

Foundational Analysis for Brent Oil Price Modeling

Task 1: Laying the Foundation for Analysis

1. Define the Data Analysis Workflow

Here's a high-level overview for analyzing Brent oil prices:

Workflow Steps:

1. Data Collection

- Brent crude oil historical price data (CSV file given).
- Key geopolitical & economic events (manually curated or from public datasets).

2. Data Cleaning & Preprocessing

- Handle missing values, convert dates, and ensure proper formats.

3. Exploratory Data Analysis (EDA)

- Plot price trends and compute rolling stats.
- Plot log returns and check for volatility clusters.

4. Stationarity Testing

- Apply ADF test on price/log returns.
- Determine if differencing is needed.

5. Modeling (Task 2)

- Implement Bayesian Change Point detection.
- Detect structural breaks and correlate with events.

6. Interpret Results

- Associate breaks with real-world events.
- Quantify the impact.

7. Dashboard Development (Task 3)

- Interactive interface using Flask + React to visualize trends and event impacts.

8. Report & Communication

- Create summary visuals, statistical insights, and brief explanations for stakeholders.

2. Research and Compile Event Data (CSV Format)

Event Category	Event Name	Approximate Date	Brief Impact
Geopolitical	Iran-Iraq War Ends	8/1/1988	Potential market stabilization after conflict.
Geopolitical	Iraq Invades Kuwait	8/1/1990	Price surge (from ~\$65 to >\$90/bbl); lower production.
Geopolitical	1991 Gulf War	1/1/1991	Price decline (to ~\$44/bbl).
Economic	Asian Financial Crisis	7/1/1997	Global economic disruption, spillover effects.
Economic	Russian Financial Crisis	8/1/1998	Preceded period of soaring oil prices, linked to Asian crisis.
Economic	Dot-Com Bubble Burst	3/1/2000	Market downturn, NASDAQ peak.
Geopolitical	September 11 Attacks	9/1/2001	Initial price spike, then decline.
Geopolitical	Iraq War (2003)	3/1/2003	Prices above \$50/bbl due to low inventory, increased demand, reduced capacity.
Economic	Global Financial Crisis (Great Recession)	2008	Price plummet (from ~\$150 to ~\$40/bbl).
OPEC	OPEC Production Cuts (2008)	10/1/2008	OPEC+ cut production by 1.5 million bpd.
Economic	US Shale Oil Revolution	Early 2010s (decade leading to 2020)	Increased US output, contributed to price fall (\$106 to \$63/bbl by 2020).
Economic	European Sovereign Debt Crisis	5/1/2010	Multi-year debt and financial crisis in EU.

Geopolitical	Libyan Civil War	2/1/2011	Repeated halts in oil production and exports.
Geopolitical	Syrian Civil War	3/1/2011	Near halt of Syrian oil production, shift to net importer.
OPEC	OPEC Lifts Production Limit	12/1/2015	Shift in policy, potential contribution to price declines.
OPEC	OPEC+ Production Cuts	11/1/2016	Joint cut by 1.8 million bpd.
OPEC	OPEC+ Joint Production Cuts	12/1/2018	Joint cut by 1.2 million bpd.
Economic/OPEC	COVID-19 Pandemic & Russia-Saudi Arabia Oil Price War	3/1/2020	65% price decline due to demand reduction and supply surge.
OPEC	OPEC+ Reaches Production Cut Agreement	4/1/2020	Major agreement to stabilize markets.
Geopolitical	Russia-Ukraine Conflict	2/1/2022	Drove oil prices up by ~\$45/bbl.
OPEC	OPEC+ Production Cut	10/1/2022	Announced production cut.

3. Assumptions and Limitations

Assumptions:

- Prices are influenced by both observable (e.g., wars, policies) and unobservable factors.
- Log returns are approximately normally distributed for modeling.
- Change point detection assumes regime shifts are detectable statistically.

Limitations:

- **Correlation \neq Causation:** Just because a change point aligns with an event doesn't prove causality.
- News may influence the market *before* official events due to speculation.
- External economic factors (e.g., demand/supply dynamics, currency rates) are not fully modeled in basic change point analysis.

4. Understand the Model and Data

Key Concepts:

- **Time Series Properties**

- **Trend:** Long-term movement.
- **Stationarity:** Statistical properties like mean/variance don't change over time. (Essential for many models)

- **Change Point Models**

- Detect structural breaks.
- Bayesian models can infer the probability of change at each point.

- **Expected Output**

- τ (tau): date(s) of regime change.
- μ_1, μ_2 : mean before/after change.
- Posterior distributions of parameters.