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) 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 (1.5 day)**. 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 **30min to 60min**. A **shorter 45min window** was finally selected to respond rapidly to mean-reversion opportunities in 1-minute frequency data.
- **Adaptive Sensitivity (0.5):** This parameter dynamically adjusts entry criteria based on market conditions. It calculates the ratio of **current volatility** to its historical baseline. When volatility spikes, the 0.5 sensitivity factor widens the entry bands, effectively raising the bar to prevent false signals during noisy, high-volatility periods.
- **Risk Controls:** We enforce a **30-minute Cooldown** to prevent rapid re-entry after an exit. Furthermore, a **Strict Stop-Loss (5.0 Z)** serves as a "hard exit" mechanism, immediately cutting positions if the price spread deviates extremely (beyond 5 standard deviations), protecting capital from fundamental breakdowns in the correlation (regime shifts).

2. Search Method (HOW)

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

- **Manual Parameter Tuning:** We determined the optimal window sizes and threshold multipliers through **iterative manual adjustments**.

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 **1 trading day** to capture immediate price shifts in the market.
- **Rebalance Frequency (R):** We matched the rebalance cycle to the momentum window of **1 trading day**. 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 **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.
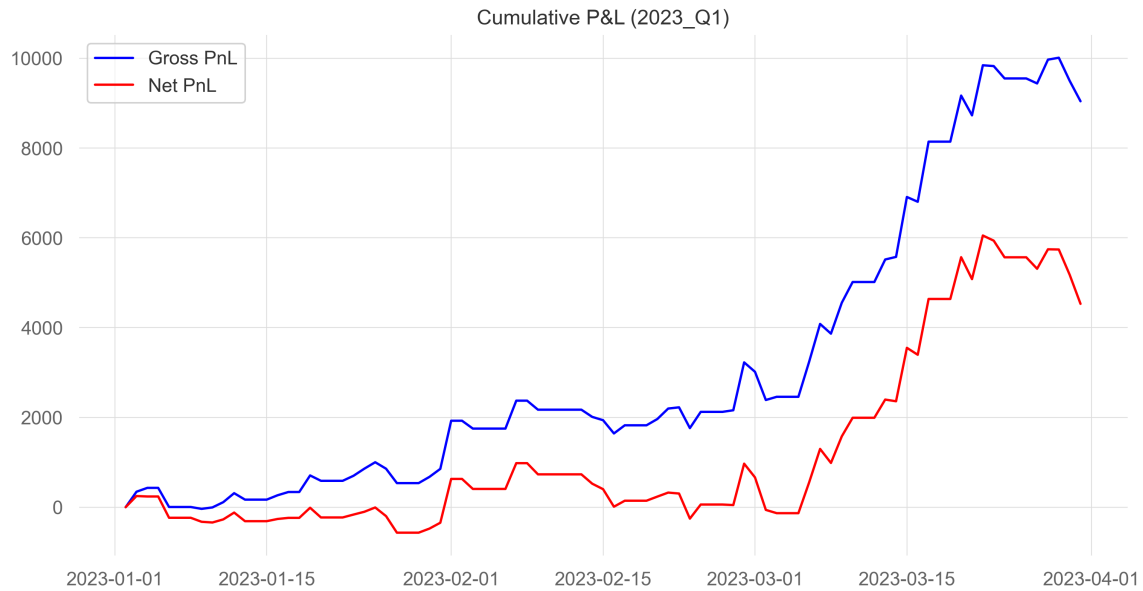
- **Approach:** Statistical Arbitrage with Dynamic Beta, Volatility-Adjusted Z-Score Bands, and Cooldown Filtering.
- **Final Parameters:**
  - **Z-Score Window (W):** 45 bars.
  - **Dynamic Beta Window (B):** 600 bars.
  - **Entry/Exit Logic:** * **Base Entry:** $|Z| > 3.0$ (Strict threshold to ensure 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

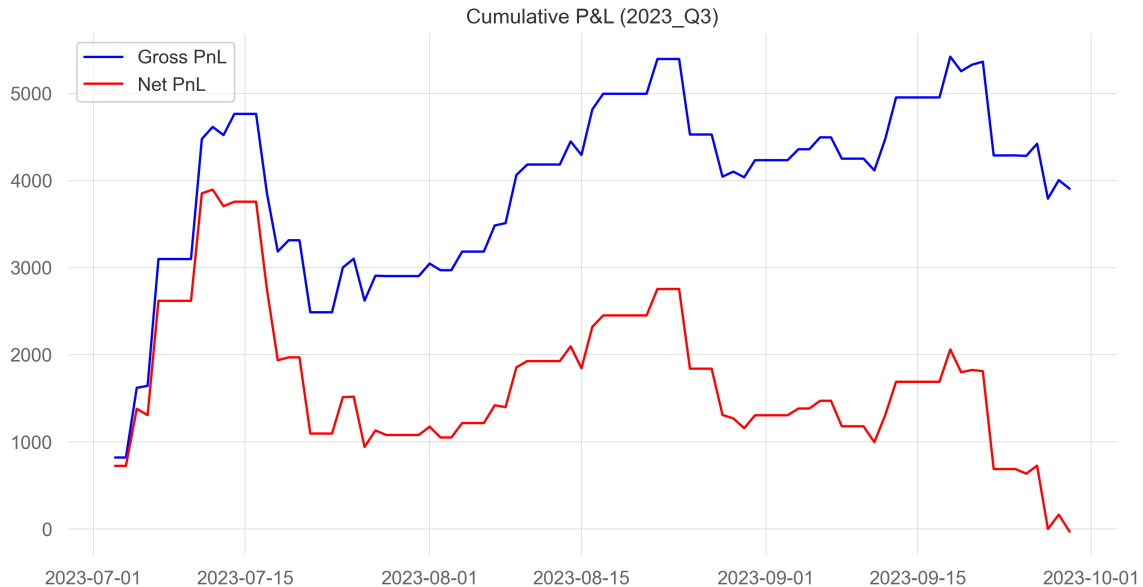| quarter	gross_SR	net_SR	gross_PnL	net_PnL	net_CR	av_daily_ntrans	stat
2023_Q1	4.24	2.20	9041.67	4529.67	23.57	2.11	2.58
2023_Q3	1.88	−0.02	3904.10	−31.90	−0.42	1.84	−0.00
2023_Q4	3.44	1.18	5603.34	1907.34	5.90	1.73	0.44
2024_Q2	−0.43	−2.21	−843.54	−4299.54	−2.45	1.62	−3.95
2024_Q4	1.07	−0.58	2307.47	−1244.53	−0.79	1.61	−0.24
2025_Q1	1.17	0.17	3826.56	562.56	−0.13	1.53	−0.00
2025_Q2	2.98	1.72	8363.07	4715.07	9.91	1.67	1.89

- **The Fees Impact:** At **2024_Q4**. The strategy actually made **$2,307** in Gross profit, but finished with a **-$1,244** Net loss. The transaction costs are eating up all the profits in choppy markets.
- **Inconsistency:** Performance is all over the place.
  - **2023_Q1** was a home run (Net SR 2.20).
  - **2024_Q2** was a disaster (Net SR −2.21), where the strategy failed fundamentally (negative Gross PnL).
- **Conclusion:** Group 1 is fragile. It requires a perfect market environment to work. When the market is too efficient or choppy, the fees ($24 round trip) turn potential winners into losers.

Equity line for group 1 – 2023Q1
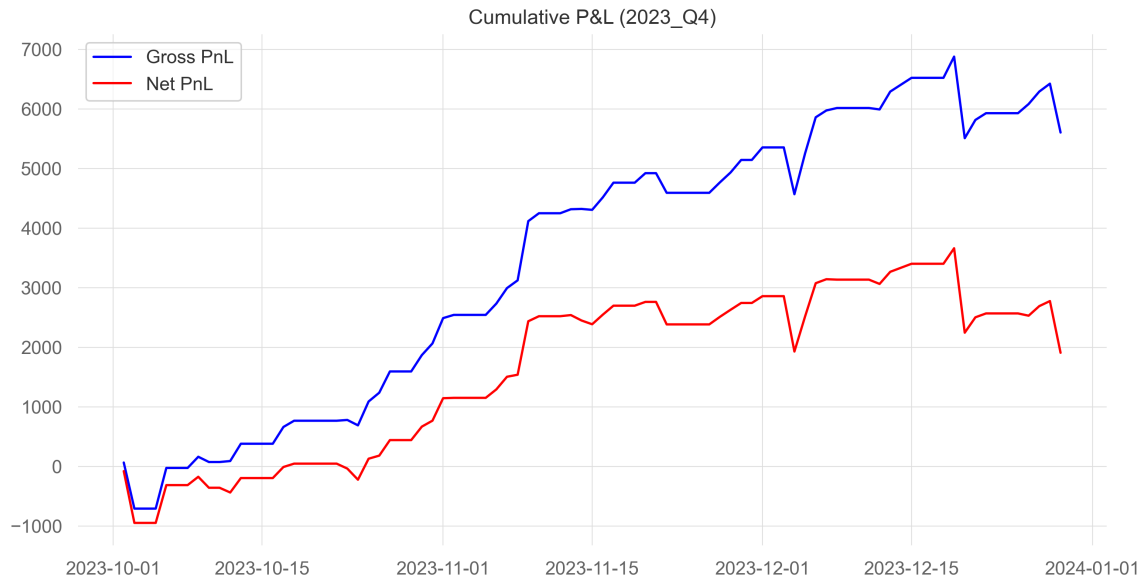

Cumulative P&L (2023_Q1)

- **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.
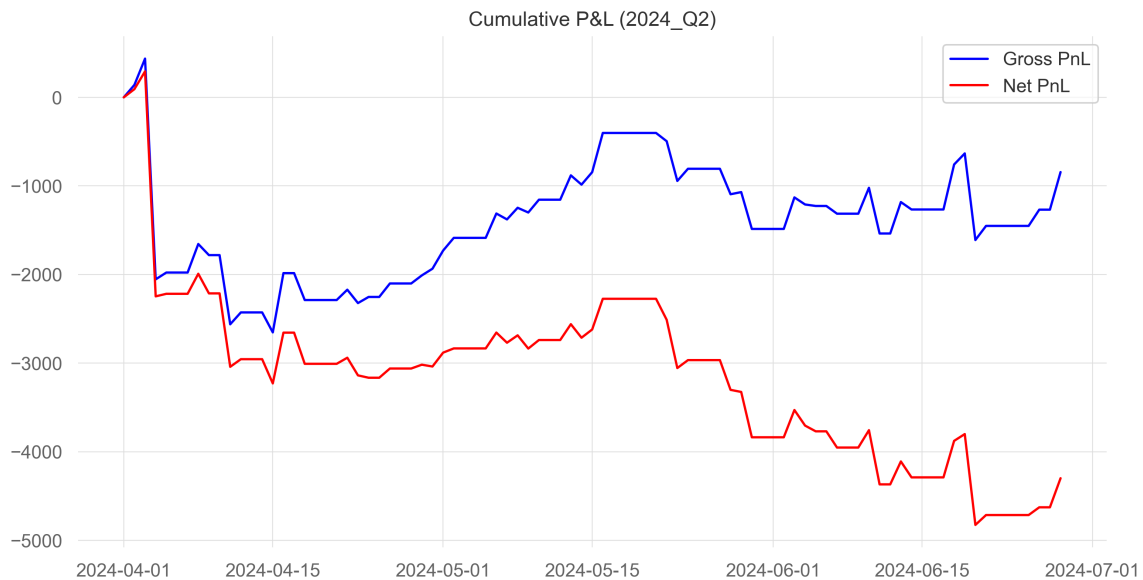
Equity line for group 1 – 2023Q3

Cumulative P&L (2023_Q3)

- **Observation:** The strategy made initial gains but gave them back in late summer.

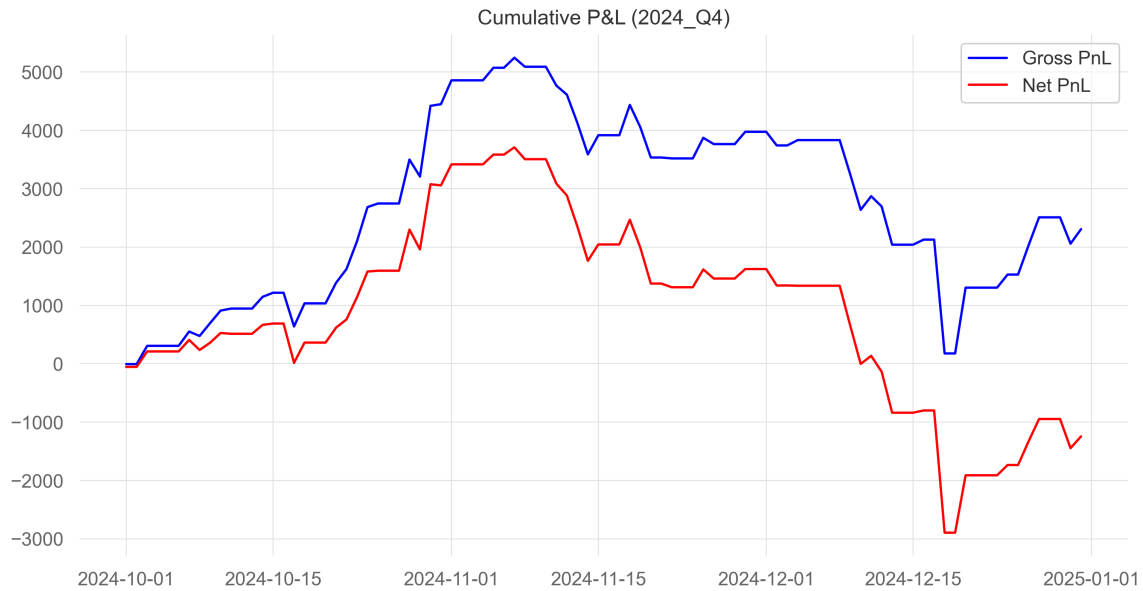## Equity line for group 1 – 2023Q4

Cumulative P&L (2023_Q4)

- **Stabilization:** Performance improved significantly here (Net SR 1.18).
- **Pattern:** As we can see a step-like 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
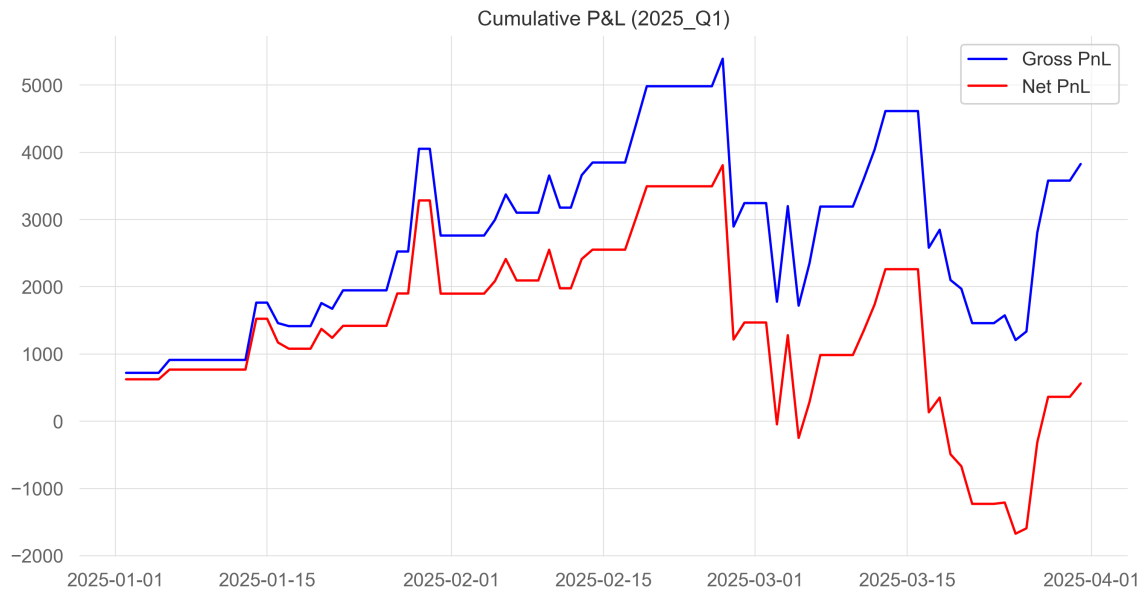

Cumulative P&L (2024_Q2)

- **The Drawdown:** This was the most challenging period (Net SR −2.21).
- **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
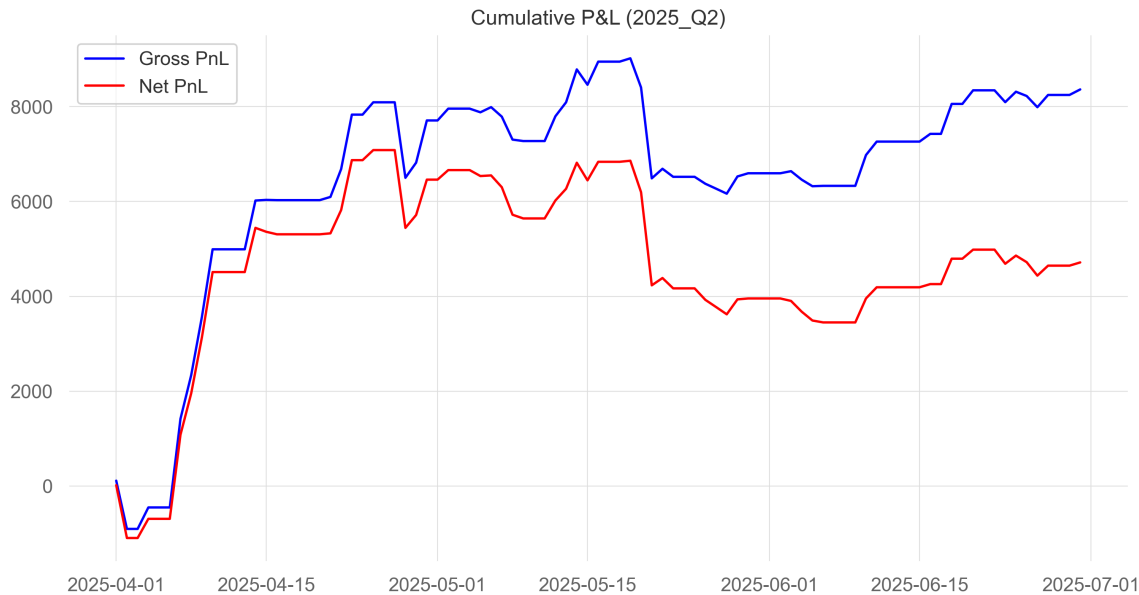
Cumulative P&L (2024_Q4)

- **Behavior:** The strategy performed well until mid-December, where a sudden market shift caused a sharp drawdown.
- **Outcome:** It finished slightly negative.

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 is essentially 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, but 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.
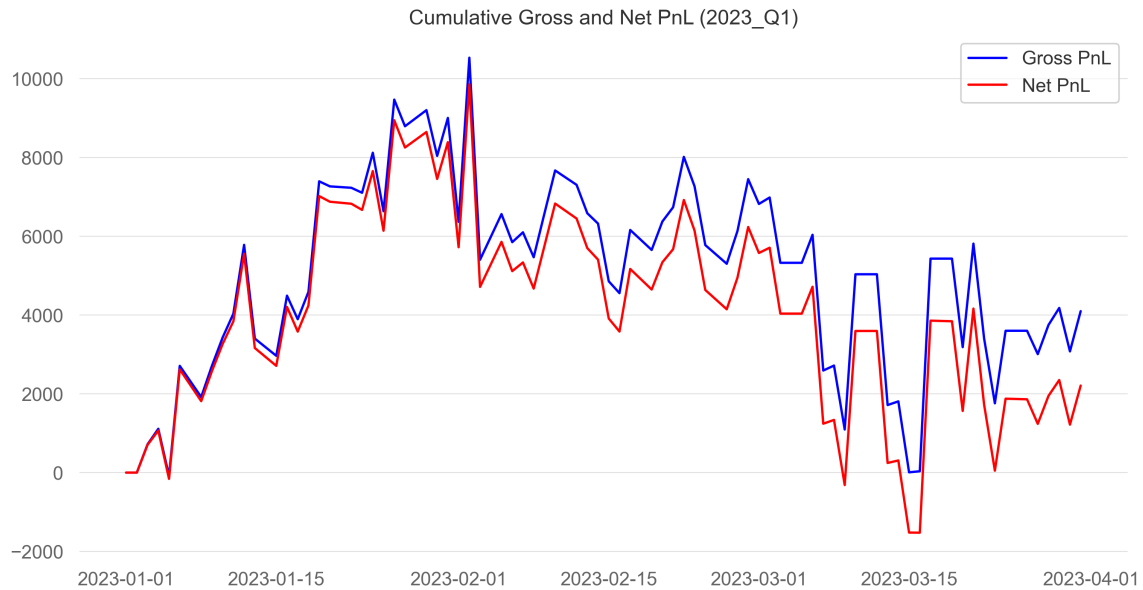
- **Approach:** Daily Relative Momentum with a 5% Confidence Filter.
- **Final Parameters:**
  - **Momentum Window (M):** 276 bars (approx. 1 trading day).
  - **Rebalance Frequency (R):** 276 bars (daily rebalancing).
  - **Silver Confidence Threshold:** 0.05 (5%). XAG is only selected if $|Mom_{XAG} - Mom_{XAU}| > 0.05$.
  - **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
2023_Q1	0.50	0.27	4099.00	2209.00	1.04	0.41	1.62	−0.18
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.
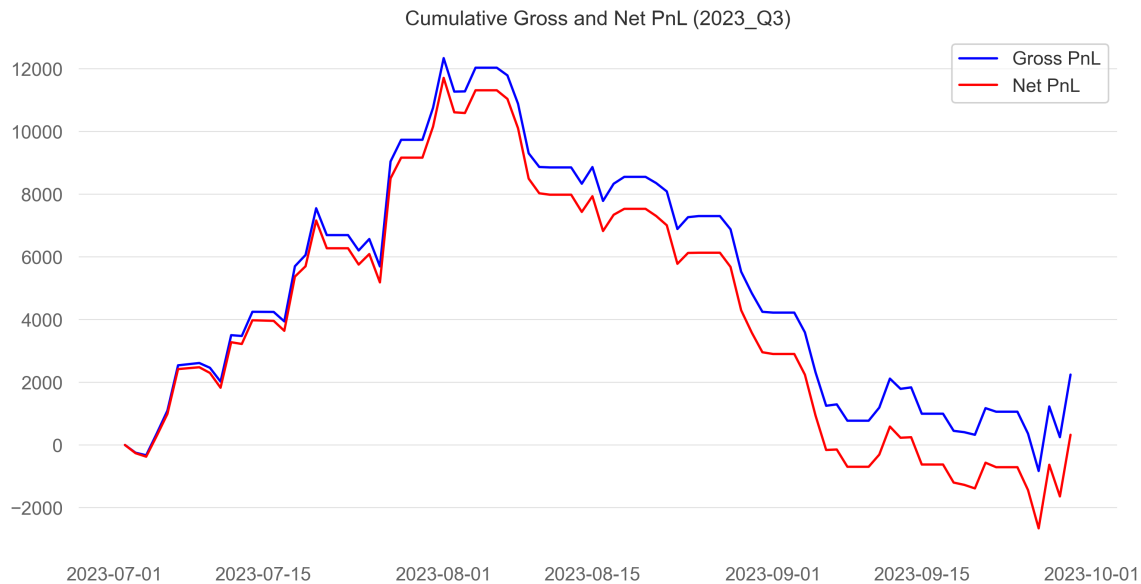
Equity line for group 2 – 2023Q1

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.
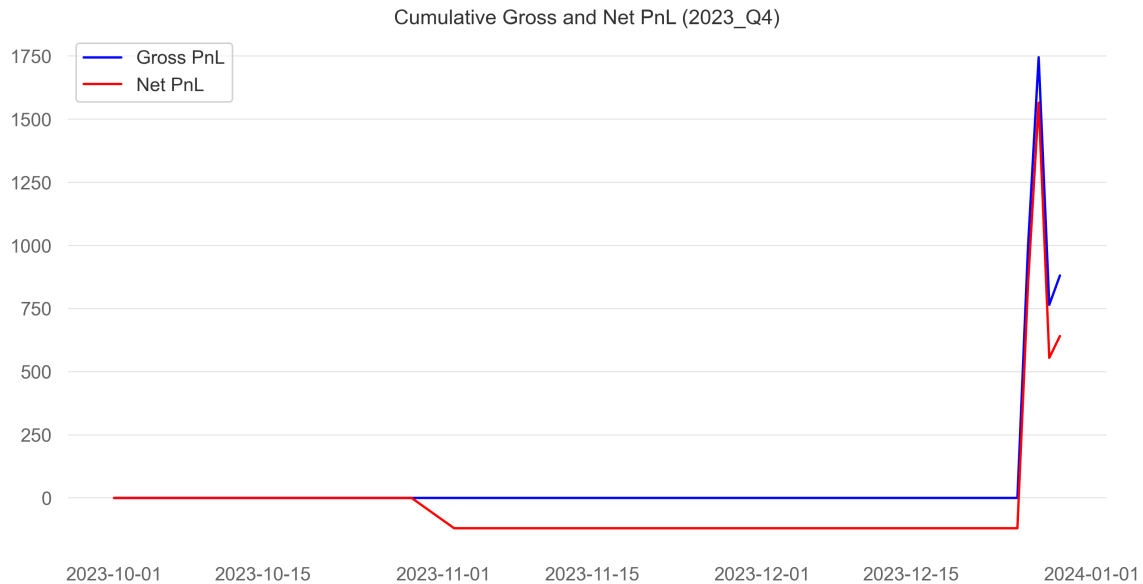
- **Result:** High transaction costs ate into gross profits, resulting in a Net SR of only 0.27. This confirms why additional filtering (like the cooldown periods) is necessary during undefined trends.

Equity line for group 2 – 2023Q3
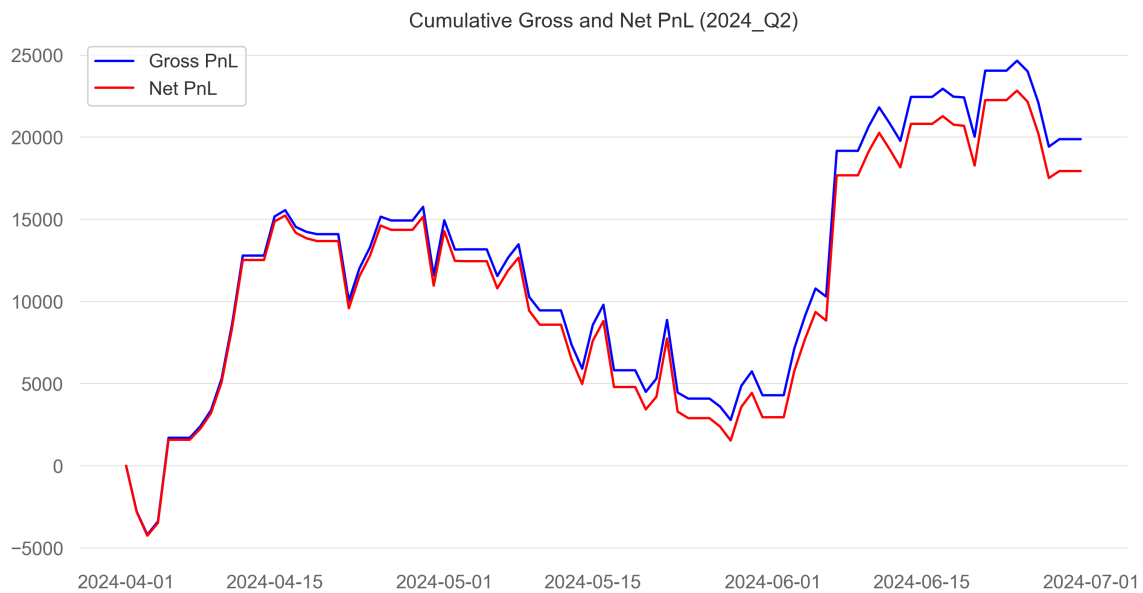
Cumulative Gross and Net PnL (2023_Q3)

- **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.
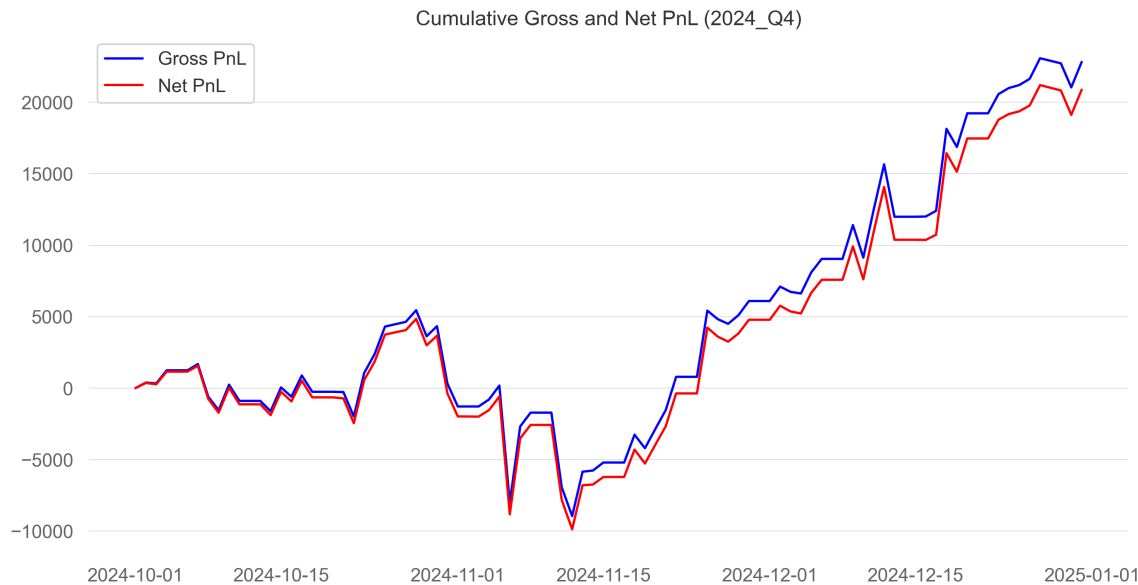
Equity line for group 2 – 2024Q2

Cumulative Gross and Net PnL (2024_Q2)

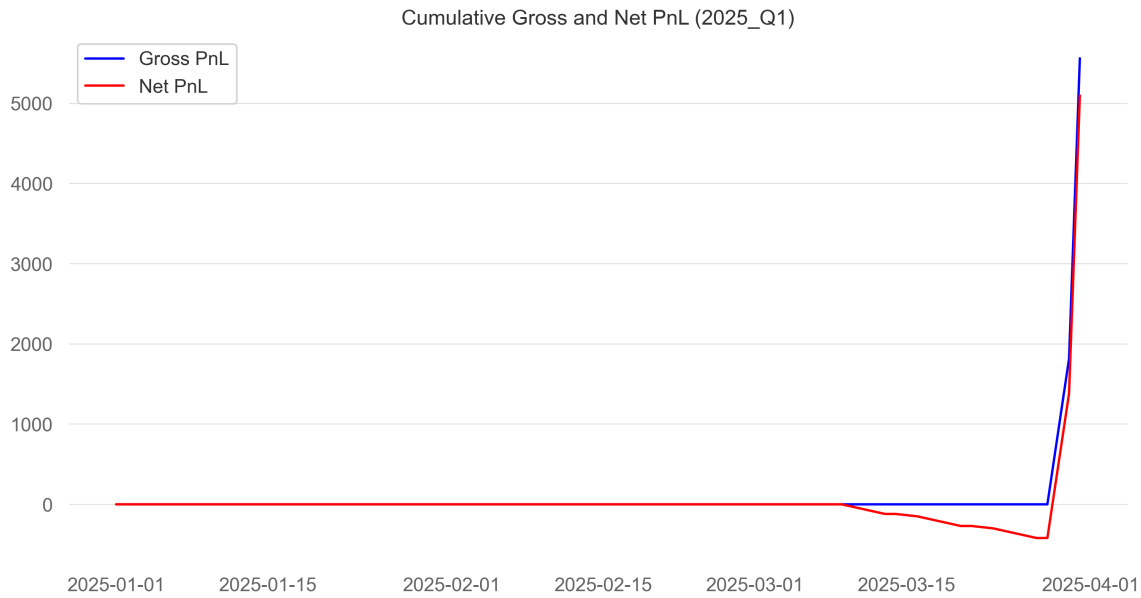- **Market Context:** A strong trending environment favorable to the strategy.

- **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
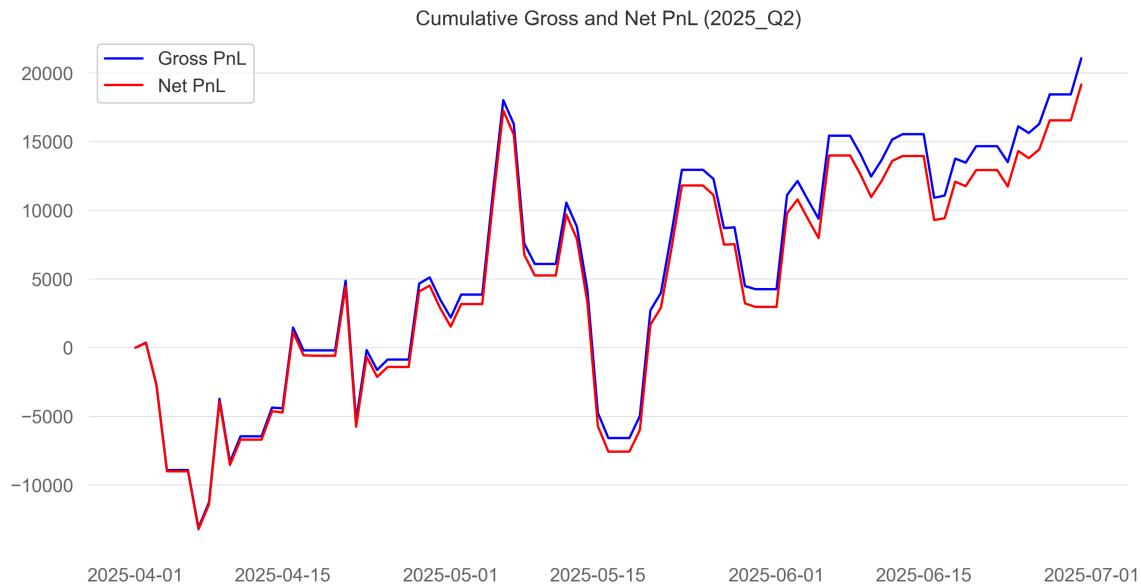
Cumulative Gross and Net PnL (2024_Q4)

- **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)

11

- **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.