What Central Bankers Need to Know about Forecasting Oil Prices

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The views expressed in this presentation, or in my remarks, are my own, and do not necessarily represent those of the Bank of Canada.

Background

- The real price of oil is one of the key variables in the model-based macroeconomic projections generated by central banks, private sector forecasters, and international organizations.

- Increased interest in real-time forecasts of the real price of oil:
  - Alquist, Kilian, and Vigfusson (Hdbk chapter 2013)
  - Baumeister and Kilian (*JBES* 2012, mimeo 2013a,b)

- New monthly real-time data set for oil markets:

  Vintages for 1991.1-present, each extending back to 1973.1

Baumeister and Kilian (*JBES* 2012)

- Focuses on VAR model motivated by global oil market model of Kilian and Murphy (*JAE* 2013):

  1. Percent change in global crude oil production
  2. Index of global real activity
  3. Real price of oil
  4. Change in above-ground global crude oil inventories

- A recursively estimated unrestricted VAR(12) model yields the most accurate forecasts among a wide range of competitors at horizons up to one year:

  - MSPE relative to no-change forecast
  - Directional accuracy

- <u>Caveat:</u>
  These forecasts are not directly suitable for central banks.

What Oil Price Forecasts Do Central Banks Need?

1. Quarterly Horizons

   Is it better to average monthly forecasts of the real price of oil or to forecast from a model estimated at quarterly frequency?

   Is the appropriate random walk benchmark the most recent quarterly real price of oil or the most recent monthly real price of oil?

   How does time aggregation to quarterly frequency affect the specification of forecasting models?

   How does time aggregation affect the properties of conventional central bank oil price forecasts based on oil futures prices?

2. Other Oil Price Measures: WTI, Brent

- Recent instability in the spread of the Brent price over the WTI price
- Increasing importance of the Brent price as a benchmark for global oil markets

Modeling choices:

- Substitute the oil price measure in the model
- Model the spread as a random walk to be added to the baseline forecasting VAR model

3. Foreign central banks forecast the real price of oil in domestic consumption units

Examples: Bank of Canada, Norges Bank, ECB

This requires the inclusion of the real exchange rate in the real-time forecasting model for all countries but the United States.

Modeling choices:

- Augment the quarterly forecasting model by one variable
- Treat the quarterly real exchange rate as a random walk

4. Other issues

Model Specification:

Alternative measures of global real activity

Structural Change:

TVP-VAR Models

Rolling windows

Model Misspecification:

Forecast Combinations

Key Parameters for Forecasting Horserace

- Variable to be forecast:

  Quarterly average of the real price of oil

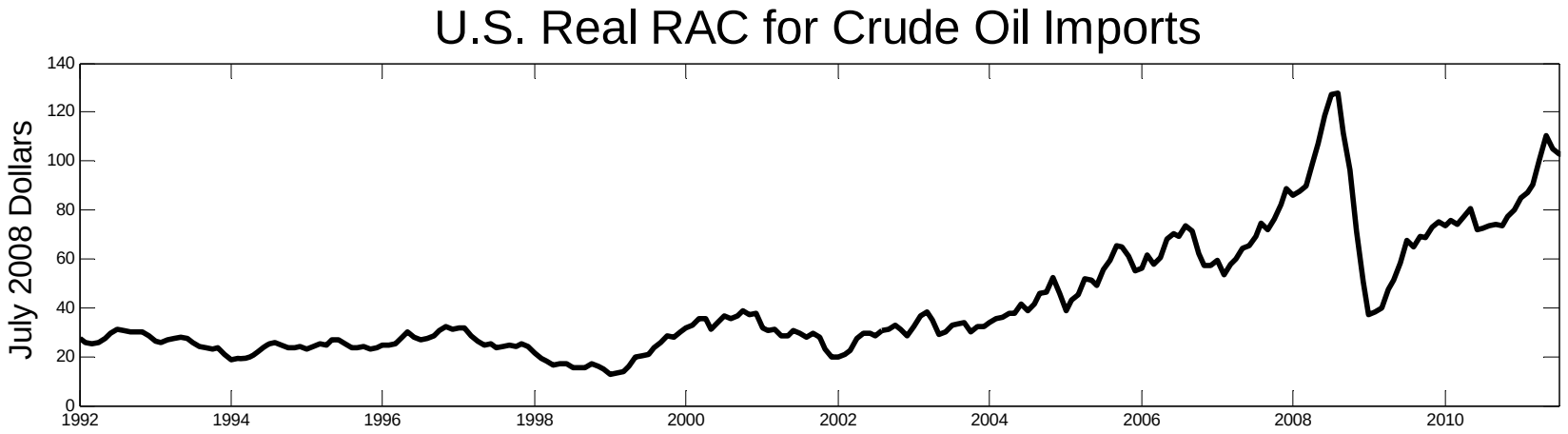
- Evaluation window: 1992.I-2011.II.
- Data for 1992.I-2011.II in the 2011.12 vintage are treated as ex-post revised data when evaluating the forecast accuracy
- Quarterly forecasts horizons $h \in \{1, 2, 3, 4\}$

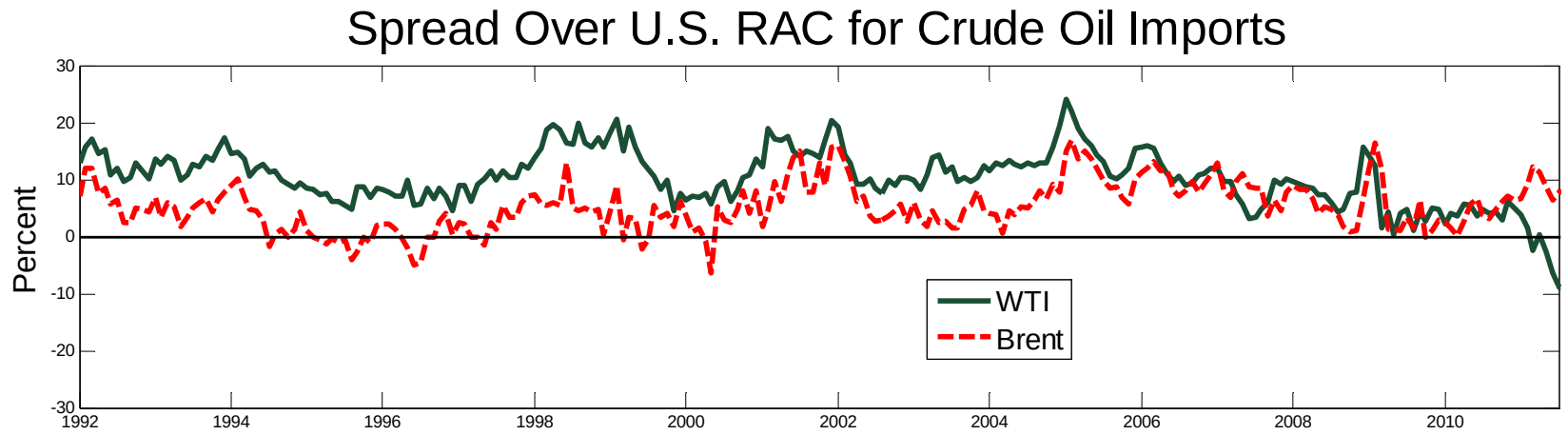
Real-Time Accuracy of Recursive Forecasts of the
Quarterly Real U.S. Refiners' Acquisition Cost for Oil Imports

Quarterly Horizon	Quarterly NC-Forecast	Monthly VAR(12)	Oil Futures	Quarterly VAR(p) $p=4$	Quarterly VAR(p) $p=6$	Quarterly VAR(p) $p=8$	Quarterly BVAR(p) $p=4$	Quarterly BVAR(p) $p=6$	Quarterly BVAR(p) $p=8$
				(a) MSPE Ratio					
1	1.68	**0.80**	**0.99**	1.59	1.86	2.18	1.65	1.58	1.62
2	1.11	**0.93**	1.06	1.17	1.32	1.40	1.13	1.10	1.13
3	**0.98**	1.02	**0.99**	1.05	1.09	1.13	1.02	**0.98**	1.03
4	**0.99**	1.01	**0.93**	1.02	1.06	1.18	1.01	**0.99**	1.05
				(b) Success Ratio					
1	-	**0.69***	**0.59***	**0.55**	**0.62***	**0.56**	**0.56**	**0.63***	**0.67***
2	-	**0.58***	**0.52**	**0.53**	**0.58**	**0.53**	**0.55**	**0.64***	**0.64***
3	-	**0.57**	**0.57***	0.45	0.50	**0.51**	**0.53**	**0.58**	**0.54**
4	-	**0.60***	**0.61***	0.48	**0.61**	**0.55**	**0.52**	**0.60**	**0.57**

NOTES: All MSPE ratios have been normalized relative to the monthly no-change forecast. Boldface indicates an improvement on the monthly no-change forecast.

Alternative Oil Prices and Their Relationship Since 1992:





Real-Time Accuracy of Recursive Forecasts of the **Quarterly Real WTI Price**

Quarterly Horizon	Quarterly No-Change Forecast	Monthly VAR(12)	Monthly VAR(12) + NC-Forecast for Spread	Oil Futures	Quarterly BVAR(6)	Quarterly BVAR(6) + NC-Forecast for Spread
			(a) MSPE Ratio			
1	1.67	**0.93**	**0.85**	1.06	1.57	1.55
2	1.11	**0.97**	**0.94**	1.13	1.07	1.10
3	**0.99**	1.02	1.01	1.07	**0.96**	**0.98**
4	**0.99**	1.01	1.00	**1.00**	**0.95**	**0.98**
			(b) Success Ratio			
1	-	**0.65***	**0.69***	**0.54***	**0.55**	**0.60***
2	-	**0.61***	**0.61***	**0.52**	**0.57**	**0.58**
3	-	**0.51**	**0.58**	**0.57***	**0.59**	**0.59**
4	-	**0.56**	**0.60***	**0.59***	**0.65***	**0.63**

Real-Time Accuracy of Recursive Forecasts of the **Quarterly Real Brent Price**

Quarterly Horizon	Quarterly NC Forecast	Monthly VAR(12)	Monthly VAR(12) + NC-Forecast for Spread	Oil Futures	Quarterly BVAR(6)	Quarterly BVAR(6) + NC-Forecast for Spread
			(a) MSPE Ratio			
1	1.68	**0.92**	**0.89**	1.69	1.73	1.61
2	1.11	**0.98**	**0.98**	1.44	1.15	1.12
3	**0.98**	1.01	1.04	1.22	1.00	1.00
4	**0.98**	1.01	1.03	-	1.00	1.01
			(b) Success Ratio			
1	-	**0.72***	**0.68***	**0.51**	**0.59**	**0.59**
2	-	**0.61***	**0.62***	**0.53**	**0.60**	**0.62****
3	-	**0.51**	**0.57****	**0.53**	**0.54**	**0.57**
4	-	**0.60***	**0.57****	-	**0.52**	**0.56**

Real-Time Accuracy of Recursive Forecasts of the Quarterly Real Price of Oil:
Alternative Monthly Measures of Global Real Activity
in the VAR(12) Model

				MSPE Ratio Quarterly Horizon				Success Ratio Quarterly Horizon			
Source		Measure	Coverage	1	2	3	4	1	2	3	4
				U.S. Refiners' Acquisition Cost for Imports							
Kilian	-	Index	World	**0.80**	**0.93**	**1.02**	**1.01**	0.69*	0.58*	0.57	0.60*
OECD	Growth	IP	OECD+6	0.83	0.96	1.06	1.06	**0.72***	**0.56***	**0.59***	**0.61***
OECD	HP	IP	OECD+6	0.88	1.01	1.15	1.19	0.68*	0.55*	0.49	0.47
OECD	LT	IP	OECD+6	0.83	1.00	1.10	1.10	0.71*	0.60*	0.59	0.56
				WTI Price							
Kilian	-	Index	World	**0.93**	**0.97**	**1.02**	**1.01**	0.65*	0.61*	0.51	0.56
OECD	Growth	IP	OECD+6	0.93	1.00	1.05	1.03	**0.67***	**0.58***	**0.58***	**0.63***
OECD	HP	IP	OECD+6	0.94	1.01	1.10	1.11	0.71*	0.55**	0.53	0.51
OECD	LT	IP	OECD+6	0.96	1.03	1.09	1.05	0.64*	0.58*	0.57	0.57
				Brent Price							
Kilian	-	Index	World	**0.92**	**0.98**	**1.01**	**1.01**	0.72*	0.61*	0.51	0.60*
OECD	Growth	IP	OECD+6	1.01	1.07	1.11	1.09	**0.64***	**0.62***	**0.59***	**0.63***
OECD	HP	IP	OECD+6	1.03	1.10	1.17	1.21	0.65*	0.56*	0.50	0.52**
OECD	LT	IP	OECD+6	1.08	1.13	1.16	1.14	0.67*	0.60**	0.61**	0.57

Real-Time Accuracy of Recursive Forecasts of the Quarterly Real U.S. Refiners' Acquisition Cost from a **Quarterly TVP-VAR(4) Model**

Quarterly Horizon	Posterior Mean	Posterior Trimmed Mean	Posterior Median
1	1.45	1.48	1.48
2	1.20	1.23	1.26
3	1.18	1.19	1.20
4	1.55	1.21	1.23
1	**0.58**	**0.58**	**0.62***
2	**0.65***	**0.61****	**0.60***
3	**0.62**	**0.62**	**0.55**
4	**0.64****	**0.63**	**0.56**

NOTES: All results are obtained by Monte Carlo integration from the pointwise posterior distribution of the TVP-VAR model forecasts. The trimmed mean eliminates the top and bottom 0.5 percent of the posterior forecasts.

Real-Time Accuracy of **Rolling Forecasts** of the Quarterly Real U.S. Refiners' Acquisition Cost for Oil Imports: Selected VAR Models

Quarterly Horizon	Monthly VAR(12)	VAR(*p*) *p*=4	VAR(*p*) *p*=6	BVAR(*p*) *p*=4	BVAR(*p*) *p*=6
	MSPE Ratio: **15-Year** Rolling Window				
1	**0.98**	2.05	2.96	1.87	1.82
2	1.16	1.63	1.82	1.45	1.36
3	1.28	1.50	1.59	1.44	1.36
4	1.35	1.24	1.46	1.49	1.44
	MSPE Ratio: **10-Year** Rolling Window				
1	1.22	2.30	5.17	1.93	1.89
2	1.33	1.67	3.96	1.41	1.38
3	1.45	1.51	2.16	1.36	1.40
4	1.52	1.29	2.25	1.40	1.52

International Comparison: Real-Time Accuracy of Quarterly Forecasts of the Real Price of Oil in Domestic Consumption Units

	Real Exchange Rate included in Baseline Monthly VAR(12) Model for RAC and No-Change Forecast of the Spread of the Benchmark Price over the RAC		Baseline Monthly VAR(12) Model for RAC with No-Change Forecasts of the Real Exchange Rate and of the Spread of the Benchmark Price over the RAC	
Quarterly Horizon	MSPE Ratio	Success Ratio	MSPE Ratio	Success Ratio
	(a) **Canada**: WTI benchmark			
1	**0.84**	**0.62***	**0.93**	**0.73***
2	**0.96**	0.48	**0.97**	**0.60***
3	1.04	**0.50**	1.02	**0.54**
4	1.03	**0.47**	**1.00**	**0.55**
	(b) **Norway**: Brent benchmark			
1	**0.92**	**0.60***	**0.90**	**0.65***
2	1.07	**0.58***	**0.98**	**0.61***
3	1.15	**0.53**	1.07	**0.55**
4	1.15	**0.53**	1.05	**0.60***
	(c) **Euro Area**: Brent benchmark			
1	**0.96**	**0.69***	**0.90**	**0.68***
2	1.08	**0.60***	1.01	**0.61***
3	1.17	**0.57****	1.08	**0.54**
4	1.17	**0.61***	1.06	**0.59***

Forecast Combinations: Real-Time Accuracy of Weighted Average of Monthly VAR(12) Model Forecast and the Forecast Based on Oil Futures

Quarterly Horizon	U.S. Refiners' Acquisition Cost for Crude Oil Imports		WTI Price		Brent Price	
	Equal weights	Inverse MSPE weights	Equal weights	Inverse MSE weights	Equal weights	Inverse MSPE weights
			(a) MSPE Ratio			
1	**0.85**	**0.83**	**0.85**	**0.86**	**0.92**	**0.93**
2	**0.94**	**0.92**	**0.93**	**0.93**	**0.97**	**0.98**
3	**0.99**	**0.95**	**0.95**	**0.95**	**0.98**	**0.98**
4	**0.98**	**0.92**	**0.92**	**0.92**	**-**	**-**
			(b) Success Ratio			
1	**0.67***	**0.71***	**0.68***	**0.68***	**0.67***	**0.67***
2	**0.60***	**0.55**	**0.56***	**0.57****	**0.58***	**0.55***
3	**0.59***	**0.51**	**0.58***	**0.53**	**0.53**	**0.50**
4	**0.59****	**0.53****	**0.53***	**0.56***	**-**	**-**

NOTES: The VAR forecasts for the real WTI price and real Brent price are obtained from the baseline model for the U.S. refiners' acquisition cost by applying the most recent price spread.

Real-Time Accuracy of Selected Forecasts at **Longer Horizons**
U.S. Refiners' Acquisition Cost for Imports

Quarterly Horizon	Monthly VAR(12)	Hybrid Method	Quarterly No-Change Forecast
		(a) MSPE Ratio	
5	1.06	1.07	**0.97**
6	1.12	1.13	**0.95**
7	1.15	1.13	**0.95**
8	1.14	1.07	**0.97**
		(b) Success Ratio	
5	**0.58***	**0.54**	-
6	**0.52**	0.47	-
7	**0.50**	0.49	-
8	**0.52**	**0.52**	-

NOTES: The hybrid method treats the 4-quarter forecast from the monthly VAR(12) model as the forecast for horizons 5 through 8.

Loose Ends …

1. Factor-augmented VAR forecasting models or alternatively large-scale Bayesian VAR forecasting models (see, e.g. Banbura, Giannone and Reichlin, *JAE* 2010).

Problem: Difficulty of obtaining suitable real-time data sets.

2. Forecasting methods in the tradition of the Mixed Data Sampling (MIDAS) model or mixed-frequency VAR models (see, e.g., Andreou, Ghysels, and Kourtellos 2011; Schorfheide and Song 2011).

Ongoing work: Baumeister, Guérin, and Kilian (2013)