Persistent Homology in Commodities

One-Page Summary

Key Questions Addressed

Theme	Question
Cyclic Structures	Are there cyclic structures in commodities pricing (e.g., wheat, crude oil)?
Quantification	Can these cyclic patterns be quantified and captured using persistent homology?
Application	Can trading strategies be developed based on these patterns?

Conceptual Ideas Proposed

- **Persistent homology** quantifies loop structures through **Betti-1** lifetimes as loop strength.
- Loops extracted from rolling window **3D PCA embeddings** of commodity prices, with custom window lengths and step sizes.
- **Loop strength thresholds** define trading signals, with optional **stop-loss mechanisms** for risk control.

Key Results

- Long-lived loops detected in crude oil and wheat; loop lifetimes vary by commodity.
- Loop strength regressed on standard stats achieves **AUC** $>$ **0.7**.
- Trading strategies deliver **70%+ CAGR**, **Sharpe** $>$ **1**, with 5–10 trades over 5 years. Results reflect initial configurations.

Illustrative Figures and Tables

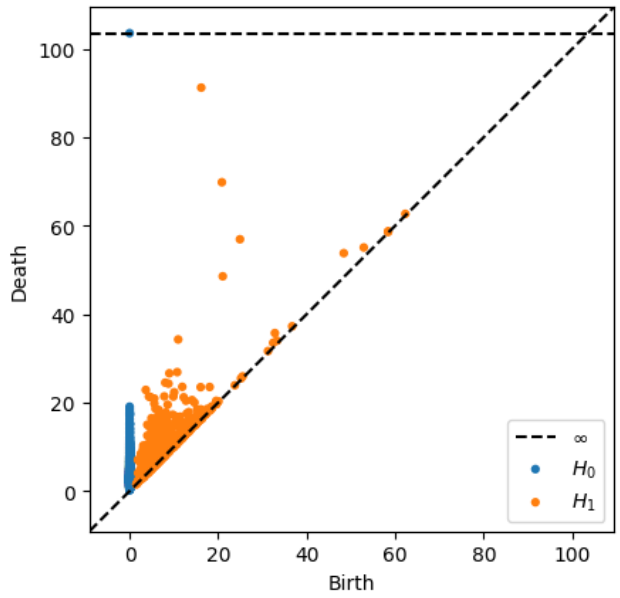

Figure 1: Persistence Diagram for Crude Oil Pricing Windows.

Metric	Value
CAGR	98.16%
Sharpe Ratio	1.24
Sortino Ratio	1.76
Max Drawdown	-39.89%
Trades	9

Table 1: Sample Trading Strategy Performance (Crude Oil)