A Time-Frequency Analysis of Oil Price Data

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Some Personal Reflections on Modeling Oil Prices

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What This Study Does

Nominal spot price of oil (Brent, WTI)
Daily data frequency
Sample period: May 1987-September 2017
Univariate time series model
Frequency domain analysis (spectral analysis)

Objectives:

1. Measure the persistence (correlation of price changes over time) and the volatility of price changes
2. Identify possible regime shifts in these features

Their approach:
Wavelet-based method of jointly estimating the key parameters (Hurst exponent, scale of volatility) of the data generating process.

This approach differs from volatility estimates based on the time invariant standard Brownian model with independent increments (or returns).

It allows the detection of "regime switches" (rather than imposing that there are none).

Regime Shifts and Structural Change

Regime shifts in the econometrics literature refers to Markov switching in the states of the economy. The "regime switches" in this paper are more like deterministic "breaks" in the time series properties:

- There are many possible reasons for discrete structural breaks since 1987 (e.g., shifts in financial regulation or in oil extraction technology)

- There are also reasons to expect smooth structural change (including hidden nonlinearities in the determination of the price of oil; changes in energy efficiency, energy substitution, and investor tastes; the convolution of many discrete shifts).

=> How good is the linear approximation to the oil price process?

When is a "Regime Shift" a Regime Shift?

The spot price of oil summarizes the interplay of supply and demand determinants. Shifts in these determinants affect the persistence of the price of oil even absent structural changes:

$$S_t = \rho S_{t-1} + u_t$$

where $u_t \sim WN(0, \sigma^2)$ and $|\rho| < 1$. Then

$$Var(S_t) = \frac{\sigma^2}{1-\rho^2}.$$

Apparent regime shifts in univariate measures of volatility and persistence may not be for real.

- ⇨ Whether we should model them as regime shifts depends on the objective of the model.

What's the Ultimate Objective?

1. Quantifying arbitrage over time based on past returns?
=> High-frequency trading is based on spreads.

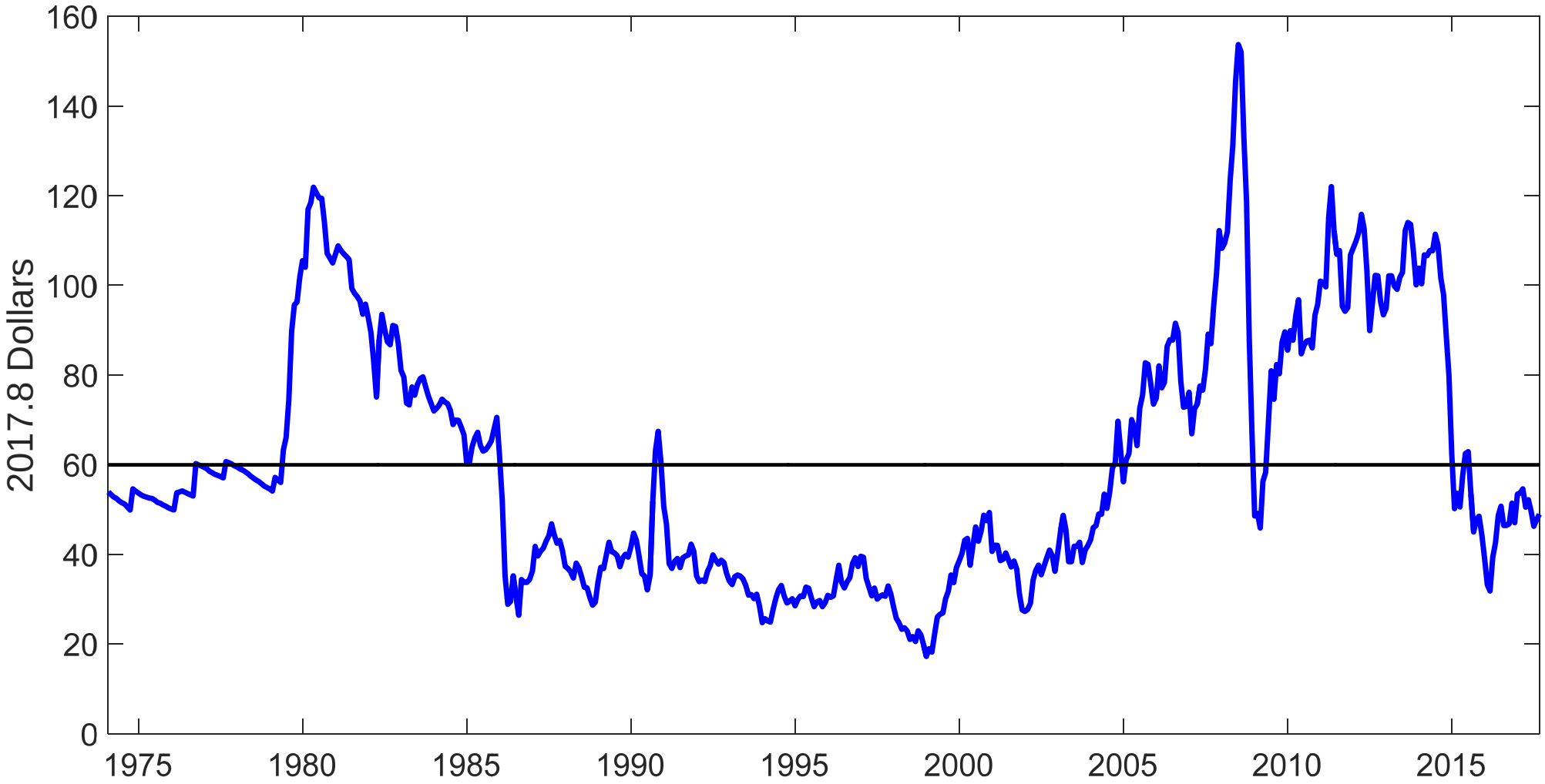
2. Volatility estimates facilitate risk assessments
=> Need for a portfolio approach with multiple assets and covariances?

3. Prediction of oil price?
=> Need for real-time out-of-sample analysis
=> Does the horizon matter? Long-horizon inference?

4. Turning point detection?
=> In real time?

5. Mixed frequency analysis?

Déjà vu all over again?



Concluding Remarks

- Oil market research remains exciting even 45 years after the first major oil price shock in 1973.
- There is lots of room for exploring new tools and ideas.
- This is a fascinating new study that will stimulate much interest.