

Using wavelets in oil future forecasting

ORF 574 Final Presentation

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Motivation

- Features of oil markets imply poor fit for traditional regression methodologies
- Noisiness of underlying signal can lead to mispricing in oil futures markets
- Solutions such as "A Discrete Affair" apply methods from physics and electrical engineering to decomposition of noisy signal
- Fourier analysis does not capture specialized features of oil markets
- Our strategy: Discrete wavelet transform

Trading hypothesis

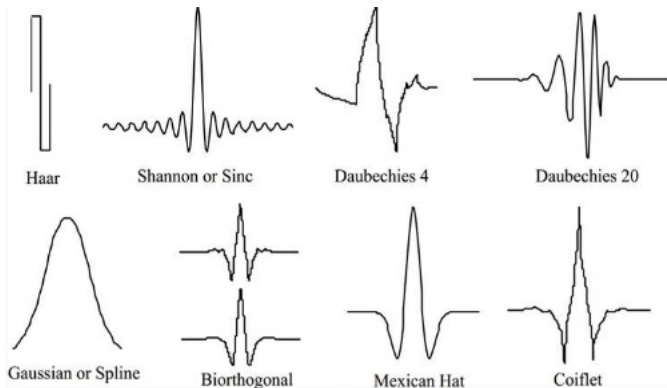
- Use wavelets to forecast future oil spot prices
- Trade discrepancies with futures markets
- Analyze strategy for 1m, 2m, 3m, and 4m forecast windows

Introduction to wavelets and comparison with Fourier

- Fourier: Project onto Fourier basis of sines and cosines
- Wavelet: Project onto scalings and translations of compact mother wavelet ψ
- Flexible choice of mother wavelet, allows us to capture local features/singularities
 - Structural breaks
 - Time-dependent volatility
 - Shifting market structure dynamics
 - Susceptibility to macroeconomic shocks

- Source: EIA
- Crude oil prices - Cushing WTI Since futures are monthly - use monthly averages for crude prices
- NYMEX futures Cushing WTI for 1m, 2m, 3m, and 4m

Wavelet example



Wavelet decomposition

- Decompose data into 5 levels using Discrete Wavelet Transform

Example

$$f = d_1 + a_1$$

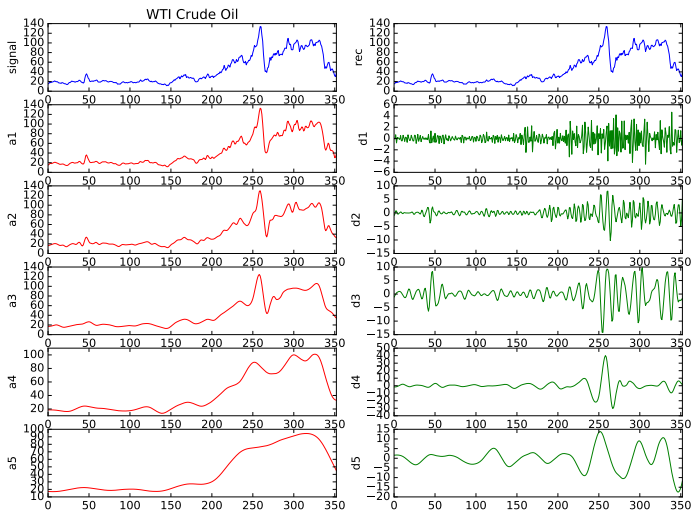
$$f = d_1 + d_2 + a_2$$

$$\vdots$$

$$f = d_1 + d_2 + \dots + d_5 + a_5$$

- a is the long-term, low-frequency trend component
- d_i s capture shorter-term, high-frequency fluctuations

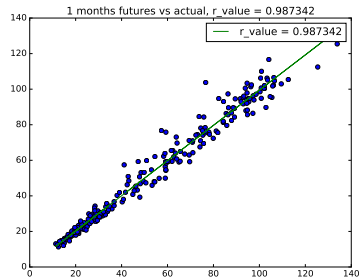
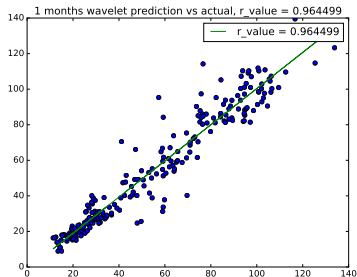
Wavelet decomposition of monthly WTI price



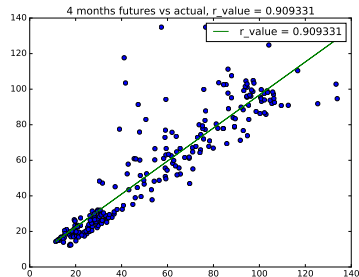
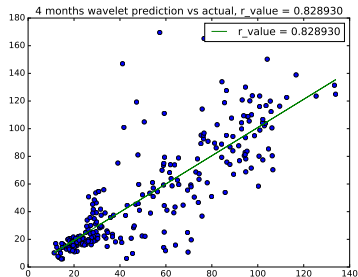
Trading strategy

- Use spline fit to forecast the slow a component
- Use Fourier fit to forecast d_i s
- Combine forecasts to obtain spot price prediction

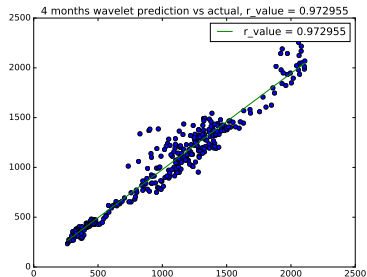
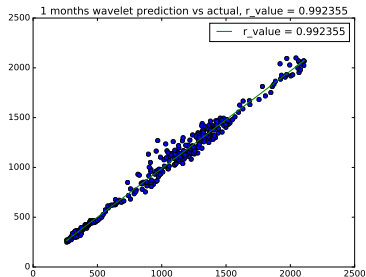
Wavelet forecast vs futures



Wavelet forecast vs futures



S&P 500 wavelet forecast



- Use Kelly criterion to size trade

Definition: Kelly Criterion

$$\text{Trade size} = (\Pi_{\text{size}} \times \text{Maximum Drawdown}) \times \left(\mathbb{P}(\text{gain}) - \frac{\mathbb{P}(\text{loss})}{\frac{\text{Gain return}}{\text{Loss return}}} \right)$$

- $\mathbb{P}(\text{Gain})$ computed using normal distribution
 - $\mu :=$ Expected return
 - $\sigma :=$ Historic rolling volatility

For Further Reading I



Ramsey, J.

Wavelets in Economics and Finance: Past and Future
Studies in Nonlinear Dynamics and Econometrics 6(3), 2002.



Thorp, E.

The Kelly Criterion in Blackjack Sports Betting and the Stock Market
Finding the Edge: Mathematical Analysis of Casino Games, 2000.



Villani, D., Ghigliazza, R., and Carmona, R.

A discrete affair
Energy Risk, Nov. 2003.



Yousefi, S., Weinreich, I., and Reinartz, D.

Wavelet-based prediction of oil prices
Chaos, Solitons and Fractals, 25: 265-275, 2005.