

Predicting Oil Prices with LLMs: Tapping into OPEC and IEA Reports

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1. Motivation and Contributions

Context:

- Central banks need **reliable tools** to forecast and analyze **oil price drivers**
- OPEC and IEA reports** offer **rich qualitative information** on oil supply & demand factors which traditional methods **fail to capture**

- Q1:** Can LLMs tap into **OPEC and IEA reports** to improve oil price forecasts?
Q2: Are there **differences in the predictive content** of OPEC vs. IEA reports?

Contributions:

- Novel **LLM + Semantic RAG** framework for **oil price forecasting** at 1-12 month horizons
- First paper to forecast Structural drivers** (forward demand, current demand, supply) from SVAR of Gazzani et al. (2024)
- Qualitative rationales:** the model provides **explanations** for each forecast

2. Methodology

Step 1 — Data Processing & Summarization

- Monthly Oil Reports from **IEA and OPEC** (May 2014 – Dec 2025)
- Reports summarized via GPT-4o → concise summaries $S_t^{(s)}$
- Embeddings via OpenAI's text-embedding-3-large

Step 2 — Semantic Retrieval-Augmented Generation (RAG)

- For each forecast at t , retrieve k most **similar** historical summaries via cosine similarity on embeddings
- Provides relevant context from **similar** past market episodes

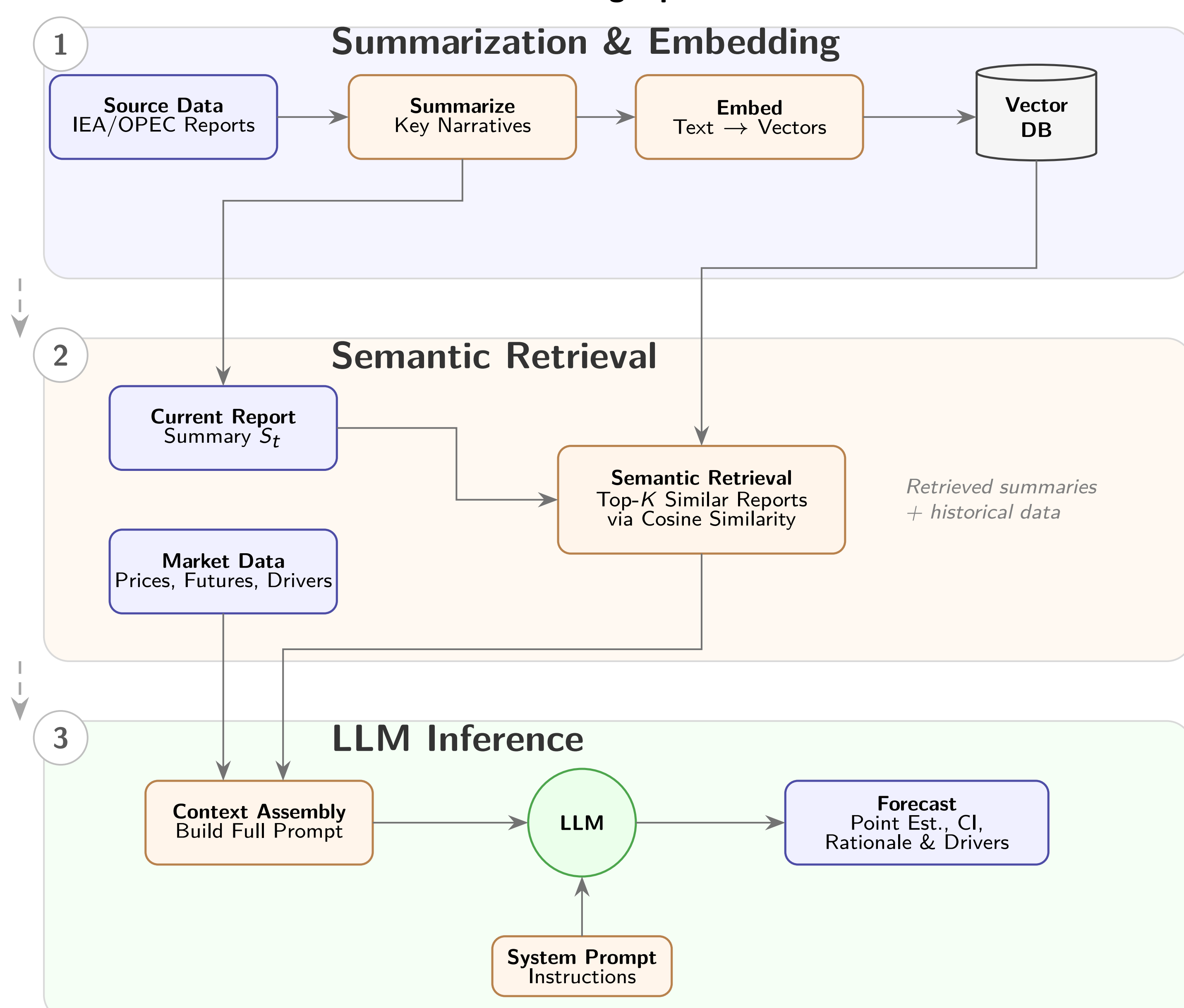
Step 3 — LLM Forecasting (OpenAI o3)

Input: summary S_t + retrieved context \mathcal{R}_t + prices, futures, past SVAR drivers

4 Outputs:

- Price forecast** for Brent at horizon h
- Agnostic decomposition:** Predicted price change into four drivers: target-month demand/supply and forward-looking demand/supply
- Structural decomposition forecast** (Gazzani et al. 2024): forward demand, current demand, oil supply
- Qualitative rationale** for price and driver forecasts

Forecasting Pipeline



3. Forecasting Results

- Predicted variable:** **Brent price** and **Structural drivers** from Gazzani et al. (2024);
- Pre-cutoff:** Jan 2015 – May 2024 (~111 obs.) — before o3's knowledge cutoff
- Post-cutoff:** Jun 2024 – Dec 2025 (6–17 obs.) — out-of-sample

Price Forecast & Structural Driver Accuracy

Horizon	Source	Price Forecast (RMSE)		Structural Drivers – Pre-Cutoff (RMSE)				N _{pre}	N _{post}
		Pre	Post	Fwd Dem.	Cur. Dem.	Supply	Avg.		
1m	OPEC	3.893***	3.175**	2.821***	2.326**	3.295***	2.814***	111	17
	IEA	4.229***	3.660	3.173**	2.197***	3.351***	2.907***	111	17
	Futures Zero	4.826	3.645	—	—	—	—	—	—
3m	OPEC	10.356***	5.868	5.195**	4.325***	6.658**	5.393***	112	15
	IEA	11.549	5.295***	5.197**	4.605**	7.024	5.608**	112	15
	Futures Zero	11.613	5.849	—	—	—	—	—	—
6m	OPEC	14.658***	4.371	6.870*	5.812***	10.370	7.684**	112	12
	IEA	14.866***	3.234***	6.789**	5.989**	10.141	7.640**	112	12
	Futures Zero	15.715	3.566	—	—	—	—	—	—
12m	OPEC	18.274***	10.210	8.929*	7.265**	11.890*	9.361***	112	6
	IEA	19.181**	6.714	9.050	7.189**	12.631	9.624***	112	6
	Futures Zero	20.959	5.295	—	—	—	—	—	—
				9.460	8.414	12.627	10.167	112	—

Price: Clark-West test vs. futures (***p<0.01, **p<0.05, *p<0.1). Drivers: Clark-West test vs. zero benchmark.

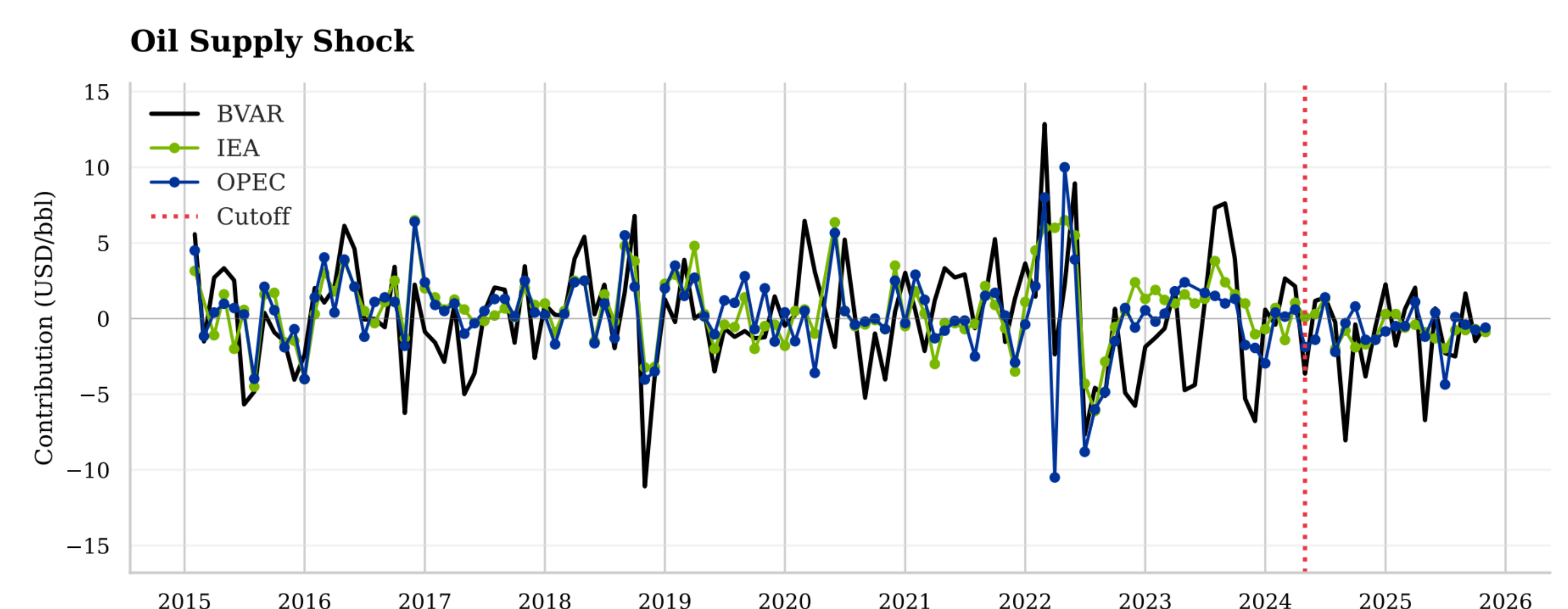
Key findings:

- Performance is **strongest at short horizons:** at 1-month, OPEC & IEA significantly outperform futures in the pre-cutoff period
- OPEC dominates pre-cutoff**, consistent with richer supply-side information
- Post-cutoff:** OPEC remains best at 1-month; IEA performs better at longer horizons
- The model performs well in **forecasting structural drivers**, including supply shocks, for which OPEC and IEA reports are most informative

4. Interpretability & OPEC vs. IEA

Key feature: the LLM that produces forecasts also generates **qualitative rationales**

Oil Supply Shock — Forecast vs. BVAR (1-month)



LLM-rationales for largest forecast errors:

Apr 2022 — OPEC and IEA read the Russia shock in **opposite directions:**

- ▷ **OPEC:** "Surprise continuity of Russian exports and the announced 180 mb US-SPR draw constituted a **negative** supply shock [for oil prices]."
- ▷ **IEA:** "Sudden, unanticipated loss of Russian supply and limited near-term OPEC+ response create a **positive** supply shock [for oil prices]"

Sep 2024 — Both underestimated supply recovery:

- ▷ **OPEC:** "Resilient US output constitute an **unanticipated** loosening of balances, nudging prices downward."
- ▷ **IEA:** "**Unanticipated** [...] U.S. output expansion increase near-term availability, weighing on prices."

Policy relevance: Transparent narratives bridge prediction and interpretation — complementing DSGE/SVAR frameworks for central bank communication