



Calendar Spread Analysis

**Analyzing Calendar Spreads and Mean Reversion
Strategies in Futures Markets**

PRESENTED BY

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Commodity Calendar Spreads in Futures Market

Problem

Objective: To analyze contango, backwardation, and seasonal patterns in futures markets and design two trading strategies:

- Method 1: Curve Analysis (Calendar Spreads)
- Method 2: Mean Reversion

Key Results

Method 1	Top Performance	Notable Insights
Contango	ALE (14.16%), GC (1.88%)	ALE shows strong upward trends; GC is volatile
Backwardation	ZNA (5.11%)	ZNA delivers positive returns but remains unstable
Seasonal	NG (0.09%)	NG benefits from contango trends
Method 2		
High Volatility	GC (15.19%), ZNA (8.03%)	GC and ZNA exhibit strong mean-reversion signals
Low Variance	HO (0.003%)	Low spread variance limits trading opportunities

Data

- Futures Categories (2014 – 2024):
 - **Backwardation**: Crude Oil (CL), Brent Crude (CO), Zinc (ZNA)
Calendar Spread: 1st-nearest vs. 6th-nearest contracts
 - **Contango**: Copper (HG), Aluminum (ALE), Gold (GC)
Calendar Spread: 1st-nearest vs. 6th-nearest contracts
 - **Seasonality**: Natural Gas (NG), Heating Oil (HO), Gasoline (XB)
Seasonal Spread: 1st-nearest vs. 12th-nearest contracts
- All prices are Last Price (PX_LAST) from Bloomberg
- Currency: USD
- Spread Calculation: Near-term futures price – Far-term futures price

Method 1 - Curve Analysis

- Assume the shape of the futures curve doesn't change as time elapse
- Time = 1M: $F(6M) \rightarrow F(5M)$, $F(1M) \rightarrow Spot$
- Time $\rightarrow 0$ (daily): $Slope(6M)$ and $Slope(1M)$
- For contango cases:
If $Slope(6M) > Slope(1M)$, long $F(1M)$ short $F(6M)$
Else long $F(6M)$ short $F(1M)$
- For Backwardated cases: the opposite direction
- For Seasonal cases: Extract trend and classify into contango or backwardation cases

Contango: Future curve upward sloping

- Copper, Aluminum, Gold

Backwardated: downward sloping

- WTI & Brent Oil, Zinc

Seasonal: has periodical cycle

- Natural gas, Heating Oil, Gasoline

Contango:
HG (copper)

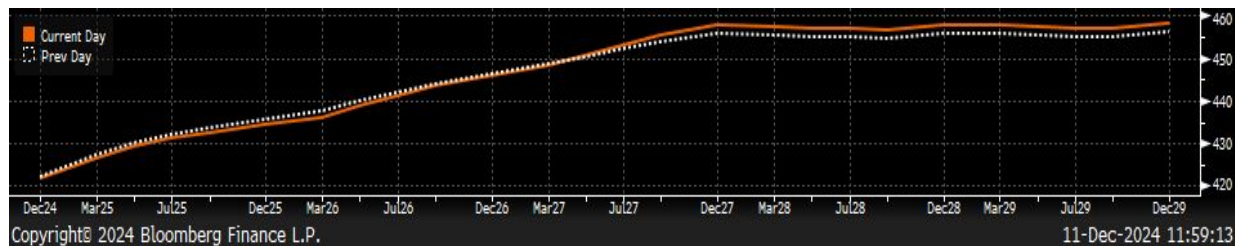


Figure 1 Future Curve of HG

Backwardation:
CL (WTI crude oil)

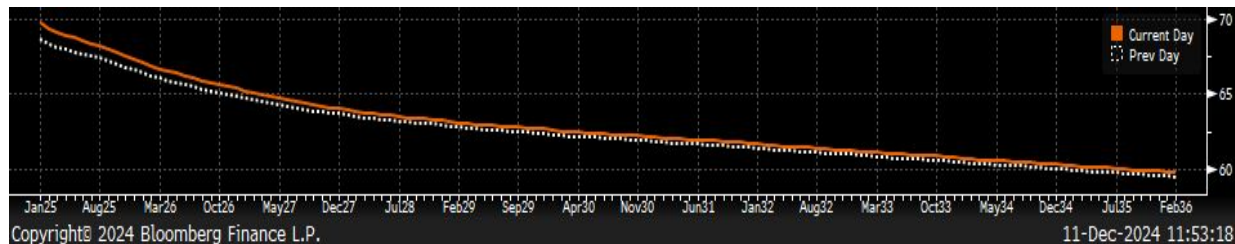


Figure 2 Future Curve of CL

Seasonal:
XB (Gasoline)

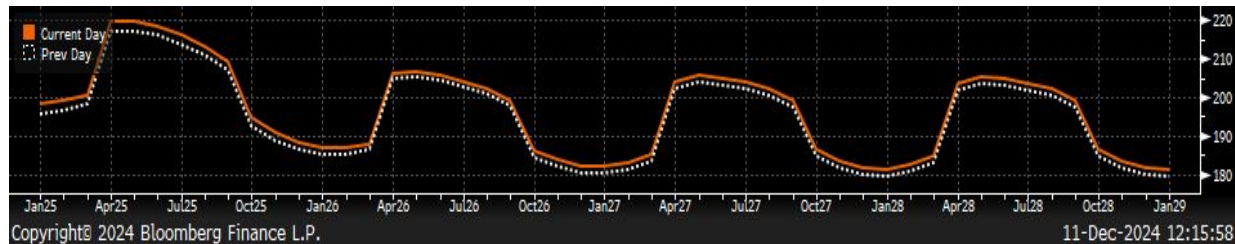


Figure 3 Future Curve of XB

Method 2

Trading Logic

- Identify mean-reverting behavior of spreads
- All 9 products have high correlation (>0.9)

Define Thresholds

- **Up** = mean + $0.25 \times \text{var}$
- **Down** = mean - $0.25 \times \text{var}$
- **Up_stop** = mean + $3 \times \text{var}$
- **Down_top** = mean - $3 \times \text{var}$

Implementation

- Contango/Backwardation: 252-day rolling mean/var
- Seasonal: Use yearly mean/var (one-year cycle)
- Normalized Spread = $(\text{Spread} - \text{Mean}) / \text{Std}$
 - Adjust for magnitude across products
 - E.g., ZNA (high var) vs. HG (negligible var)



NYU

-> Less trading signals

Entry and Exit (Figure 4)

Entry

- Day $t-1$ spread $>$ up: spread expected to narrow \rightarrow buy near-term, sell far-term
- Day $t-1$ spread $<$ down: spread expected to widen \rightarrow sell near-term, buy far-term

Close

- Extreme spread levels

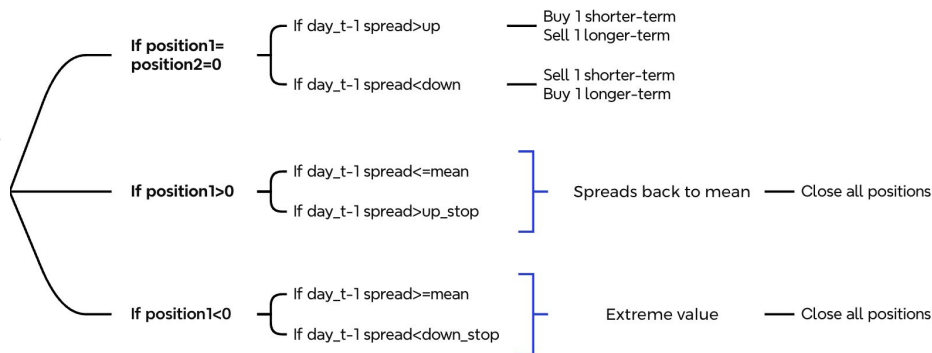
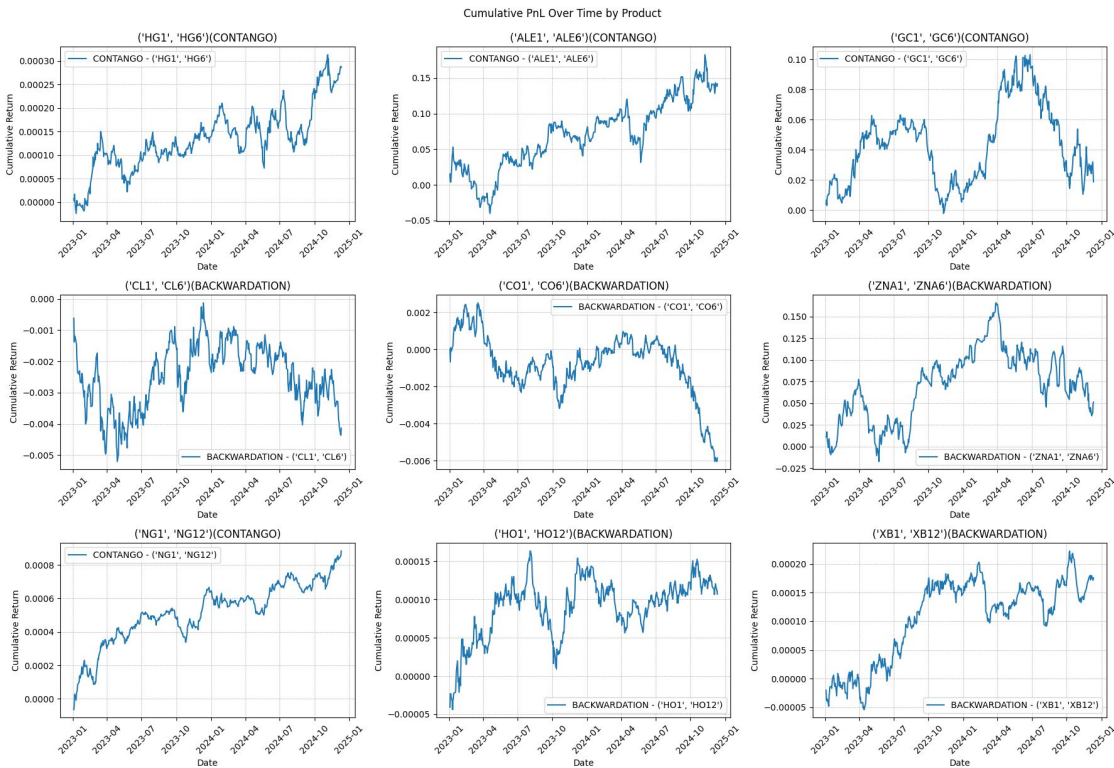


Figure 4 Mean Reversion Strategy

Performance Metrics

- The forward curve at the time of data collection reflects the market's current state
- We assume the shape of the curve (Contango or Backwardation) remained unchanged for the last two years (2023–2024)
- The backtest period spans from January 1, 2023 to December 31, 2024, with daily PnL calculations
- Each product is tested with a single contract throughout the backtest period
- $\text{Daily PnL} = \text{Position1} \times \text{Price Diff (near month)} - \text{Position2} \times \text{Price Diff (far month)}$
- $\text{Total return} = \text{Final Cum PnL} / \text{Initial Capital}$
Initial Capital = 10,000
- Figure 5 and 6 show the cumulative PnL over the backtest period

Method 1 Results



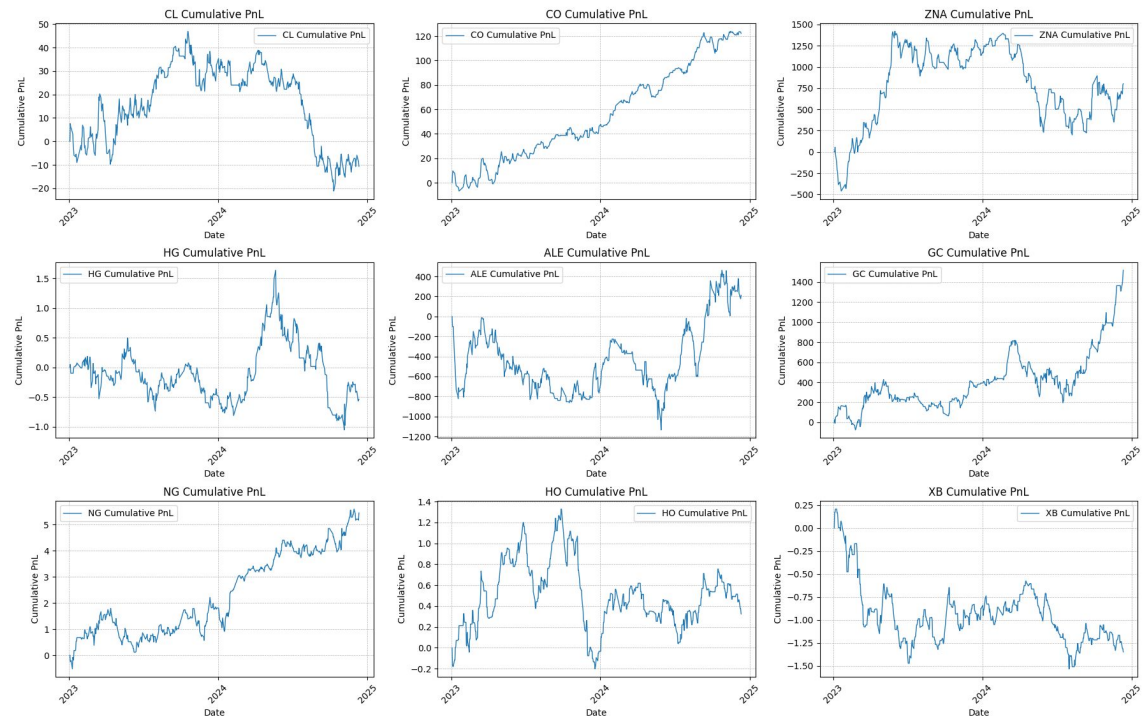
Performance

Group	Return	Comment
Contango		Both HG and ALE exhibit upward trends GC shows a more volatile pattern
HG	0.03%	
ALE	14.16%	
GC	1.88%	
Backwardation		CL demonstrates instability with significant fluctuations; CO continues to incur losses; ZNA achieves positive returns but lacks stability
CL	-0.41%	
CO	-0.58%	
ZNA	5.11%	
Seasonal		NG benefits from the Contango assumption HO and XB capitalize on the Backwardation assumption
NG	0.09%	
HO	0.01%	
XB	0.02%	

Figure 5: Curve Analysis Results

Method 2 Results

Cumulative PnL Over Time by Product



Performance

Product Group	Return	Reason
High Volatility Products		
ZNA	8.030%	Strong mean-reversion behavior
GC	15.190%	
ALE	2.130%	
Low Variance Products		
HG	-0.005%	Low spread variance with narrow threshold
XB	-0.010%	
HO	0.003%	
Contango/Backwardation		
CL	-0.110%	Significant volatility disrupts mean-reversion signals (spikes in late 2023) Moderate spread movements align with mean-reversion
CO	1.220%	
Seasonal Products		
NG	0.050%	Exhibit cyclical patterns and spreads remain close to yearly mean
HO	0.003%	
XB	-0.010%	

Figure 6: Mean Reversion Results

Conclusion

Curve Analysis Performance

- Contango strategies demonstrate strong potential, particularly with upward-trending products like ALE and HG, despite some volatility in GC.
- Backwardation strategies face challenges with instability and consistent losses, except for ZNA, which shows promise but remains volatile.

Mean reversion calendar spread strategy performance

- For Contango/Backwardation: High volatility products with clear mean-reverting spreads provide profitable opportunities
- Seasonal Products: Cyclical behavior with spreads align closely to yearly mean so rare deviations from the mean, poor performance

Appendix

Data with Bloomberg Excel API:

https://docs.google.com/spreadsheets/d/1yz90X37BCUbZ95zj48JV1Hqi7aftJ6US/edit?usp=drive_link&oid=112630864128128665983&rtpof=true&sd=true

Literature:

Y. Yang, "Variance Ratio Test of Random Walk Hypothesis and a Calendar Spread Strategy for the WTI Oil Futures Market," in *Proc. 7th Int. Conf. Industrial and Business Engineering (ICIBE '21)*, ACM, 2022, pp. 154-158, doi: 10.1145/3494583.3494636.

Code:

https://colab.research.google.com/drive/1NK6CuTFPWQhgo2e4pRUmovWTdsn67RwA?usp=drive_link
https://drive.google.com/file/d/1zM08R_r7GjUEMy6zk8yhDWPBpH_nZmiU/view?usp=drive_link