

Persistent Homology in Commodities

One-Page Summary

Key Questions Addressed

Theme	Question
Cyclic Structures	Whether latent cyclic regimes exist in commodity pricing including wheat and crude oil
Quantification	Whether these structures can be measured and localized using persistent homology applied to sliding window embeddings
Application	Whether loop-derived signals can support predictive models and real-world trading strategies

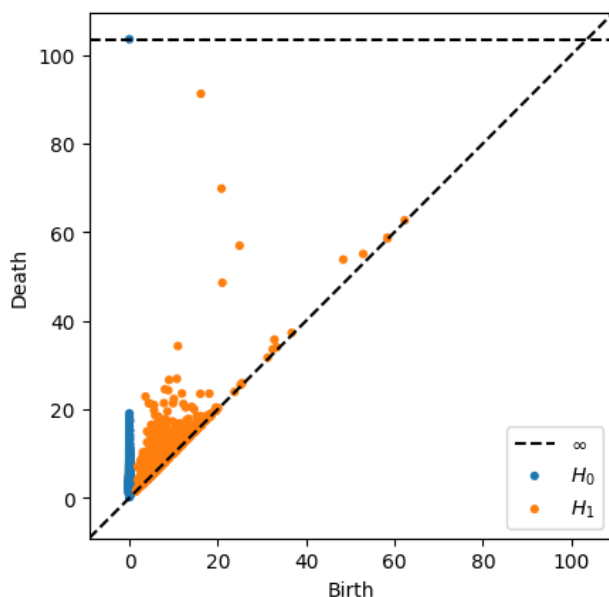
Conceptual Ideas Proposed

- **Loop strength quantified through Betti-1 lifetimes** from sliding window PCA embeddings of price trajectories
- **Commodity-specific window tuning** for oil and wheat reflecting structural differences
- **Classification using local statistics** including mean, volatility, skewness, and autocorrelation
- **Trading signals derived from classifier probabilities** with scope for further threshold optimization

Key Results

- **Persistent loops detected** with clear differences between oil and wheat structures
- **Classifier AUC scores above 0.74** using only interpretable features
- **Backtested strategies deliver 70 to 98 percent CAGR** with Sharpe above 1 and low trade counts
- **Strategy parameters can be systematically optimized** for risk-return trade-offs

Illustrative Figures and Tables



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

Table 1 shows sample trading strategy performance based on loop-predicted intervals for crude oil

Figure 1 shows a persistence diagram from crude oil sliding window embeddings highlighting loop structures