Evidence for Oil Market Risk Sharing From A Bayesian Perspective

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IB3120: Project, BA (Hons) Law and Business Studies
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Overview

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Motivation

- Crude oil is ubiquitous in modern life - used in everything from refined fuels to fertilizers
- Important for companies and other economic agents to hedge against risks in the oil market, for example airlines
- However, risk dynamics in the oil market have changed since around 2000, when academics agree commodity markets first became financialized (Cheng and Xiong, 2014)

Theory — What is Financialization?

- Broadly defined as the acceptance of an asset by a wider set of market participants than before (Fattouh, Kilian and Mahadeva, 2013)
- Associated with increased levels of speculation, though the pricing implications of speculation are unknown (ibid)
- Speculation generally defined as the volume of trading above volume needed to hedge spot positions (Working, 1960)

Theory — What is Financialization?

- Working's T index captures our definition of speculation by calculating volume of futures trading exceeding volume for hedging

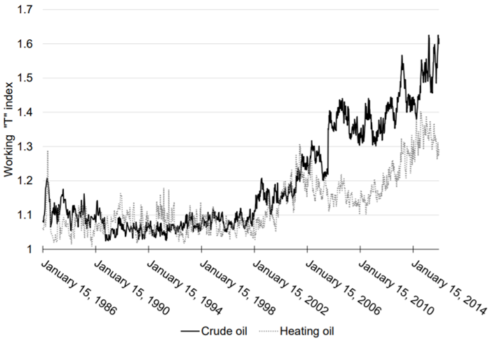


Figure: (Isleimeyyeh, forthcoming)

Theory — Effects of Financialization

- **Asset Price Bubbles:** Financialization and associated speculation causes asset price bubbles as speculators decouple expectations from fundamentals (Brown and Sarkozy, 2009).
- **Information Discovery:** Oil futures can be a 'barometer' for global economic strength (Cheng and Xiong, 2014).
- **Risk Sharing:** Financialization causes increased integration with traditionally segmented markets and consequently less diversification benefits (Silvenoinen and Thorp, 2013).

Research Questions

My research focuses explicitly on the risk sharing element of financialization. While past studies gives good evidence of increasing co-movements between oil and the stock market, frequentist regression models are used and as such cannot capture granular time-variance. I hope to use Bayesian modelling to test the following:

Research Questions

1. Does the risk sharing theory between oil and equity markets hold?
2. How has the risk sharing relationship changed over time?
3. Does risk sharing encompass short-term shocks, or solely long-term co-movements?

Model — Co-movement

Traditionally, systematic risk is defined as co-movement between an asset and a wider market. For the following let y be the return of oil and x the return of an external market.

Co-movement Model

$y = \beta x + \epsilon$

Derivation From CAPM

$y - r_f = \alpha + \beta(x - r_f) + \epsilon$

Assume inter-period risk free rate is negligible...

$y = \beta x + \epsilon$

Derivation From Proportionality

$y \propto x$

$y = \beta x$

Add market noise...

$y = \beta x + \epsilon$

Model — Impulse Response

Silvenoinen and Thorpe (2013) suggest that risk-sharing may also occur with short-term shocks, which we can test with an impulse response function.

Impulse Response Model - adapted from Kilian (2008)

$y_t = \Sigma_{h=0}^{1} \beta_{t-h} S_{t-h} + \epsilon_t$

I use a simple distributed lag model to calculate the impact response to shock variable S at horizons 0, 1.

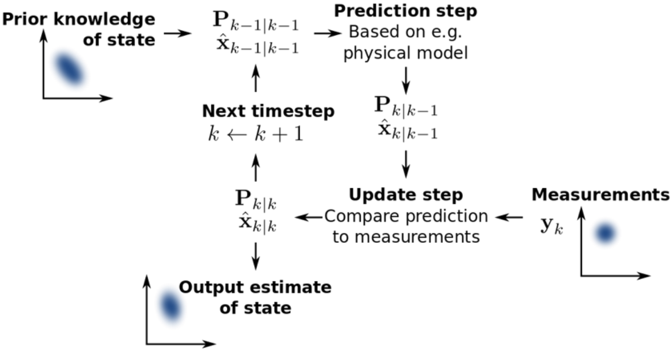
Definition of S

$S_t = \%\Delta V - \%\Delta(\frac{1}{12}\Sigma_{i=1}^{12} V_{t-i})$

Shock is defined as the difference in between the percentage change of some volatility indicator V (e.g. VIX/EWMA volatility) and the percentage change in the rolling 12-month average value of V. Theoretically, S is thus the unexpected portion of percentage change in volatility compared to to expected percentage change in volatility using information from the last 12 months.

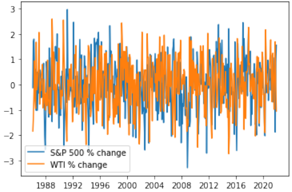
Model — Kalman Filter

I will transform the β coefficients to be modeled as a state space variable using the Kalman filter. The Kalman filter is a Bayesian modelling technique that updates the most likely position of a state through recursive estimation and observation of priors and posteriors.

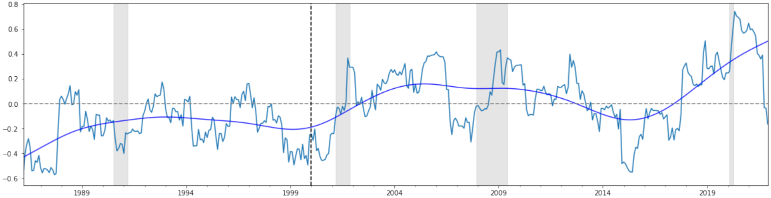


Data

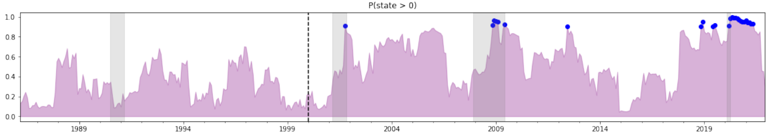
- **Oil Market:** I use rolling front-month WTI futures at monthly intervals collected from the EIA
- **External Markets:** I collect monthly data on various financial indices from Bloomberg, and commodity prices from the EIA.
- **Data Cleaning:** Dollar values are deflated using monthly US CPI figures from the FRED database. Then, I calculate the simple returns of the data and standardize annually as well as de-seasonalize the data to arrive at a stationary series.



Co-movement Results — S&P 500

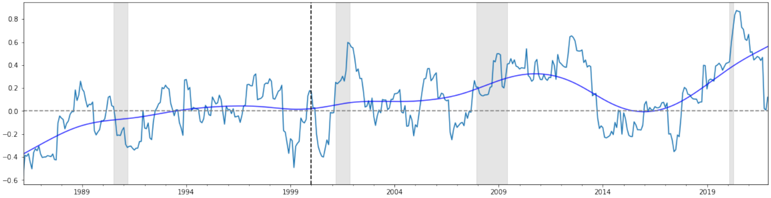


S&P 500 Co-movement Coefficients

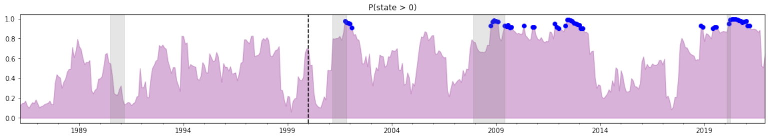


$P(\hat{\beta} > 0)$ for S&P 500 Co-movement Coefficients, $P > 0.9$ Highlighted

Co-movement Results — MSCI World

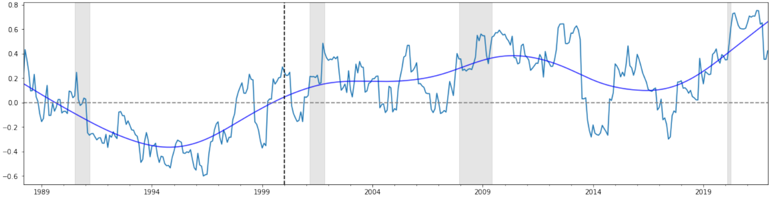


MSCI World Co-movement Coefficients

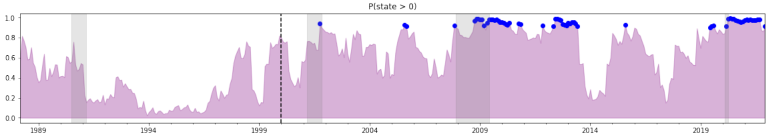


$P(\hat{\beta} > 0)$ for MSCI World Co-movement Coefficients, $P > 0.9$ Highlighted

Co-movement Results — MSCI Emerging Markets



MSCI Emerging Markets Co-movement Coefficients



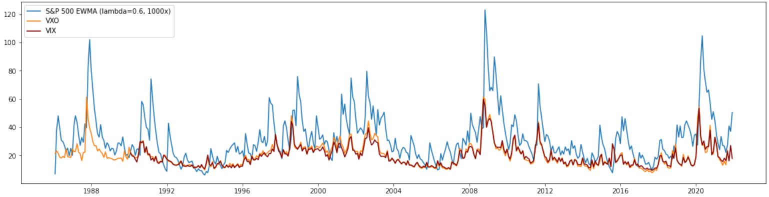
$P(\hat{\beta} > 0)$ for MSCI Emerging Markets Co-movement Coefficients, $P > 0.9$ Highlighted

Co-movement Results — Benchmarking

Since the Kalman filter is used for inference rather than prediction, I backtest on in-sample data.

Variable	**OLS estimate**	**KF mean**	**RW RMSE**	**OLS RMSE**	**KF RMSE**
S&P 500	-0.0191	-0.0227	0.9947	0.9945	0.9136
MSCI World	0.0912	0.0848	0.9947	0.9905	0.9065
MSCI EM	0.0911	0.0980	0.9946	0.9954	0.8993

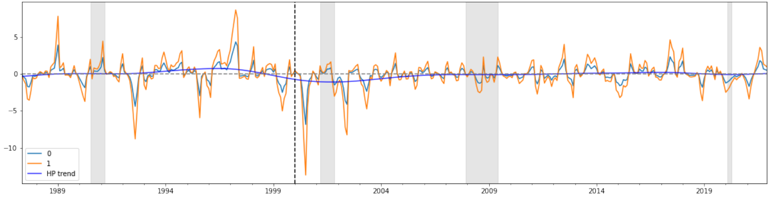
Impulse Response Results — Note on Volatility Measures



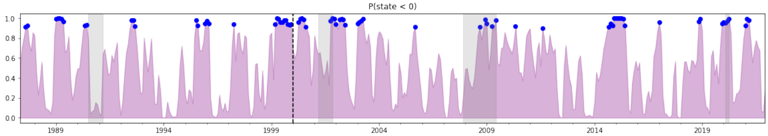
VIX, VXO and S&P 500 EWMA (lambda=0.6)

- VXO is the options implied volatility of the S&P 100 index
- Realized volatility given by EWMA is fitted to roughly match the VXO using lambda 0.6

Impulse Response Results — S&P 500 EWMA

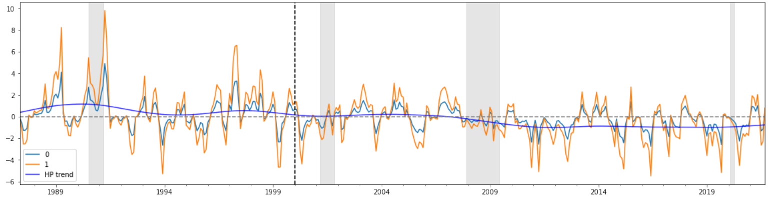


S&P 500 EWMA Impulse Response Coefficients

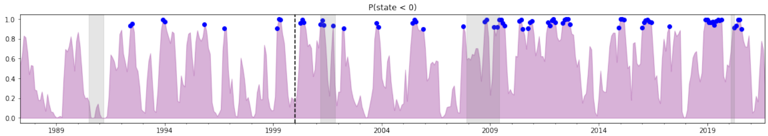


$P(\hat{\beta} < 0)$ for S&P 500 EWMA Impulse Response Coefficients, $P > 0.9$ Highlighted

Impulse Response Results — VXO



VXO Impulse Response Coefficients



$P(\hat{\beta} < 0)$ for VXO Impulse Response Coefficients, $P > 0.9$ Highlighted

Other Results

Type	Dependent	Independent	Trend
Co-movement	GS Commodity Index	Equity Indices (S&P, MSCI)	Increasing
Co-movement	Oil Futures	Natural Gas Futures	Decreasing
Co-movement	Natural Gas Futures	Equity Indices (S&P, MSCI)	No Trend

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