Lagged Effects of Crude Oil Price Spikes on Market Volatility: A Post-Event Analysis of the VIX

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Agenda

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1. Thesis
2. Motivation
3. Data and Assumptions
4. Methodology
5. Results
6. Key Findings
7. Conclusion

Thesis

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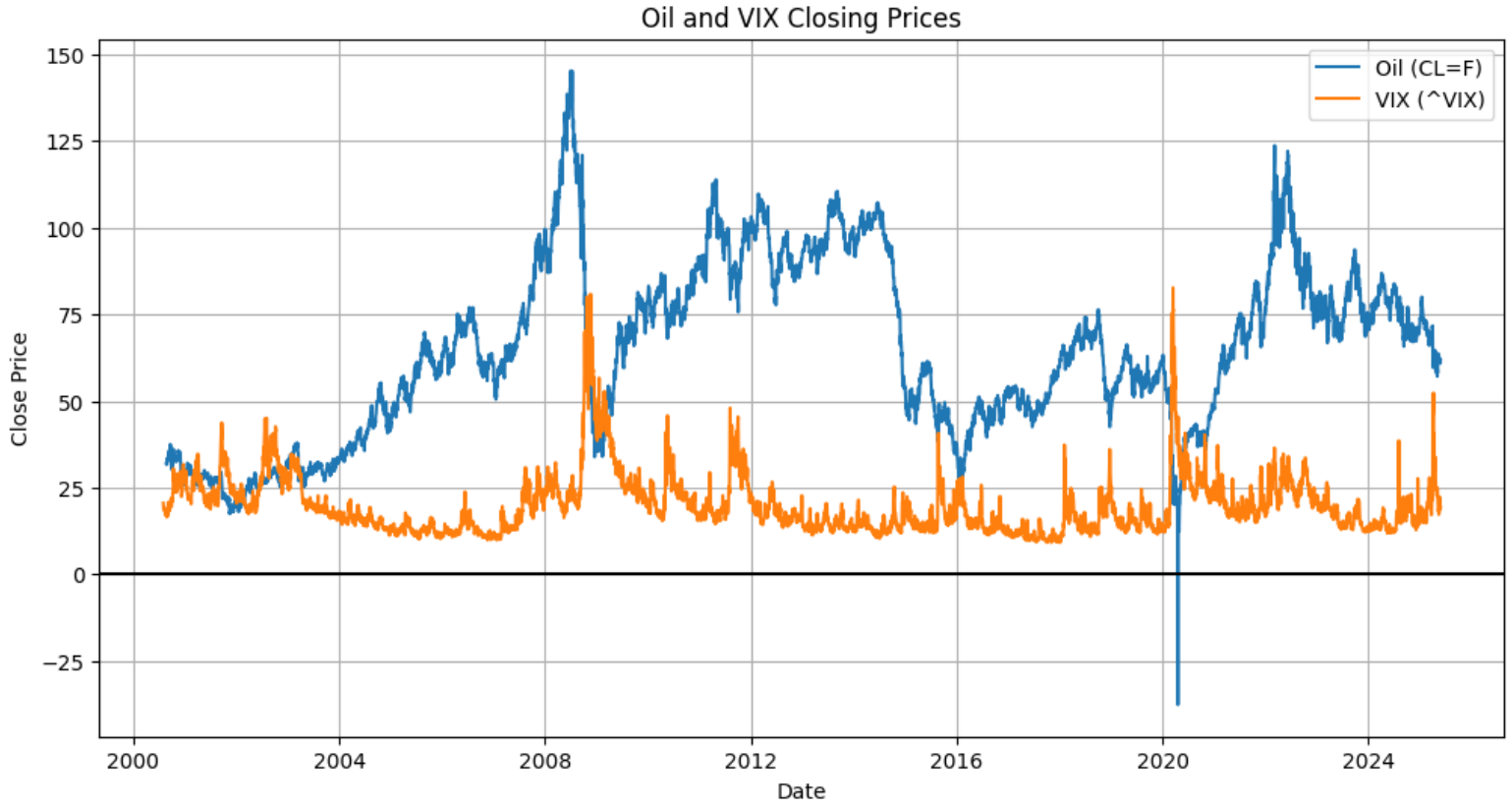
This project investigates whether large crude oil price spikes have a delayed and measurable impact on market volatility, as captured by the VIX. By analyzing post-event VIX behavior over various lag periods, the study aims to determine whether oil shocks serve as predictors of future volatility in financial markets.

Null Hypothesis (H_0):
There is no significant change in the VIX following a crude oil price spikes.

Alternative Hypothesis (H_1):
There is a significant change in the VIX following a crude oil price spikes.



Motivation

Why Crude Oil?

- Crude oil is a core input for many industries including airlines, automotive, logistics, and manufacturing.
- Even non-energy companies are exposed through transportation, supply chains, or operating costs.

Why Volatility?

- The **^VIX** (volatility index) reflects investor fear and market uncertainty.
- If oil shocks predict future volatility, they may serve as early warning signals for risk managers and investors.

Quantitative traders frequently incorporate the VIX into their strategies. Understanding its delayed response to oil price shocks offers valuable insights for making informed directional bets across financial markets.

"Oil is the lifeblood of the global economy." – The Economist

Source: Reuters (2025). Oil prices and volatility. www.reuters.com/article/venezuelan-crude-ban

Data and Assumptions

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Data

CBOE Volatility Index (^VIX):
The Chicago Board Options Exchange measures the stock market's expectation of near-term volatility based on S&P 500 options and is often referred to as the market's "fear gauge."

Crude Oil Commodity Price (CL=F):
Represents the futures contract price for West Texas Intermediate (WTI) crude oil, a benchmark used to gauge U.S. oil market prices and expectations.

Assumptions

How Spikes Are Defines:
Spikes are determined by z-score. Z-scores in oil return greater than 2 are considered “peaks”, Z-scores in oil return less than -2 are considered “troughs.”

Window of Time:
The analysis considers VIX responses only within a 0 to 90 day window following an oil price spike. Any VIX movement beyond 90 days is treated as coincidental.

Methodology

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1. Data Collection:
Historical daily closing prices for WTI Crude Oil (CL=F) and the VIX (^VIX) were retrieved using the *yfinance* Python package, covering data from August 2000 onward.

2. Return Calculation
Daily returns were computed for both crude oil and VIX using percentage change, this was done for normalization.

$$return_t = \frac{price_t - price_{t-1}}{price_{t-1}}$$

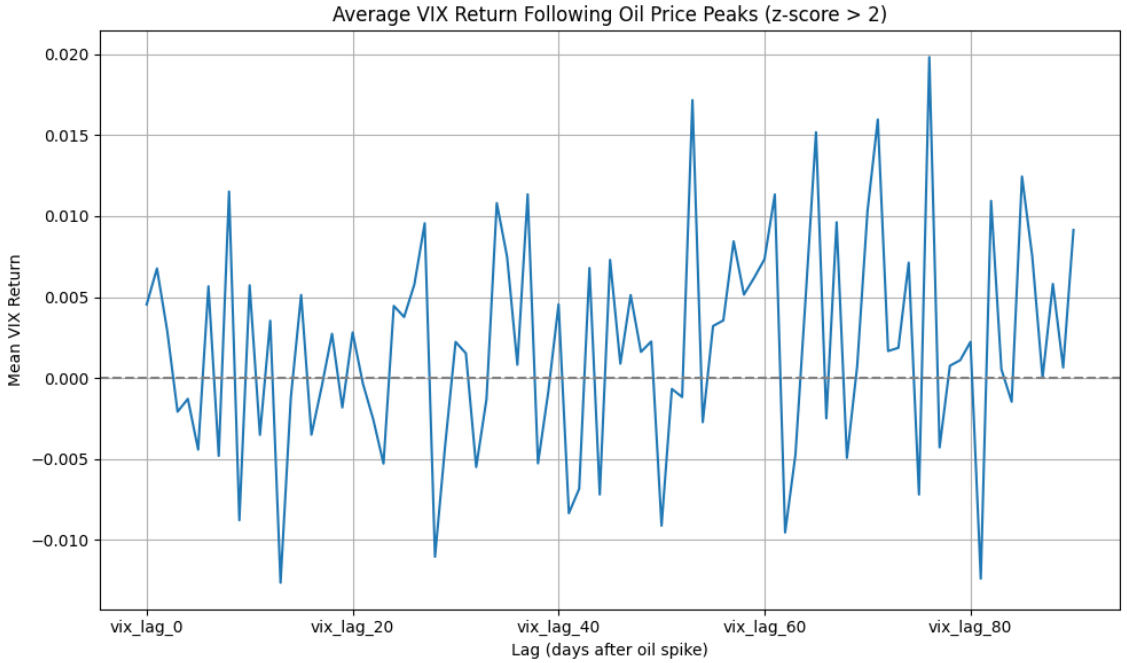
3. Peak and Trough Identification
Z-scores of daily oil returns were calculated using a 30-day rolling window. Days with z-score > 2 were labeled as spikes, and z-score < -2 as troughs.

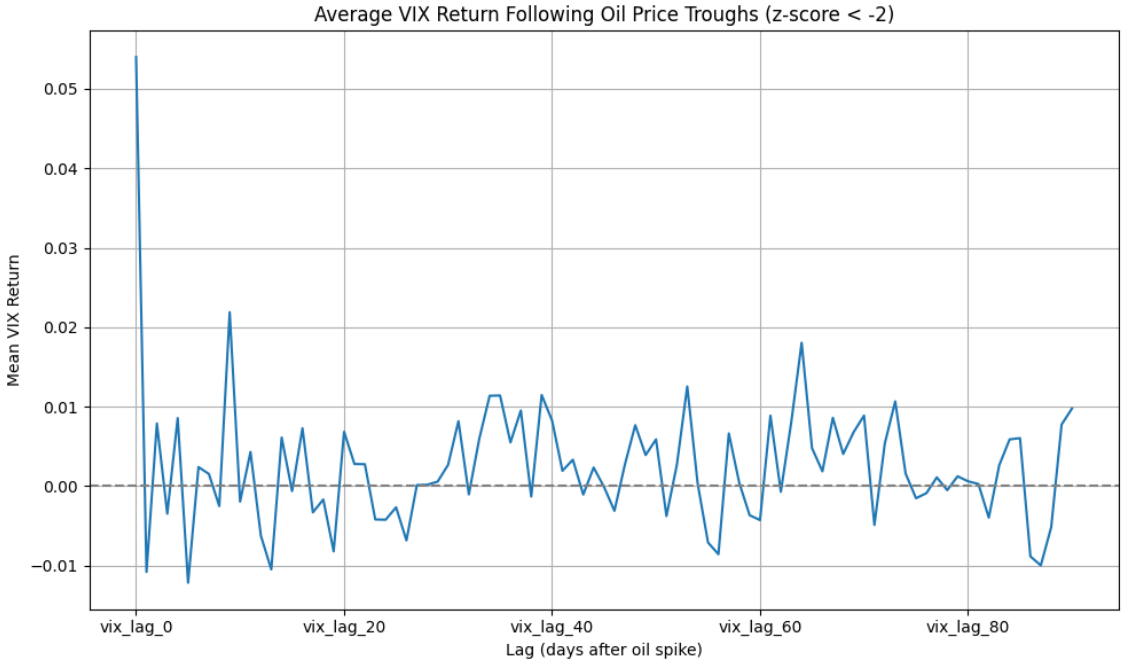
4. Lagged VIX Return Matrix
For each spike or trough, the corresponding VIX return at lag t (0 to 90 days after the event) was computed using $shift(-t)$.

5. Statistical Testing
For each lag, a runs a two-tailed, one-sample t-test was conducted to determine whether the mean VIX return at that lag was significant. The resulting p-values and means were recorded to identify which lag(s) had statistically significant changes in volatility.

GitHub Link

Results

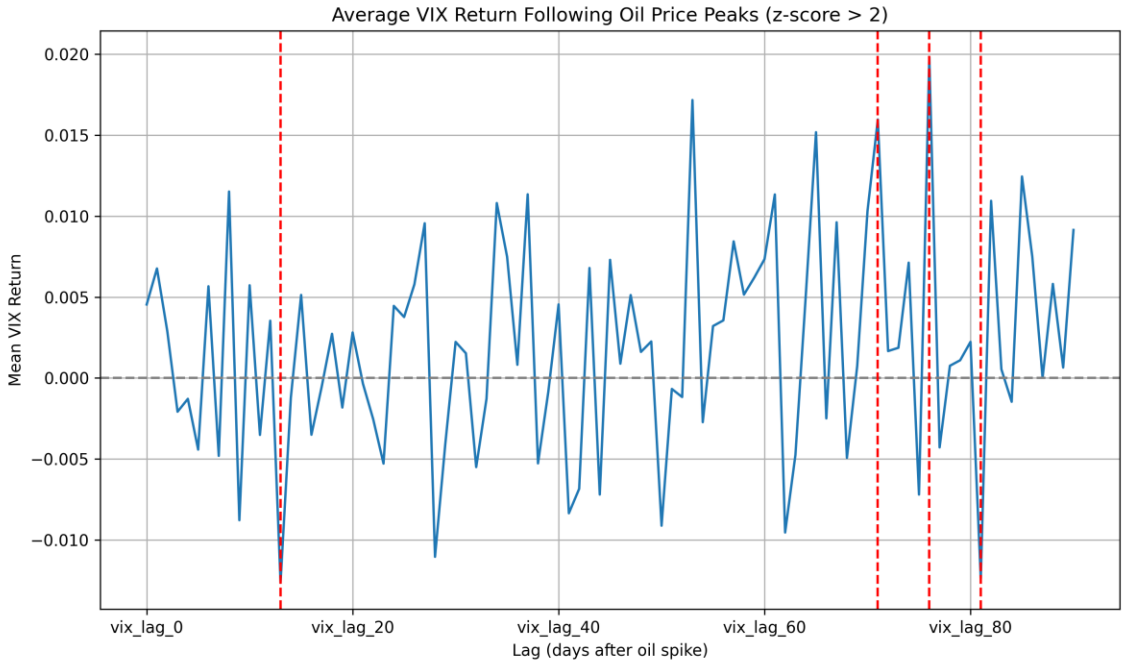


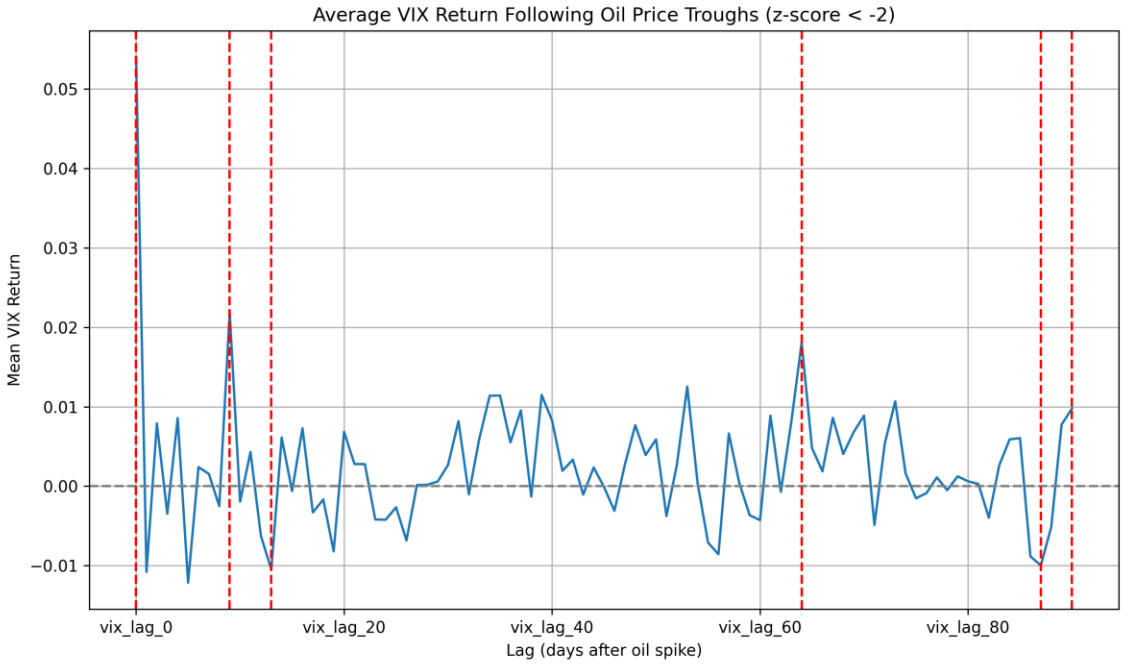


lag	n	mean	std	t_stat	p_val
81	117	-0.0123916	0.0558403	-2.40034	0.01797047
76	117	0.01982404	0.09015369	2.37849079	0.01901719
13	118	-0.0126421	0.06050856	-2.2695673	0.02506552
71	117	0.01597092	0.08321009	2.07609342	0.04009472

lag	n	mean	std	t_stat	p_val
0	169	0.05399548	0.1513987	4.63637612	7.09E-06
9	169	0.02189106	0.09770538	2.91267254	0.00407091
64	167	0.01804758	0.08140532	2.86499942	0.00470952
87	167	-0.0099671	0.06324592	-2.0365517	0.04328385
13	169	-0.0104744	0.06717144	-2.0271658	0.04422618
90	167	0.00978245	0.06254228	2.02130555	0.04485474

Results





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Key Finding

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Peaks (z-score > 2)

lag	n	mean	std	t_stat	p_val
81	117	-0.0123916	0.0558403	-2.40034	0.01797047
76	117	0.01982404	0.09015369	2.37849079	0.01901719
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- VIX returns are significant at lags 81, 76, 13, and 71.
- Lag 81 and 13 show negative mean returns, suggesting VIX declines following these peaks — possibly delayed optimism or overreaction correction.
- Lags 76 and 71 show positive VIX movement, suggesting heightened volatility after about 2.5-3 months.

Troughs (z-score < -2)

lag	n	mean	std	t_stat	p_val
0	169	0.05399548	0.1513987	4.63637612	7.09E-06
9	169	0.02189106	0.09770538	2.91267254	0.00407091
64	167	0.01804758	0.08140532	2.86499942	0.00470952
87	167	-0.0099671	0.06324592	-2.0365517	0.04328385
13	169	-0.0104744	0.06717144	-2.0271658	0.04422618
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- VIX responses are more immediate and stronger.
- Lag 0 (same day) has a very significant p-value (7.09e-06) and a high mean return (~5.4%).
- Lag 87 and 13 show negative mean returns, suggesting VIX declines following these troughs
- Lags 9, 64, and 90 also show significant VIX increases.

Conclusion

Oil price troughs lead to faster and stronger volatility responses than peaks.

- VIX increases immediately and again at multiple intervals.

Oil peaks have weaker and more delayed effects.

- Some of the lagged responses are positive, but the effects are smaller and less consistent.
- Negative VIX movement at some lags may reflect market stabilization after a brief oil surge.

Possible Explanations:

- **Asymmetry in market perception**: Large troughs may be interpreted as signs of economic slowdown, triggering fear and volatility.
- **Peaks** might be more associated with short-term supply disruptions, not longer-term systemic risk, leading to muted or even calming effects after the initial move.

Since Lag 13 appears significant in both peaks and troughs, it may be a meaningful window for a follow-up study

Source: IG Bank (2024). WTI crude oil prices. https://www.ig.com/en-ch/news-and-trade-ideas/_wti-crude-oil-price-remains-under-pressure-240909

Thank You