

Elder and Serletis [2010]: Oil price volatility reduces aggregate investment in the United States. Similar result is found in Elder and Serletis [2010b] for Canada.

Lee et al. [2011]: An oil price shock has a greater effect on delaying a firms investment the greater the uncertainty faced by that firm.

What is an Oil Price Shock?

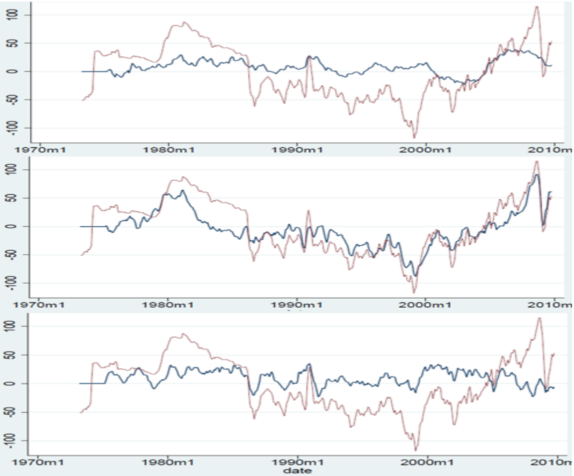
- Standard definition:
  An unexpected change in the price of oil (innovation of the oil price series)
- Other definitions:
  1. A sustained change in the price of oil.
  2. A spike in the price of oil (rare in the data, but common in public debate).
  3. An increase in the price of oil beyond its highest value in recent memory.
- All definitions implicitly assume that oil prices are exogenous.

Oil market

But ...

- Oil price is not exogenous with respect to macroeconomic variables. (Hamilton [2009], Dvir and Rogoff [2010], Kilian and Park [2009], Alquist and Kilian [2010])
- Oil market has three main participants:
  - oil producers, basically oil producing countries,
  - oil consumers, mainly industries,
  - speculators.
- The factors affecting oil prices
  1- the amount of oil coming out of the ground, flow supply,
  2- the amount of oil being consumed, flow demand,
  3- the amount of above-ground oil inventory, stock demand/speculative demand.
- There are important differences in the relative contribution of the three factors to the real price of oil.

Historical Decomposition of the Real Price of oil



- The concluding result of many empirical studies (recent literature on oil market): Demand shocks better explain oil price changes.

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- If so, what is the implication for investment in oil industry?
- It leaves a room for further research on the relation between oil price changes and investment decisions.

Graph generating Model

$$A_0 Z_t = \alpha + \sum_{i=1}^{24} A_i Z_{t-i} + \varepsilon_t.$$

$$Z_t = (\Delta oil\ production, real\ activity, real\ oil\ price)'$$

$$\varepsilon_t \equiv (supply\ shock, demand\ shock, other\ oil\ shocks)'$$

$$e_t \equiv \begin{pmatrix} e_{1t}^{\Delta oil\ production} \\ e_{2t}^{real\ activity} \\ e_{3t}^{real\ price\ of\ oil} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_{1t}^{oil\ supply\ shock} \\ \varepsilon_{2t}^{oil\ demand\ shock} \\ \varepsilon_{3t}^{oil-specific\ shocks} \end{pmatrix}$$

Baseline Model

$$A_0 Z_t = \alpha + \sum_{i=1}^{24} A_i Z_{t-i} + \varepsilon_t.$$

$$Z_t = (\Delta oil\ production, real\ activity, \Delta real\ oil\ price, stock\ return)'$$

$$\varepsilon_t \equiv (supply\ shock, demand\ shock, other\ oil\ shocks, stock\ market\ shock)'$$

$$e_t \equiv \begin{pmatrix} e_{1t}^{\Delta oil\ production} \\ e_{2t}^{real\ activity} \\ e_{3t}^{\Delta real\ price\ of\ oil} \\ e_{4t}^{stock\ market\ return} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} \varepsilon_{1t}^{oil\ supply\ shock} \\ \varepsilon_{2t}^{oil\ demand\ shock} \\ \varepsilon_{3t}^{oil-specific\ shocks} \\ \varepsilon_{3t}^{stock\ market\ shocks} \end{pmatrix}$$

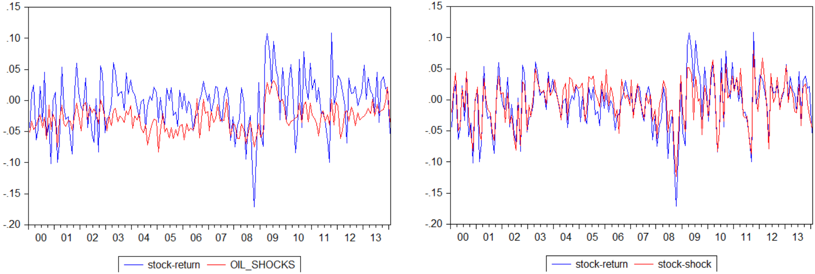

Figure: Historical decomposition of aggregate stock market return

Investment Model

$$(\frac{I}{K})_{it} = b_0 + b_1(\frac{I}{K})_{it-1} + b_2 Q_i t - b_3 Q_{it-1} + B_1 X_{it} + B_2 X_{it-1} + \eta_i^* + \zeta_t^* + \nu_{it}$$

$$X_t = [\sigma^2_{supply}, \sigma^2_{demand}, \sigma^2_{oil-specific}, \sigma^2_{stock}]_t$$

The panel regression is estimated by applying two-step system generalized method of moments (system GMM) proposed by Blundell and Bond[1998].

Data

A panel of 60 U.S. firms in oil and gas industry annual data from 2000 to 2013 from COMPUSTAT

Monthly stock returns are from CRSP.

Oil market factors are from U.S. department of energy.

Real activity data is from Kilian website.

Volatility of oil price and stock market return is obtained by fitting a GARCH(1,1) model on the simulated series for oil price and stock market return.

Estimation results

	Coefficient	Corrected Standard Error	Prob
$\frac{I}{K}(-1)$	0.392*	(0.062)	0.000
Q	0.633**	(0.253)	0.012
Q(-1)	0.254	(0.207)	0.220
σ^2_{supply}	0.044	(0.101)	0.663
$\sigma^2_{supply(-1)}$	-0.065	(0.106)	0.539
σ^2_{demand}	-0.165*	(0.028)	0.000
$\sigma^2_{demand(-1)}$	0.039	(0.029)	0.181
$\sigma^2_{oil-specific}$	-0.028	(0.033)	0.397
$\sigma^2_{oil-specific(-1)}$	-0.021	(0.027)	0.442
σ^2_{stock}	-0.067*	(0.020)	0.001
$\sigma^2_{stock(-1)}$	0.032	(0.030)	0.284
_cons	0.167*	(0.033)	0.000
AR(1)	-3.53		0.000
AR(2)	1.53		0.125
Hansen	55.01		0.994

Values in parenthesis are standard errors,
*, ** and *** indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table: Estimation results from investment model using two-step system GMM estimation methodology

Conclusion

- ✓ No significant relation when uncertainty comes from oil supply or oil market specific demand shocks.
- ✓ A significant but transitory negative effect when uncertainty comes from global demand shock.
- ✓ A significant negative effect from stock market uncertainty on investment.
- ✓ Q is not sufficient to explain investment decision of firms.
- ✓ There is important role for uncertainty in investment decisions of firms, consistent with option theory of investment.

Thanks for you your patience

Applying 24 months of lags:

- Hamilton and Herrera [2004] and Kilian and Park [2009] moving cycles in the oil market are very slow and a low number of lag would fail to capture the whole dynamics of the cycle.
- The alternative way of setting the lag order is Testing the goodness of fit using information criteria. However, some researchers argue against the validity of such methods specially when there is a prior on the number of lags. For example Leeb and Potscher [2006] argue that any lag order selection based on data used in the analysis invalidates inference.
- Hamilton and Herrera [2004]: Strongly claims that the value of lag order in the oil market based on prior studies and the AIC estimates would make a lower bound.

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