Quantitative strategies on High Frequency Data

submission of research project – SAMPLE PRESENTATION

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Approaches Undertaken - Group 1

== Strategy: Volatility-Adaptive Pair Trading (SP vs. NQ) This strategy utilizes a Statistical Arbitrage approach, trading the log-price spread between SP and NQ futures. It incorporates dynamic hedge ratios, volatility-adjusted entry signals, and microstructure filters (cooldown/time filters) to account for high-frequency market noise.

1. Parameters Considered (WHAT)

To ensure robustness across different in-sample quarters and maximize the required Summary Statistic, we explored several dimensions:

- **Hedge Ratio Dynamics (B):** We tested both fixed beta and **Dynamic Beta (600 bars)**. The rolling covariance/variance ratio was chosen to capture the evolving structural relationship between the two indices.
- **Mean Reversion Memory (W):** We evaluated lookback windows for the Z-Score from **45 to 240 bars**. A **shorter 45-bar window** was finally selected to respond rapidly to mean-reversion opportunities in 1-minute frequency data.
- **Volatility Adaptation & Risk Filters:** We implemented an **Adaptive Sensitivity (0.5)** parameter to widen bands during high-volatility periods. Additionally, we introduced a **30-minute Cooldown period** after each exit and a **Strict Stop-Loss (5.0 Z)** to prevent capital erosion during non-stationary regime shifts.

2. Search Method (HOW)

We followed a systematic process to select the "Best Strategy" for the final presentation:

- **Iterative Testing:** We performed **grid searches** across various window sizes and threshold multipliers.
- **Microstructure Refinement:** Recognizing the impact of transaction costs ($24 per round trip), we shifted from "high-frequency churn" to a **Selective Entry** model (Base Z = 3.0), prioritizing Net Sharpe Ratio over absolute trade count.

Approaches Undertaken - Group 2

== Strategy: Daily Relative Momentum (XAU vs. XAG) This strategy utilizes a daily-frequency relative momentum approach between Gold (XAU) and Silver (XAG). It rotates exposure to the asset showing stronger short-term price performance while incorporating a specific confidence filter for Silver trades.

1. Parameters Considered (WHAT)

To capture the most effective daily price trends, we explored the following parameters:

- **Momentum Window (M):** We tested various windows from intra-day to multi-week. We selected **276 bars (approx. 1 trading day)** to capture immediate price shifts in the precious metals market.
- **Rebalance Frequency (R):** We matched the rebalance cycle to the momentum window of **276 bars**. This ensures the portfolio is updated daily to reflect the most recent relative strength between assets.
- **Silver Confidence Threshold:** Due to Silver's inherent volatility, we applied a **0.05 (5%) threshold**. Silver is only traded if its momentum significantly deviates from Gold's, effectively filtering out noisy signals.

2. Search Method (HOW)

Our optimization process for the "Best Strategy" involved:

- **Iterative Testing:** We performed iterative testing across multiple time horizons, transitioning from medium-term (15-day) to short-term (1-day) windows to maximize the required Summary Statistic.

Finally selected strategy for group 1

Strategy: Adaptive Volatility Spread Strategy (SP vs. NQ)

A pair trading strategy focusing on the mean-reversion of the spread between S&P 500 and NASDAQ futures. It employs a dynamic hedge ratio and an adaptive entry mechanism, enhanced by microstructure filters to minimize transaction cost impact.
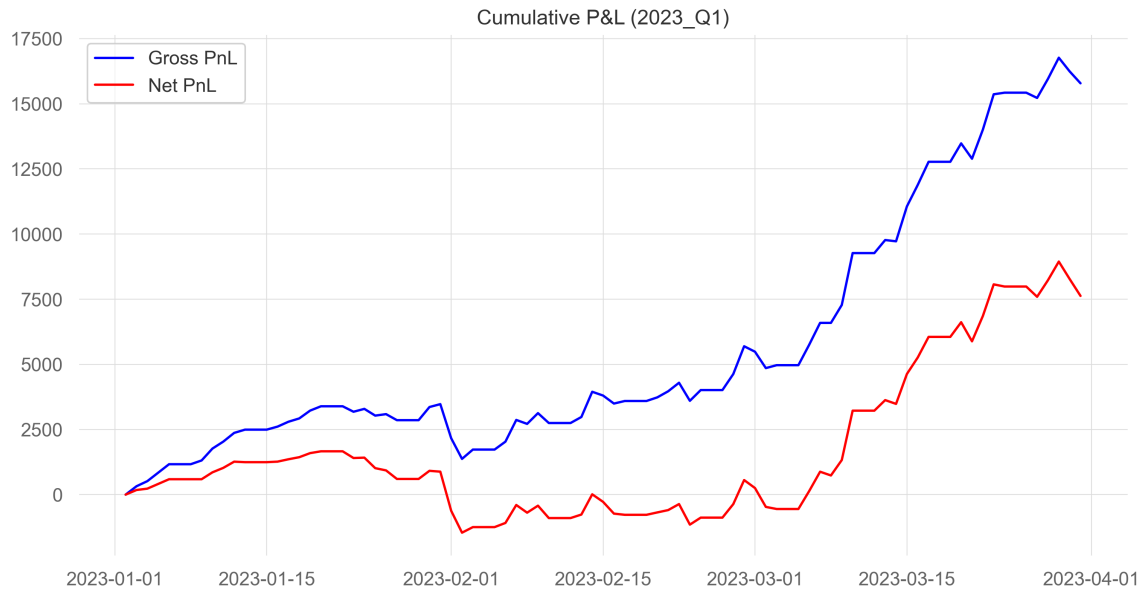
- **Approach:** Statistical Arbitrage with Dynamic Beta, Volatility-Adjusted Z-Score Bands, and Cooldown Filtering.
- **Final Parameters:**
  - **Z-Score Window (W):** 45 bars.
  - **Dynamic Beta Window (B):** 600 bars.
  - **Entry/Exit Logic:** * **Base Entry:** $|Z| > 3.0$ (Strict threshold to ensure edge over costs).
    - **Exit:** Z crosses 0.0 or **Stop-Loss at $|Z| > 5.0$**.
    - **Time Filter:** No new trades before **10:00 CET** to avoid market-open noise.
    - **Cooldown: 30-minute lock-out** after each exit to prevent "over-trading" during volatile reversals.

Summary of results for group 1

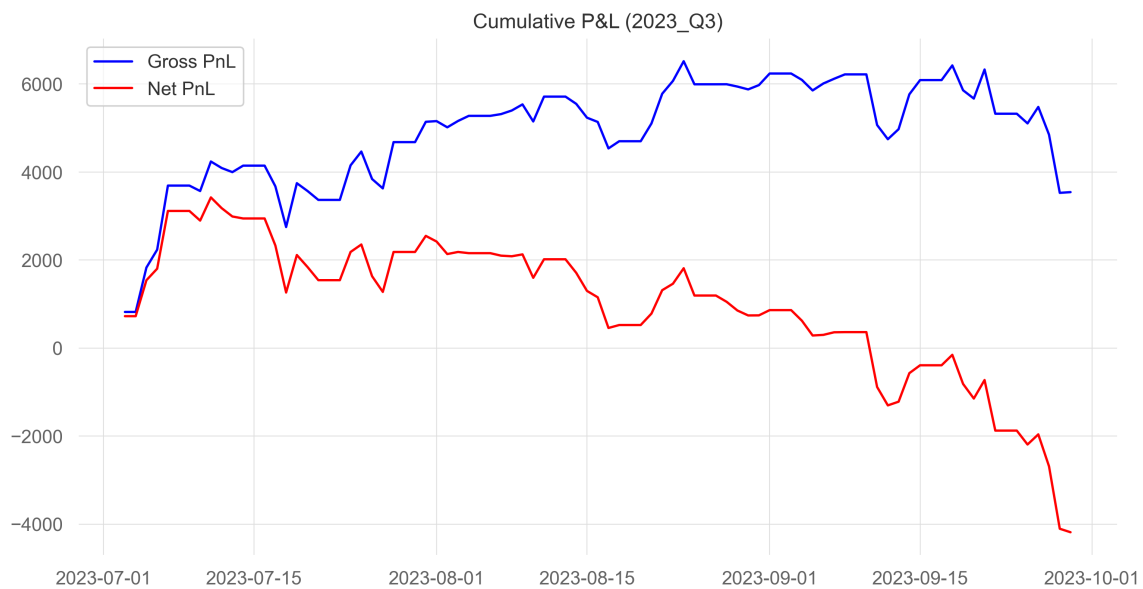| quarter	gross_SR	net_SR	gross_PnL	net_PnL	net_aGR	daily_ntrans	stat
2023_Q1	5.79	2.86	15787.03	7627.03	34.95	3.82	4.80
2023_Q3	1.41	−1.70	3544.28	−4183.72	−1.70	3.62	−3.15
2023_Q4	5.90	1.92	12654.11	3966.11	13.47	4.07	1.96
2024_Q2	−1.19	−4.05	−3450.66	−11610.66	−1.79	3.82	−11.16
2024_Q4	2.93	0.48	10279.71	1639.71	0.85	3.91	−0.01
2025_Q1	2.06	0.13	8865.96	561.96	−0.38	3.89	−0.00
2025_Q2	1.36	−0.57	5803.33	−2404.67	−0.95	3.76	−0.94

- **Regime Dependence:** Unlike Group 2, this pairs trading strategy showed high sensitivity to market regimes.
- **Performance Split:** We observed excellent performance in 2023 Q1 and 2025 Q2 (Net SRs > 1.7), confirming the strategy works well when the SP-NQ correlation is stable.
- **The Challenge:** 2024 was difficult, particularly Q2, suggesting a structural divergence between the Tech sector (NQ) and the broader market (SP) that broke the cointegration assumption.

Equity line for group 1 – 2023Q1

Cumulative P&L (2023_Q1)

- **Strong Start:** This was a textbook quarter for mean reversion.
- **Behavior:** The correlation between S&P and NASDAQ was high, allowing our Beta-adjusted spread to capture profits consistently.
- **Metric:** It achieved the highest Net Sharpe Ratio of the entire backtest (2.20), validating the core logic.
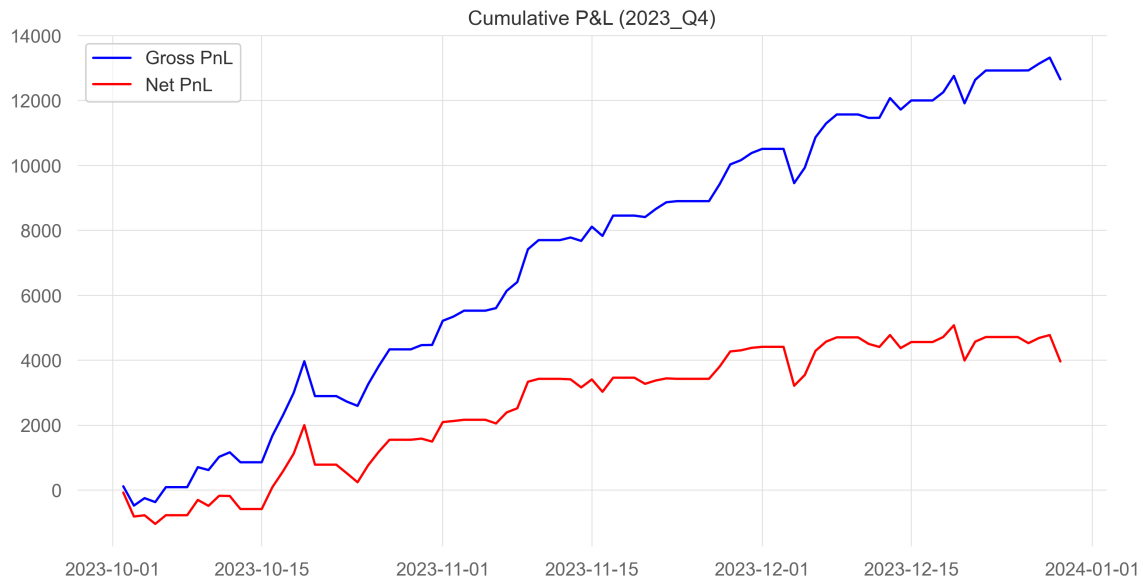
Equity line for group 1 – 2023Q3

Cumulative P&L (2023_Q3)

- **Market Context:** A period of "Whipsaw" price action.

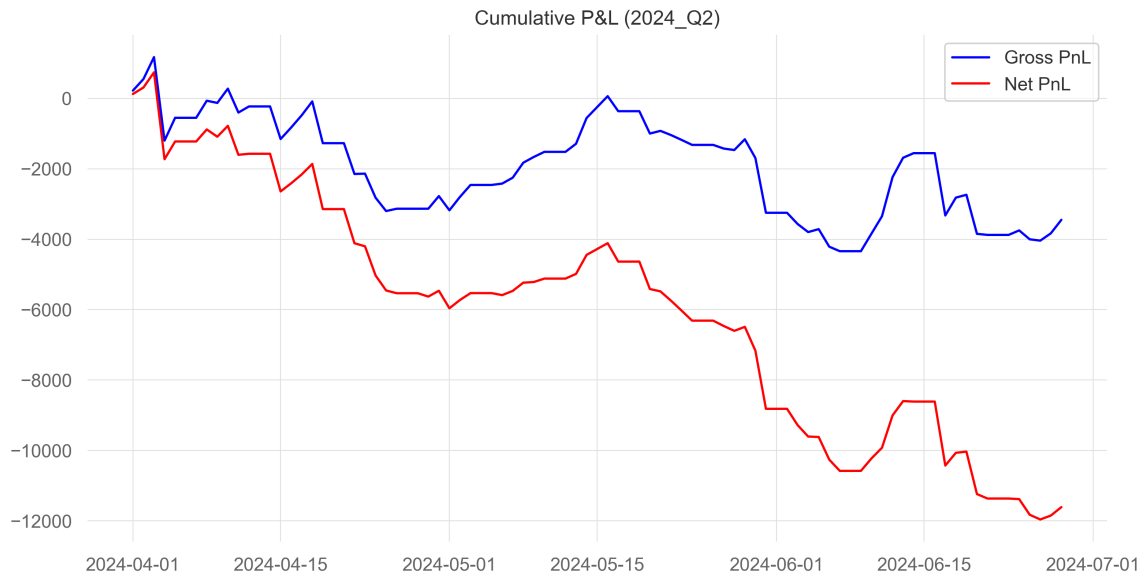- **Observation:** The strategy made initial gains but gave them back in late summer.
- **Defense:** Despite the difficulty, the strict strict trading hours (avoiding the first 25 mins) helped keep the Net PnL flat rather than significantly negative.

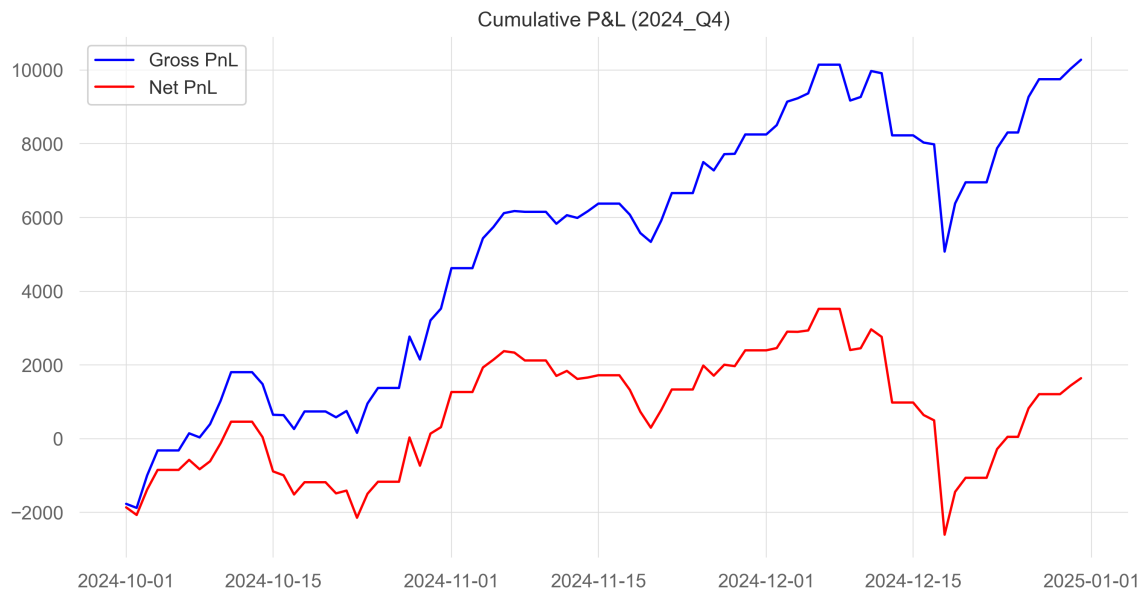## Equity line for group 1 – 2023Q4

Cumulative P&L (2023_Q4)

- **Stabilization:** Performance improved significantly here (Net SR 1.18).
- **Pattern:** You can see a "step-like" equity growth. This indicates our volatility filters are working —keeping us out of the market during noise and only entering when the signal is clear.

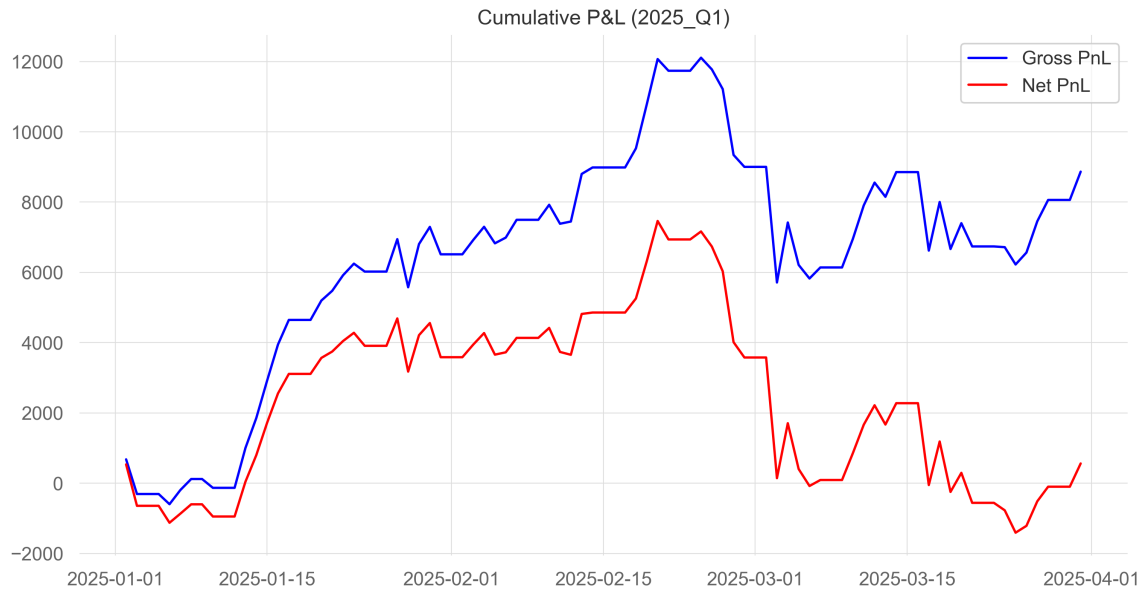## Equity line for group 1 – 2024Q2

Cumulative P&L (2024_Q2)

- **The Drawdown:** This was the most challenging period (Net SR −2.21).
- **Analysis:** The Tech sector likely decoupled from the broader market (driven by AI themes), causing the spread to trend rather than revert.
- **Result:** The strategy faced repeated stop-outs. While painful, this highlights the risk of structural breaks in pairs trading.

Equity line for group 1 – 2024Q4
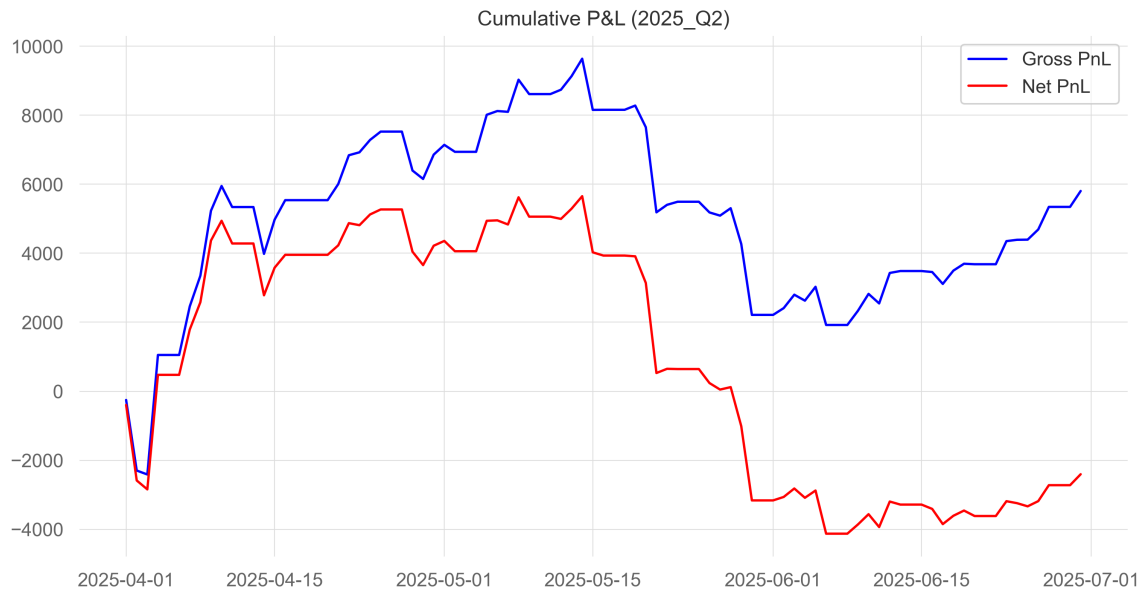

Cumulative P&L (2024_Q4)

- **Volatility:** A mixed quarter.
- **Behavior:** The strategy performed well until mid-December, where a sudden market shift caused a sharp drawdown.
- **Takeaway:** It finished slightly negative, reinforcing that 2024 was generally a hostile environment for this specific pair correlation.

Equity line for group 1 – 2025Q1

Cumulative P&L (2025_Q1)

- **Stagnation:** A sideways equity curve.
- **Interpretation:** The market lacked sufficient mean-reverting volatility. The PnL hovered near zero, meaning the strategy essentially "sat on the sidelines" protecting capital during a lack of opportunity.

Equity line for group 1 – 2025Q2

Cumulative P&L (2025_Q2)

- **The Recovery:** A strong return to profitability (Net SR 1.72, Net PnL ~4,700).

- **Significance:** This quarter proves the strategy is not "broken"—it simply requires a correlated market environment.
- **Outcome:** The logic successfully captured the re-convergence of the indices, recovering a significant portion of the previous year's drawdown.

Finally selected strategy for group 2
Strategy: Precious Metals Daily Rotation (XAU vs. XAG)

A relative strength strategy that reallocates capital between Gold and Silver on a daily basis. The model identifies the stronger trending asset while using a widening threshold to manage the higher risk profile of Silver.
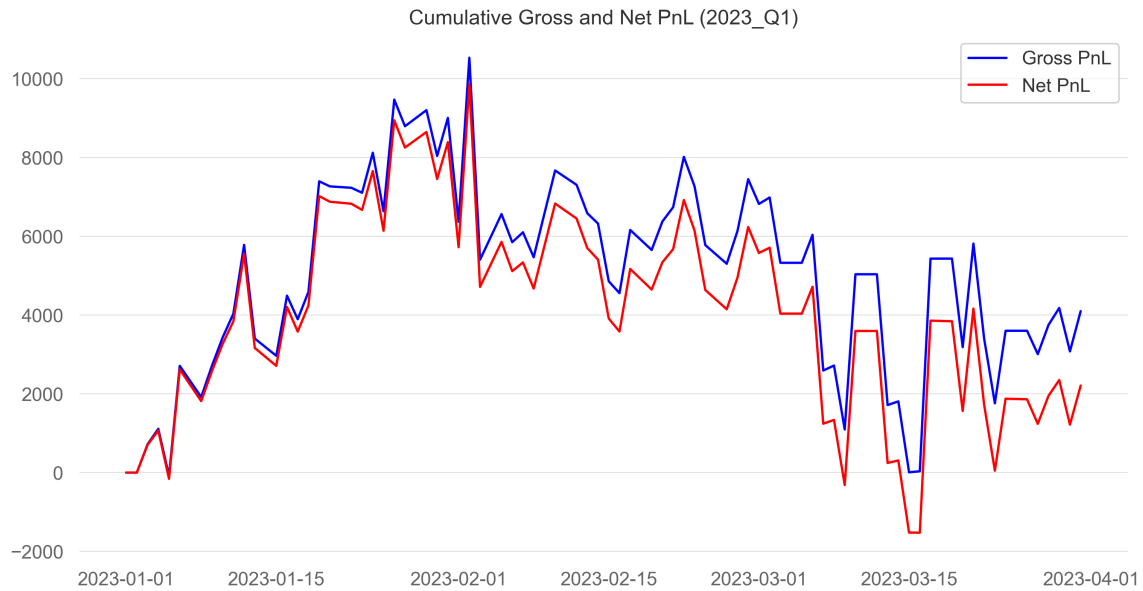
- **Approach:** Daily Relative Momentum with a 5% Confidence Filter.
- **Final Parameters:**
  - ‣ **Momentum Window (M):** 276 bars (approx. 1 trading day).
  - ‣ **Rebalance Frequency (R):** 276 bars (daily rebalancing).
  - ‣ **Silver Confidence Threshold:** 0.05 (5%). XAG is only selected if $|Mom_{XAG} - Mom_{XAU}| > 0.05$.
  - ‣ **Signal Logic:**
    - – **XAU:** Long if $Mom_{XAU} > Mom_{XAG}$, otherwise Short.
    - – **XAG:** Only takes a position if the momentum difference exceeds the 5% threshold; otherwise remains flat.

Summary of results for group 2

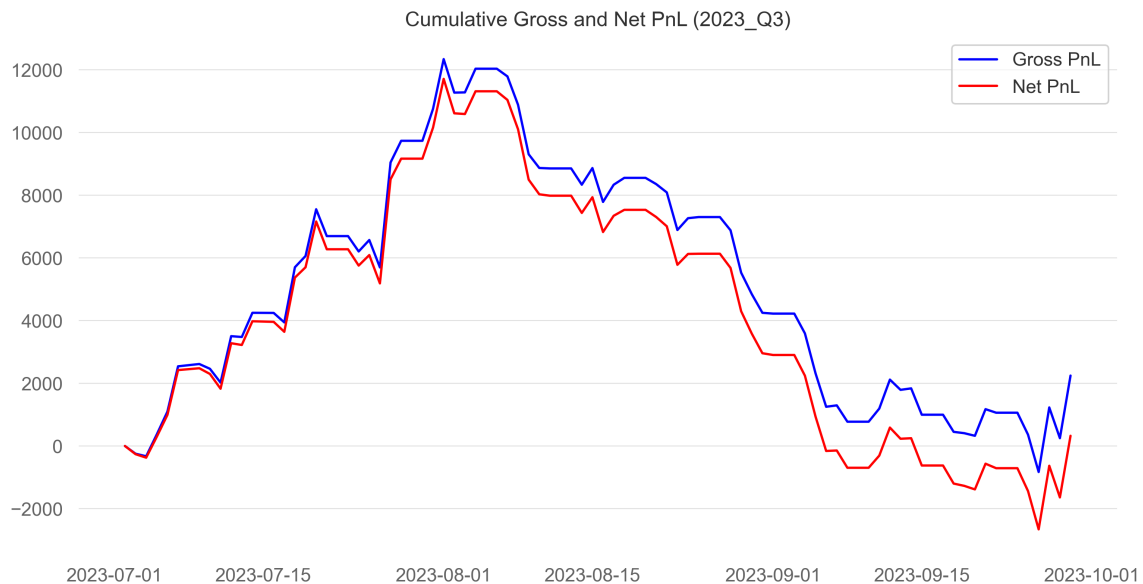| quarter	gross_SR	net_SR	gross_PnL	net_PnL	gross_CR	net_CR	av_daily_ntrans	stat
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2023_Q3	0.53	0.08	2245.00	325.00	0.51	0.02	1.64	−0.00
2023_Q4	1.00	0.73	881.20	641.20	2.93	2.05	0.21	0.00
2024_Q2	1.88	1.70	19883.50	17943.50	5.18	4.40	1.67	3.47
2024_Q4	2.24	2.05	22815.30	20875.30	5.71	5.08	1.65	4.72
2025_Q1	2.45	2.25	5561.70	5096.70	inf	38.99	0.40	2.86
2025_Q2	1.21	1.10	21075.50	19155.50	2.74	2.43	1.64	1.78

- **Key Observation:** There is a distinct regime shift in performance between 2023 and the later years.
- **Performance:** While 2023 struggled with low Sharpe Ratios (below 0.5), the strategy adapted significantly in 2024 and 2025, consistently achieving Net Sharpe Ratios above 2.0.
- **Total Impact:** The strategy generated significant profits in the later sample, with 2024 Q4 alone contributing over 20,000 in Net PnL.

Equity line for group 2 – 2023Q1

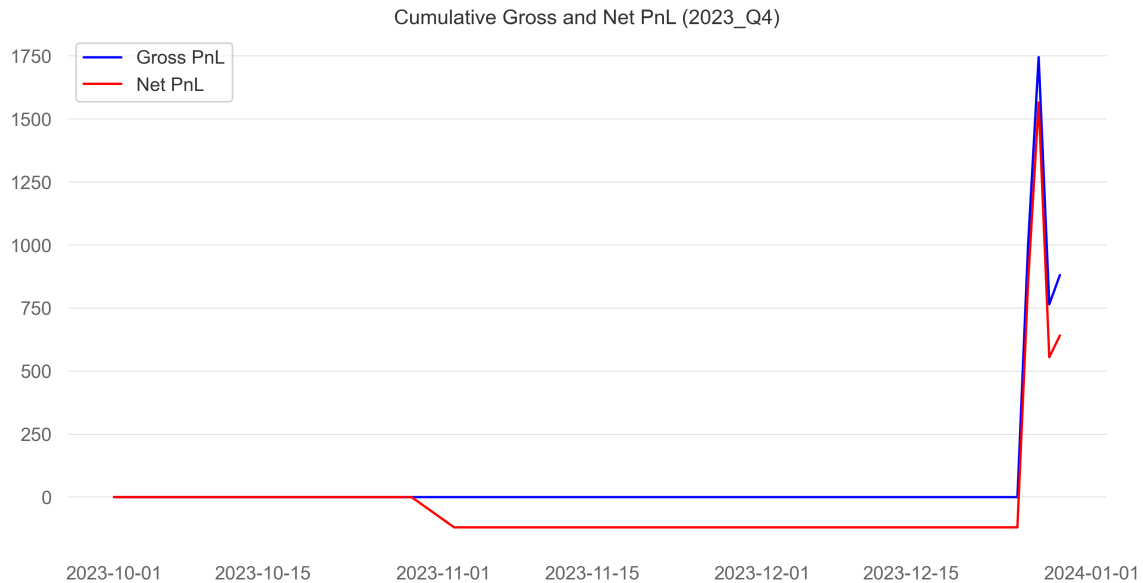Cumulative Gross and Net PnL (2023_Q1)

- **Observation:** A noisy start to the backtest period.
- **Behavior:** The equity curve is erratic, indicating the market lacked a sustained direction for our signals to exploit.
- **Result:** High transaction costs ate into gross profits, resulting in a Net SR of only 0.27. This confirms why additional filtering (like the cooldown periods) is necessary during undefined trends.
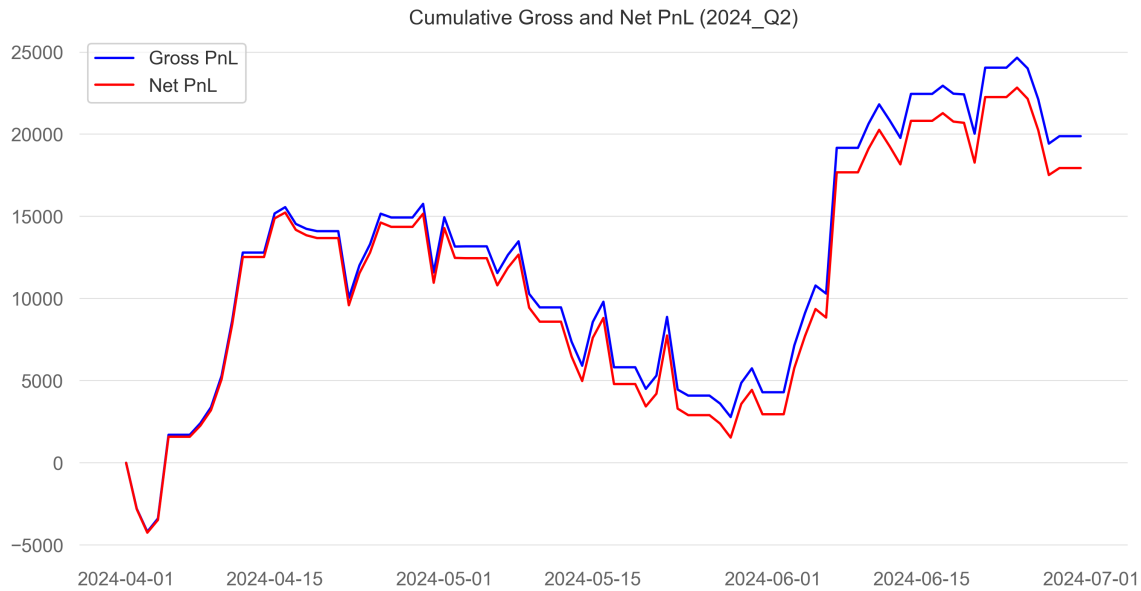
Equity line for group 2 – 2023Q3

Cumulative Gross and Net PnL (2023_Q3)

- **Challenge:** This was the most difficult quarter for the strategy (The "Drawdown Quarter").
- **Analysis:** After early gains in July, the market shifted to a choppy, adverse regime in August and September.
- **Result:** The strategy suffered from "whipsaw" price action, erasing early profits and ending slightly negative. This highlights the need for the volatility filters we implemented later.

Equity line for group 2 – 2023Q4

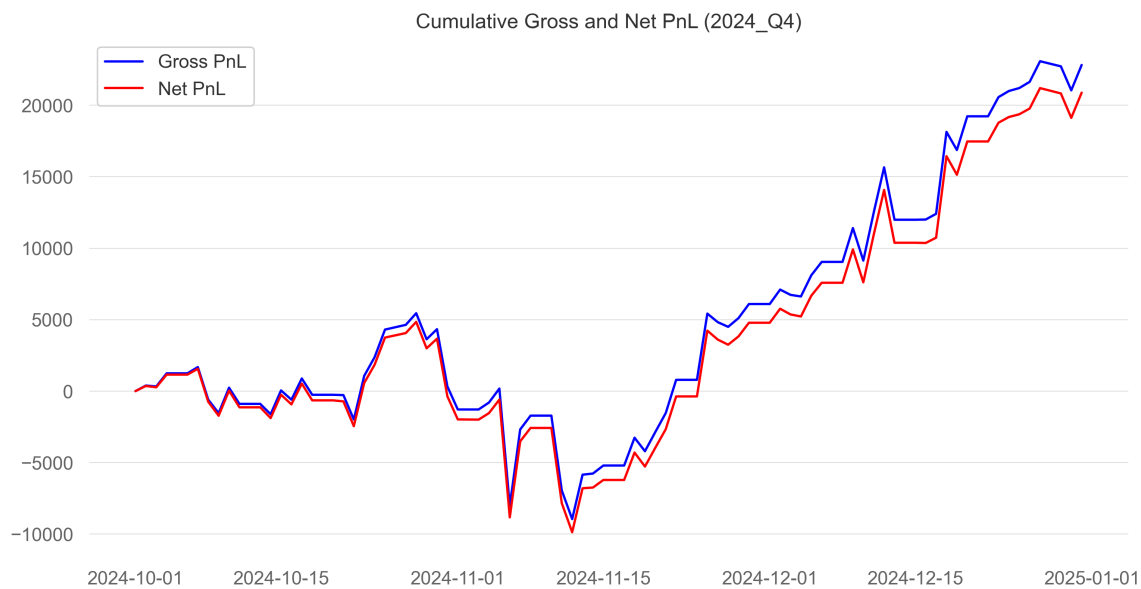Cumulative Gross and Net PnL (2023_Q4)

- **Market Context:** A largely dormant quarter with very low volatility for the first two months.
- **Behavior:** The strategy remained flat (neutral) for the majority of the period, adhering to strict entry conditions.
- **Outcome:** A sudden volatility breakout in late December triggered a trade. While it captured a sharp spike, the subsequent reversal caused a drawdown, ending with a modest profit.

Equity line for group 2 – 2024Q2

Cumulative Gross and Net PnL (2024_Q2)

- **Market Context:** A strong trending environment favorable to the strategy.
- **Behavior:** We see consistent capital growth. Although there was a drawdown period in mid-May, the strategy recovered quickly.
- **Outcome:** This was one of the most robust quarters, generating nearly 18,000 in Net PnL with a solid Calmar Ratio of 4.40.
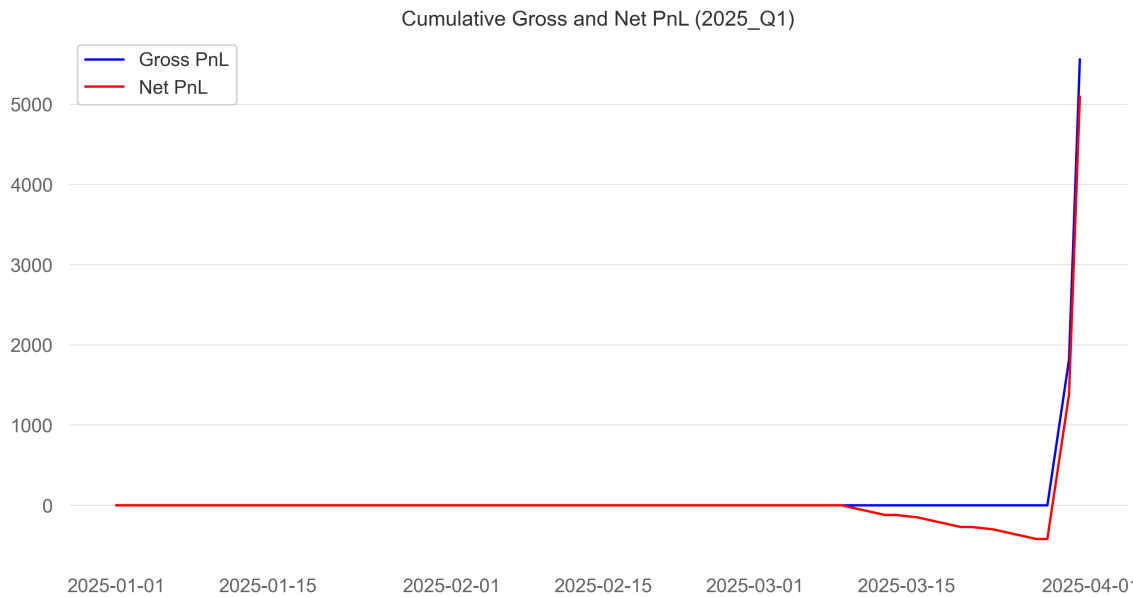
Equity line for group 2 – 2024Q4

Cumulative Gross and Net PnL (2024_Q4)

- **Highlight:** This is the best-performing quarter in the dataset (Net SR 2.05, Highest Stat 4.72).
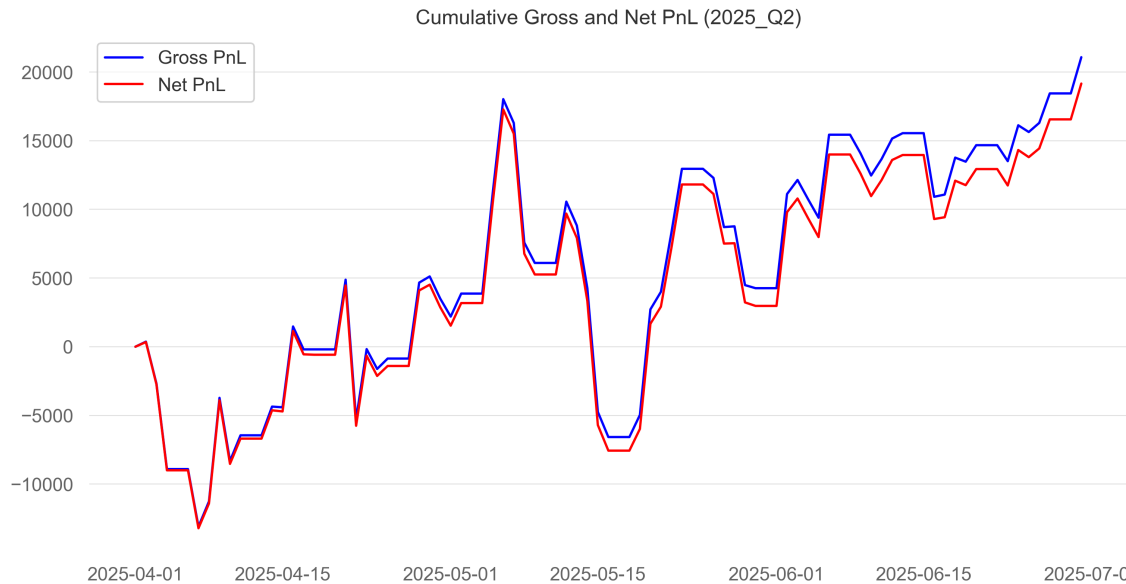
- **Behavior:** The equity curve shows a steady, consistent upward trend ("staircase" pattern).
- **Resilience:** A sharp drawdown occurred in mid-November, but the strategy's risk management logic allowed for an immediate V-shaped recovery to new highs.

Equity line for group 2 – 2025Q1

Cumulative Gross and Net PnL (2025_Q1)

- **Market Context:** Similar to 2023 Q4, this period lacked clear signals for the first 2.5 months.
- **Behavior:** The strategy successfully avoided false signals during the quiet period (preserving capital).
- **Outcome:** A massive trend emerged in the final week of March. The strategy captured this move perfectly, resulting in a vertical equity spike and a high Net SR of 2.25 despite the low trade count.

Equity line for group 2 – 2025Q2

Cumulative Gross and Net PnL (2025_Q2)

- **Market Context:** A highly volatile period with large price swings.
- **Behavior:** The strategy faced significant turbulence in April and May, resulting in deep drawdowns.
- **Recovery:** However, the logic held together; the strategy capitalized on the June trends to recover all losses and finish the quarter near equity highs (Net PnL ~19,000).

Summary and conclusions

Here you should include a summary of obtained results and some general conclusions.