Oil and US GDP: A Real-Time Out-of-Sample Examination

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Introduction: What we do

- Real-time OOS forecasting study of predictability from crude oil prices to US GDP growth rates:

  1. Point forecasts.
  2. Density forecasts.
  3. Main OOS findings: strong predictability from the mid-1980s to the Great Recessions; for density forecasting predictability for the full sample.
  4. OOS analysis done conditional on finding very strong IS evidence of predictability.

Why Do This? Revisiting 'Oil and the Macroeconomy' Question

- Hamilton (1983) showed that jumps in crude oil prices preceded all but one post-WWII US recessions:
  1. Oil prices Granger-causal for GDP growth 1948-1980, 1948-1972, and 1972-1980.
  2. Analysis suggested these oil price increases were exogenous wrt business cycle movements.
- Mork (1989) showed results persist in a longer sample (through the middle of 1988), but an asymmetry in the responses is quite apparent.

Challenge to the 'Oil Prices Cause Output' View

- Some work suggesting this relationship has changed:
  1. Hooker (1996) showed that Hamilton's (1983) results are not robust to extension of sample period to mid 1990s.
  2. Bernanke, Gertler, and Watson (1997) argued that it was the endogenous response of the fed funds rate, as opposed to sharp oil price increases per se, that generate the output response.
  3. Blanchard and Galí's (2008) work suggests that the macro response to oil shocks now is considerably less than earlier.

Hamilton's Response to 'The Relationship Has Changed' View

- Hamilton (1996) reply to Hooker (1996):

  1. Points out that much of oil price increases in 1980s to mid-1990s in oil prices came after considerably larger declines.

  2. Introduces a 'net oil price increase' measure and using it shows that Granger-causal relationship established in Hamilton (1983) - Mork (1989) still holds.

Hamilton's Response to 'The Relationship Has Changed' View

- Hamilton and Herrera (2004) reply to Bernanke, et al. (1997), questioning:
  1. Whether Fed could have carried out actions they model.
  2. Econometric (lag) specification they use and effect of Fed action they assume conditional on lag structure imposed.

Hamilton's Response to 'The Relationship Has Changed' View

- Hamilton (2009) reply to Blanchard and Galí (2008), noting that their estimates imply:

  1. Counterintuitively, that the US 1981-82 recession would have been deeper in the absence of the crude oil price shocks that preceded it.
  2. That 2007Q4-2008Q3 period would not have been start of a recession without large oil price increases beforehand.

Hamilton Has Not Only Poked Holes

- Hamilton (2003):

  1. Applies random fields approach of Hamilton (2001), provides further support for claim that oil price increases are more important than decreases.
  2. Provides a causal interpretation, by way of instrumental variables regression, to these key oil price increases in terms of five military conflicts in Middle East.

Hamilton Has Not Only Poked Holes

- Hamilton (2009) compares 2007-2008 run-up in oil prices to earlier oil price shocks:

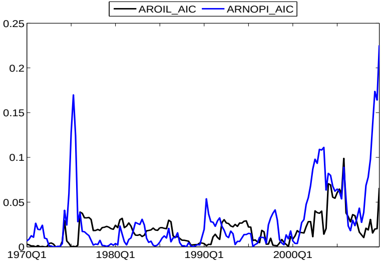
  1. In contrast, recent period of oil price increases due to strong world demand for oil, not supply disruptions.
  2. But macro consequences appear to have been similar.
  3. Argues that, absent demand-induced crude oil price increases, it's unlikely that pre-Lehman 2007Q4-2008Q3 period would have been characterized as period of recession for US.

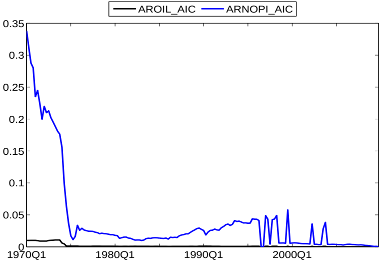
Does it Make Sense to Examine OOS Predictability?

- Welch and Goyal (2008) argue that it is not reasonable to search for evidence of OOS predictability in the absence of IS predictability:

  1. In Figure 1 we present evidence of such IS predictability from crude oil prices to US GDP using sequence of rolling windows of post-World War II data.
  2. The first and last IS periods are 1955Q1-1969Q4 and 1995Q1-2009Q4.
  3. Each data window consists of the next vintage of real-time data.
  4. Oil price measure: West Texas intermediate crude spot price.

Introduction: IS Predictability Evidence





AIC BF

OOS Forecasts

- OOS period:
  1. 160 1-step ahead forecasts (1970Q1-2009Q4)
  2. 157 4-step ahead (direct) forecasts (1970Q4-2009Q4) [see paper]
- Models estimated using vintage j, and forecast errors computed using vintage $j+1$ for 1-step ahead forecasts and vintage $j+4$ for 4-step ahead forecasts.

Forecasting Models

- Linear AR(p) benchmark:

$$y_t = \alpha + \sum_{i=1}^{p} \beta_i y_{t-i} + \sigma \epsilon_t, \tag{1}$$

where $\epsilon_t \sim N(0,1)$ and y_t = GDP growth rate.

Forecasting Models

- Linear alternative extends the AR(p) with an oil price measure:

$$y_t = \alpha + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{i=1}^{p} \gamma_i oil_{t-i} + \sigma \epsilon_t, \qquad (2)$$

where $\epsilon_t \sim N(0, 1)$ and $oil_t =$ oil price measure.

- Two oil price measures:

1. $oil_t = \ln(p_t) - \ln(p_{t-1})$, where p_t WTI spot price
2. Hamilton's (1996) NOPI measure, $oil_t = \max[(\ln(p_t) - \max[\ln(p_{t-1}), .., \ln(p_{t-4})]), 0]$.

Forecasting Models

- Equations (1) and (2) are estimated with a 15-year moving window schemes.

- The lag order p is:

  1. Fixed to 4. Models are referred to as AR(4), ARX(4)^{o}, ARX(4)^{n}.
  2. Seleced via AIC for each vintage. Models are referred to AR(p)$_{AIC}$, ARX(p)$^{o}_{AIC}$, ARX(p)$^{n}_{AIC}$.

Forecasting Evaluation: Point Forecasts

- MSPEs-adjusted comparisons based on Clark and West (2007).
- Clark and West (2007) test for equal predictive accuracy.
- Hubrich and West (2010) test against data snooping.
- Both tests appropriate for nested model case.

Forecasting Evaluation: Density Forecasts

- Log score comparison.
- Amisano and Giacomini (2007) test on the difference between two log scores.
- The test is appropriate for nested model, fixed size rolling window case; we report results with ‘center of distribution’ weighting function.

Point Forecasts

Tests of Equal Out-of-Sample Point Forecast Accuracy for Quarterly US GDP Growth Rates with AR Benchmarks

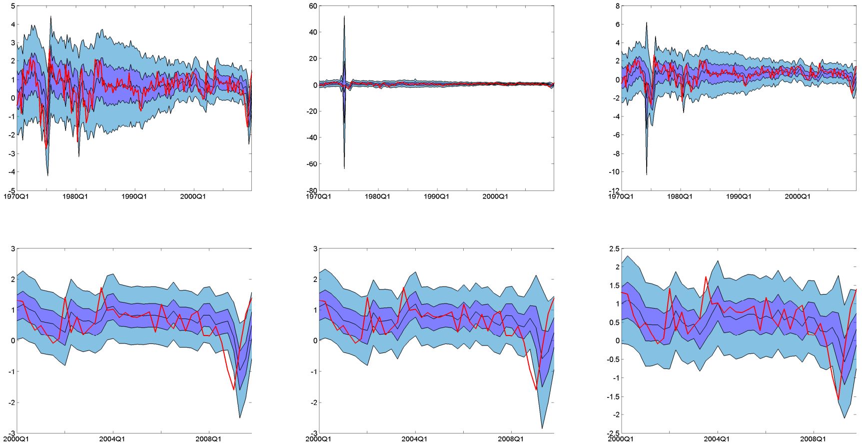
	1970-2009	1975-2009	1980-2009	1985-2009	1990-2009	1995-2009	2000-2009
	Forecast horizon *h=1*						
AR(4) (bench)	0.623	0.574	0.440	0.251	0.290	0.316	0.389
vs. ARX$(4)^o$	0.388	1.101	0.869	0.725	0.734	0.684	0.591
	(0.105)	(0.624)	(0.224)	**(0.051)**	**(0.060)**	**(0.057)**	**(0.044)**
vs. ARX$(4)^n$	0.657	1.010	0.846	0.688	0.632	0.560	0.449
	(0.065)	(0.536)	(0.109)	**(0.026)**	**(0.015)**	**(0.013)**	**(0.010)**
HW: vs. 2 models	**(0.099)**	(0.772)	(0.144)	**(0.038)**	**(0.021)**	**(0.018)**	**(0.014)**
$AR(p)_{AIC}$ (bench)	0.576	0.495	0.418	0.258	0.294	0.321	0.395
vs. $ARX(p)^o_{AIC}$	0.927	0.984	0.986	1.017	0.987	1.009	0.995
	(0.127)	(0.298)	(0.366)	(0.606)	(0.421)	(0.549)	(0.479)
vs. $ARX(p)^n_{AIC}$	0.886	0.984	0.897	0.814	0.797	0.779	0.719
	(0.139)	(0.442)	**(0.017)**	**(0.006)**	**(0.005)**	**(0.011)**	**(0.006)**
HW: vs. 2 models	(0.229)	(0.508)	**(0.034)**	**(0.011)**	**(0.011)**	**(0.021)**	**(0.013)**

Density Forecasts

Log Scores for Out-of-Sample Density Forecasts for Quarterly US GDP Growth Rates

	1970-2009	1975-2009	1980-2009	1985-2009	1990-2009	1995-2009	2000-2009
	Forecast horizon $h=1$						
AR(4) (bench)	-1.184	-1.186	-1.187	-1.171	-1.227	-1.295	-1.376
vs. $ARX(4)^o$	-1.138	-1.144	-1.146	-1.110	-1.142	-1.187	-1.209
	(0.227)	(0.220)	(0.222)	**(0.040)**	**(0.015)**	**(0.017)**	**(0.012)**
vs. $ARX(4)^n$	-1.110	-1.120	-1.116	-1.094	-1.123	-1.163	-1.181
	(0.044)	**(0.049)**	**(0.035)**	**(0.017)**	**(0.007)**	**(0.008)**	**(0.008)**
$AR(p)_{AIC}$ (bench)	-1.204	-1.199	-1.205	-1.195	-1.256	-1.332	-1.427
vs. $ARX(p)^o_{AIC}$	-1.177	-1.172	-1.175	-1.161	-1.211	-1.276	-1.342
	(0.127)	(0.298)	(0.366)	(0.606)	(0.421)	(0.549)	(0.479)
vs. $ARX(p)^n_{AIC}$	-1.149	-1.155	-1.147	-1.132	-1.177	-1.231	-1.273
	(0.139)	(0.442)	**(0.017)**	**(0.006)**	**(0.005)**	**(0.011)**	**(0.006)**

Fan Charts: $\mathbf{AR(p)}_{\mathrm{AIC}}$, $\mathbf{ARX}(p)^{o}_{\mathrm{AIC}}$, $\mathbf{ARX}(p)^{n}_{\mathrm{AIC}}$



Omitted variables

- Alternative linear models:

$$y_t = \alpha + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{i=1}^{p} \delta_{n,i} z_{j,t-i} + \sigma \epsilon_t, \qquad (3)$$

where $\epsilon_t \sim N(0,1)$.

- z: import price deflator, PCE deflator, nominal freight index of Killian (2009), linear detrended real freight index of Killian (2009) [for OOS subperiods from 1985], 3m T-Bill rate, yield spread (3m-FFR), term spread (10y-3m), credit spread (Baa-Aaa), macro "factor" computed as PCA of previous variables.
- Evidence of OOS predictability for import price, PCE deflator, linear detrended real freight index of Killian (2009) and macro factor.

Omitted variables

- We compare previous equation (3) to:

$$y_t = \alpha + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{i=1}^{p} \gamma_i oil_{t-i} + \sum_{i=1}^{p} \delta_{n,i} z_{j,t-i} + \sigma \epsilon_t, \quad (4)$$

where $\epsilon_t \sim N(0, 1)$.

- CW and HW tests do not reject null hypothesis of equal predictive accuracy.
- We compare models with OIL in (2) to (4).
- Adding the linear detrended real freight index of Killian (2009) provides low CW and HW p-values against the $\text{ARX}(4)^o$ and $\text{ARX}(4)^n$.
- Demand shocks?

Further robustness checks

- Barsky and Kilian (2002) argue that feedback from macro variables to oil prices needs to be considered.
- No feedback.
- Similar results when we use Brent and Dubai oil indices.

Conclusion

- Strong OOS predictability from oil crude prices (above nopi measure) to US GDP.
- Massive bout of forecast uncertainty following the late 1973 crude oil price increases.
- Blinder and Rudd (2009): "something new, if not indeed something *sui generis*, at the time (1973)". Perhaps, massive increase in forecast uncertainty.

Conclusion

- Possible omission of Killian (2009)'s real global activity measures.
- Our analysis is agnostic about demand shocks, supply shocks or both shocks.
- Issues related to it:
  1. Short samples for world crude oil production.
  2. Hamilton (2009) notes that large precautionary demand for oil and actual oil inventories are negative correlated.