Quantitative strategies on High Frequency Data

final report

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academic year 2024/2025

Group 1

Approaches undertaken

For the first group of assets, we considered the implementation and evaluation of Moving Averages (MA) and Volatility Breakout models across distinct the given indices, namely Nasdaq and SP500. Each strategy was tailored to extract meaningful signals based on the unique characteristics of the asset classes. The common assumptions were:

- do not use in calculations the data from the first and last 10 minutes of the session (9:31-9:40 and 15:51-16:00) – put missing values there,
- do not hold positions overnight (exit all positions 20 minutes before the session end, i.e. at 15:40),
- do not trade within the first 25 minutes of stocks quotations (9:31-9:55), but DO use the data for 9:41-9:55 in calculations of signal, volatility, etc.

Regarding the specifics of our projects, we considered combinations of strategies (momentum, mean-reverting) for 2 assets, and for each combination the quarters were testes separately (for each quarter, iterate through the space of strategy parameters). For MA model, we considered SMA (roll_mean and roll_median were tested separately) and EMA, while for Volatility break-out model, we used rolling standard deviation as our indicator. In addition, various lengths of memories for both, MAs and Volatility measures were taken into account. As an instance, for the crossover of MAs: fastEMA looped through 10, 15, 20, 30, 45, 60, 75 minutes, while slow EMA tried 60, 90, 120, 150, 180, 210 minutes. The same method was used for the single Volatility Break-out model, i.e. signalEMA in 10, 15, 20, 30, 45 minutes; slowEMA in 60, 90, 120, 150, 180 minutes; volat.sd in 60, 90, 120 minutes; and a multiplier among 1, 1.5, 2, 2.5, 3. It is worth mentioning that a systematic grid search combined with sensitivity analysis was conducted. Obviously, we also made sure that we do not trade during the weekends.

Finally, we the evaluated our strategies based on gross/net SR, CR and PnLs. We selected such a set of parameters that had the highest sum of cumNetPnL across all quarters. Consequently, these parameters assembled our best strategy.

For this group of assets, the best parameters for 2EMA-crossover were for the case when all strategies are Momentum. The same was observed for Volatility breakout strategy.

Parameters

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## Warning in read.table(file = file, header = header, sep = sep, quote = quote, :
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NQ	SP	fast_ema	slow_ema	cum_net_pnl
mom	mom	10	180	53190.66

NQ	SP	signal_ema	slow_ema	vol_sd	mult	cum_net_pnl
mom	mom	10	120	90	3	55780.8

As we can see, the Volatility-breakout strategy slightly outperforms its peer. Thus, Volatility-Breakout is chosen as out best strategy.

Summary of results

Finally selected strategy for group 1

Our winner strategy had the following parameters: - Momentum strategy - Single Volatility Break-out technique - Slow EMA 120 - Rolling standard dev. 90

Summary of results for group 1

quarter	grossSR	netSR	grossCR	netCR	av.daily.ntrades	grossPnL	netPnL	stat
2022_Q1	2.24	2.08	8.08	7.34	3.53	37297.41	34585.41	26.00
2022_Q2	0.53	0.31	0.98	0.54	3.63	6824.30	3992.30	0.75
2022_Q3	2.19	1.92	9.59	7.95	3.27	21882.72	19290.72	23.53
2022_Q4	0.43	0.21	0.84	0.40	3.91	5989.66	2941.66	0.43
2023_Q1	2.18	1.73	4.24	3.24	5.08	19514.03	15578.03	8.89
2023_Q2	-0.98	-1.54	-2.74	-3.64	6.03	-7832.07	-12416.07	-9.18
2023_Q3	0.57	0.11	1.81	0.34	4.09	3922.93	754.93	0.00
2023_Q4	1.88	1.55	3.51	2.78	3.12	13526.72	11126.72	6.69
2024_Q1	0.52	0.16	1.69	0.45	3.50	3853.04	1165.04	0.07
2024_Q2	0.25	-0.10	0.59	-0.21	4.00	2207.32	-912.68	0.00
2024_Q3	-1.77	-2.07	-3.37	-3.56	3.33	-15410.98	-18050.98	-10.31
2024_Q4	3.24	3.03	25.20	22.97	3.26	38455.33	35911.33	82.26

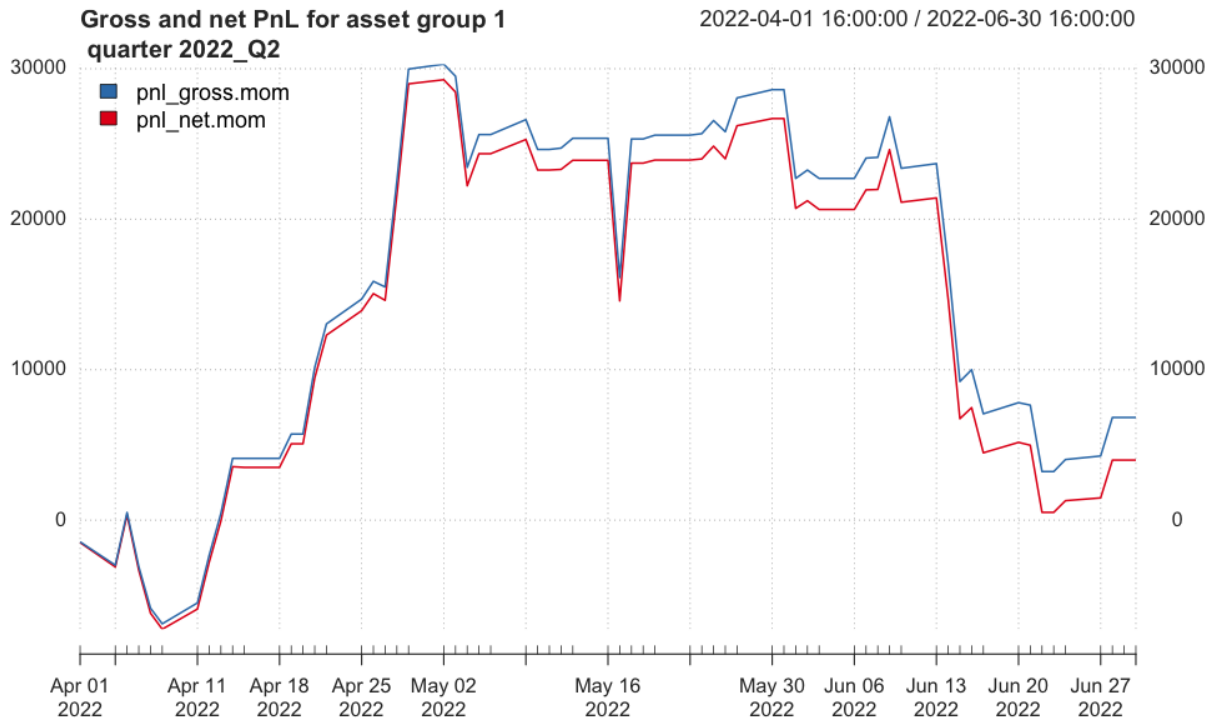
The summary of results for Group 1 demonstrates that in general, the strategy managed to end the periods with positive PnLs, except for 2023_Q2 and 2024_Q2 while the average daily trades remained consistent.

The strategy performed in poorly in 1/5 of the Out-of-Sample data (2024_Q3), while the other quarters showed positive netPnL. This highlights the strategy's consistency, though high variability might raise concerns about reliability across different market conditions.

PnL of results for group 1 – quarter 2022Q1

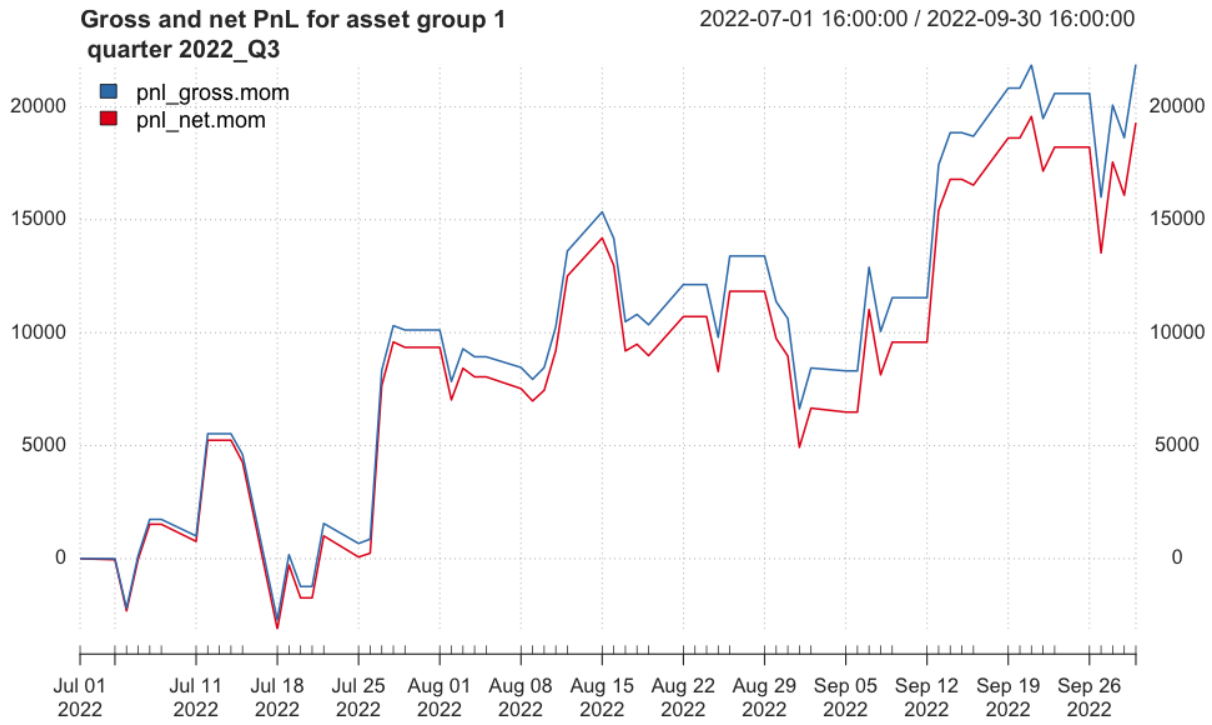
The strategy demonstrates consistent growth in both gross and net PnL over 2022_Q1, with only a minor divergence between gross and net PnL due to transaction costs. The performance shows resilience during drawdown periods and strong upward trends, indicating effective parameterization and market adaptability.

PnL of results for group 1 – quarter 2022Q2



Here, we can see that the PnL show an initial positive trend, peaking in May, followed by a sharp decline in June.However, the sharp drop in June indicates possible adverse market conditions.

PnL of results for group 1 – quarter 2022Q3

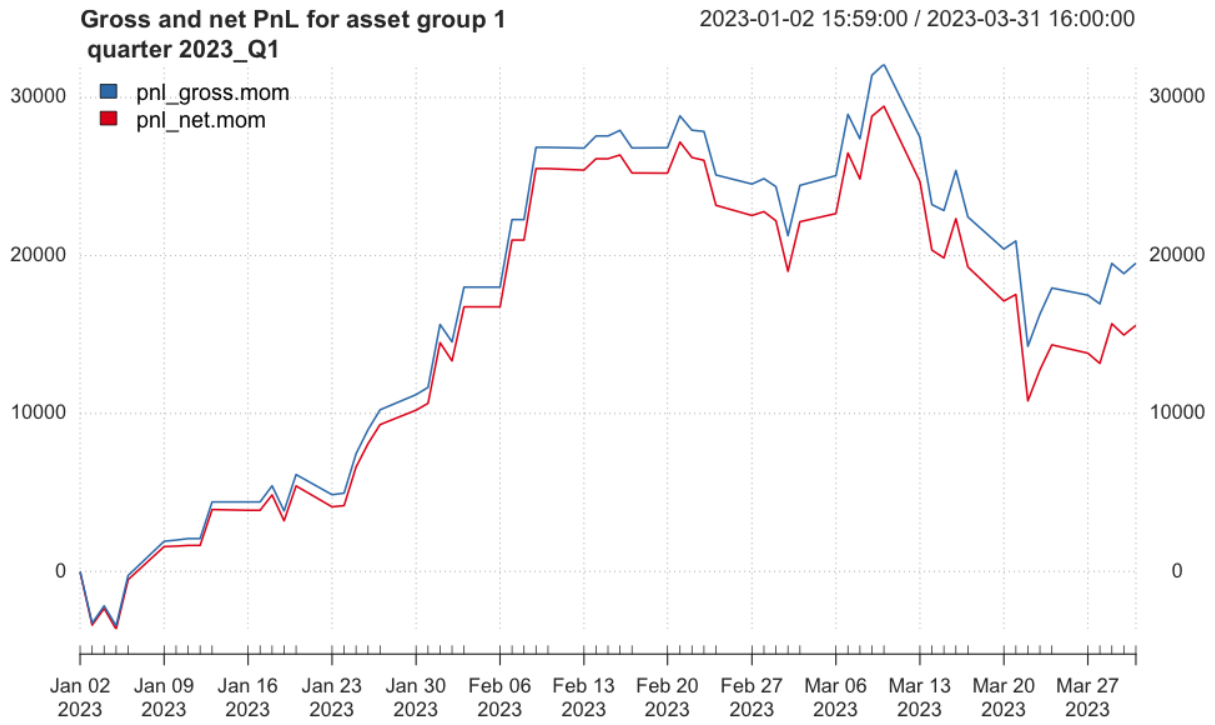


Some periods of stagnation and drawdowns can be observed, but it recovers effectively. The small gap between gross and net PnL indicates manageable transaction costs.

PnL of results for group 1 – quarter 2022Q4

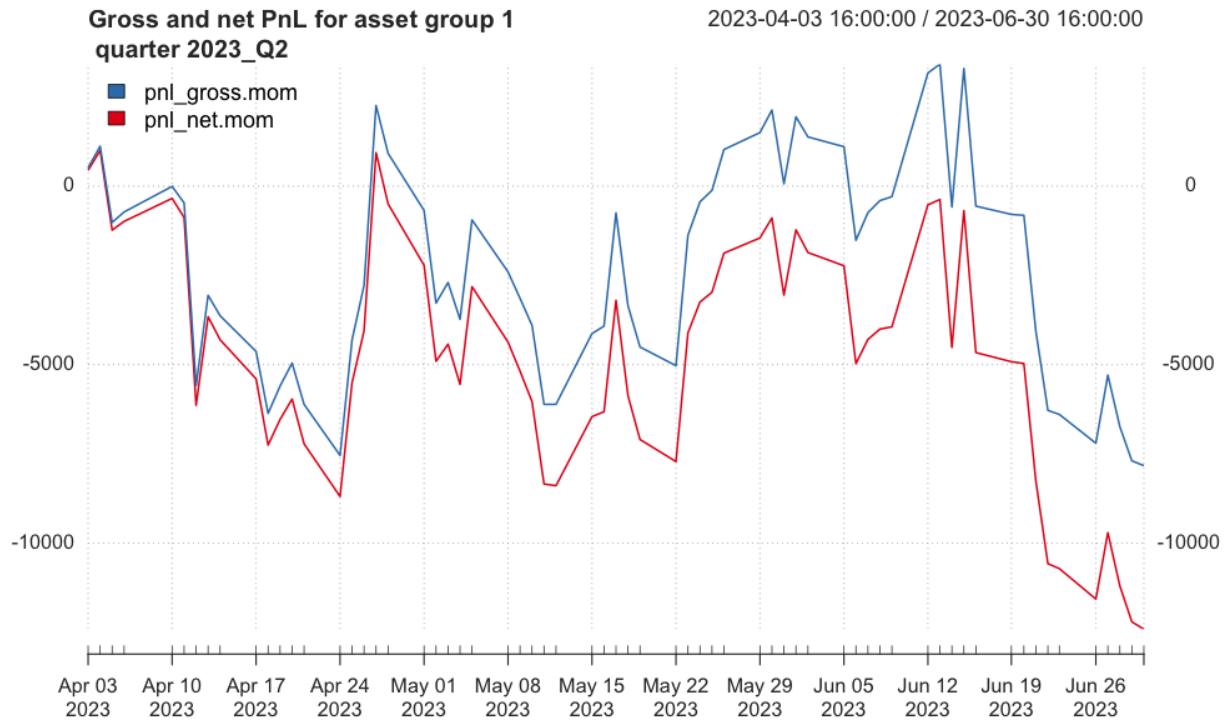
A strong start in 2022_Q4 was followed by a significant drawdown mid-quarter, indicating vulnerability during certain market conditions. However, it recovered well, ending the quarter positively, though net PnL lagged slightly

PnL of results for group 1 – quarter 2023Q1



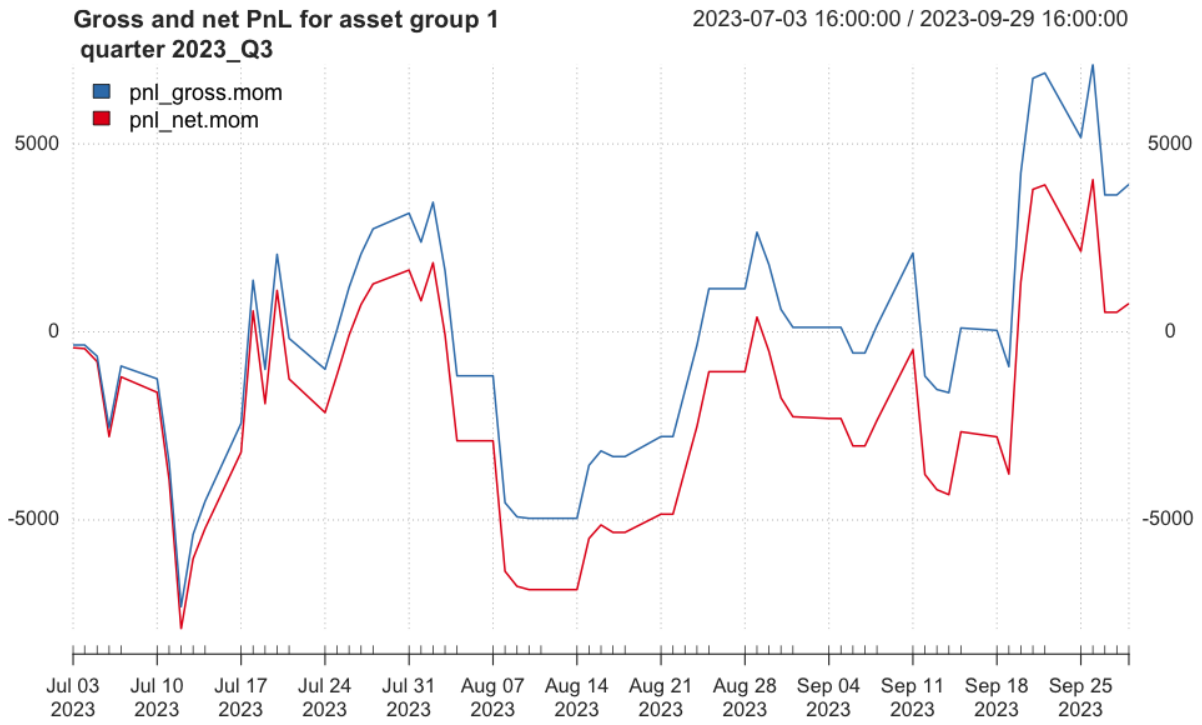
For 2023_Q1, there is a steady upward trend through February, indicating strong performance. However, the PnL stabilizes and starts to decline in March. The quarter ends with a moderate recovery but highlights some volatility in performance.

PnL of results for group 1 – quarter 2023Q2



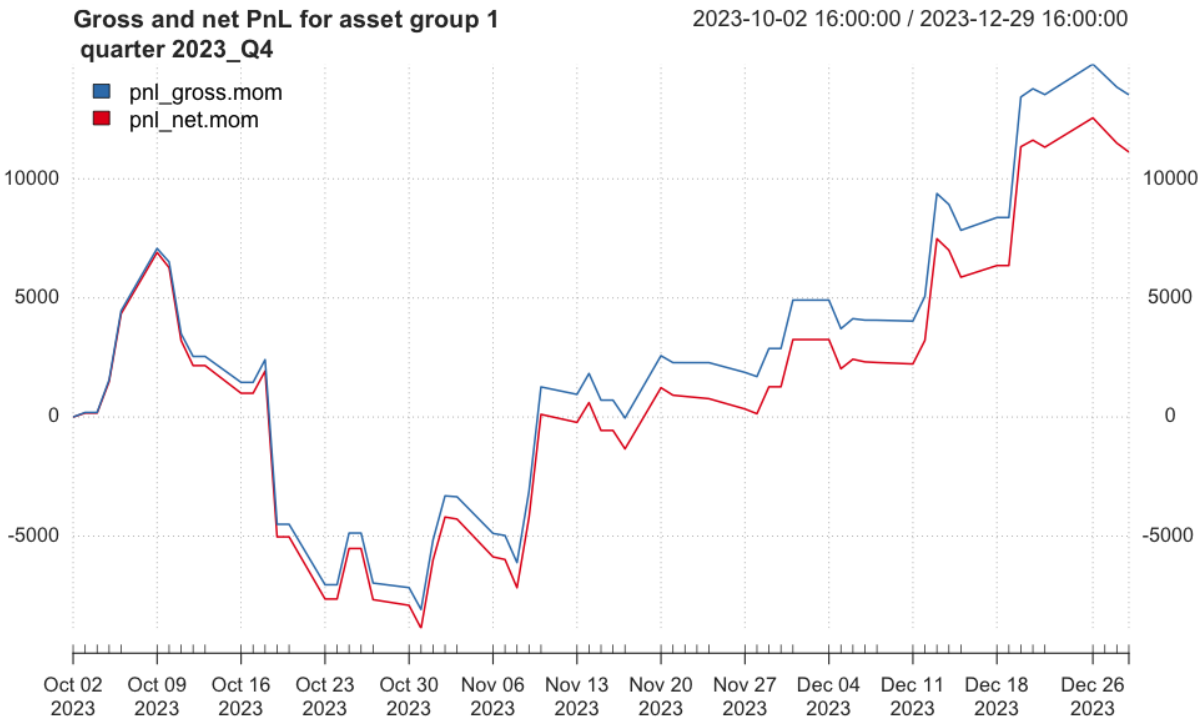
2023_Q2 shows a challenging period for the strategy, with a consistent downtrend in both gross and net PnL.

PnL of results for group 1 – quarter 2023Q3



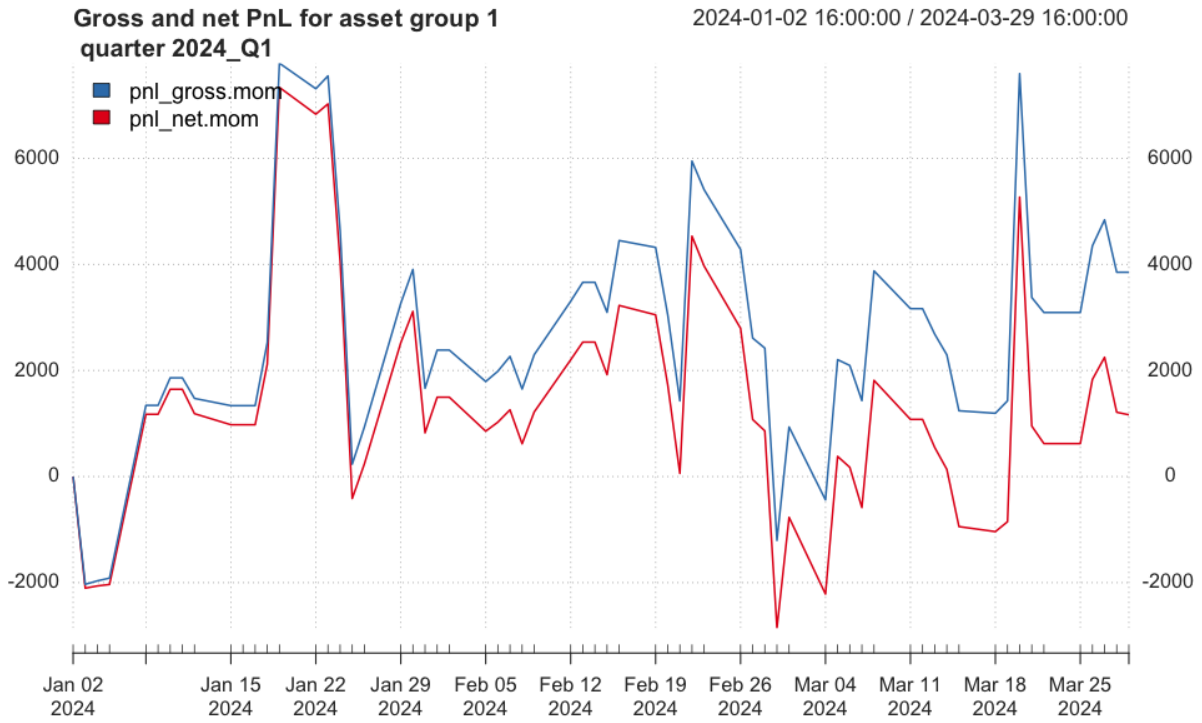
2023_Q3 exhibits high volatility with frequent sharp fluctuations.

PnL of results for group 1 – quarter 2023Q4



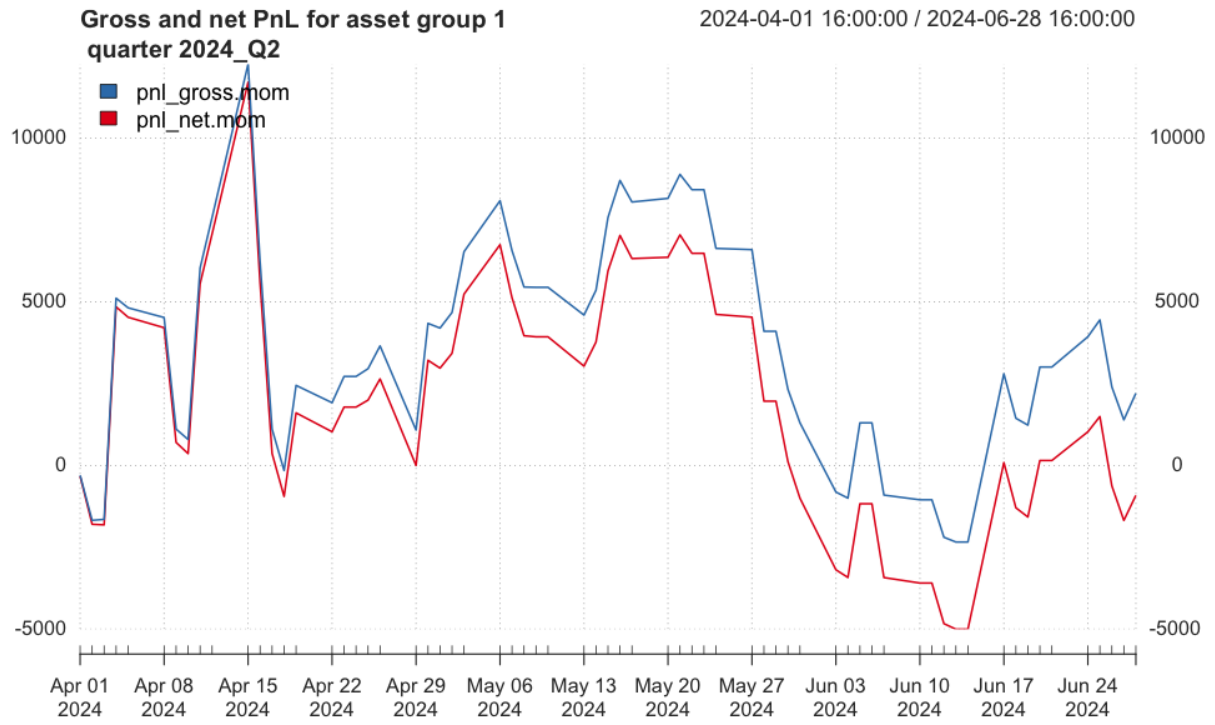
2023_Q4 reflects a strong recovery after a challenging start, with a steady upward trend in both gross and net PnL during the latter half of the quarter. Huge drawdowns, high volatility.

PnL of results for group 1 – quarter 2024Q1



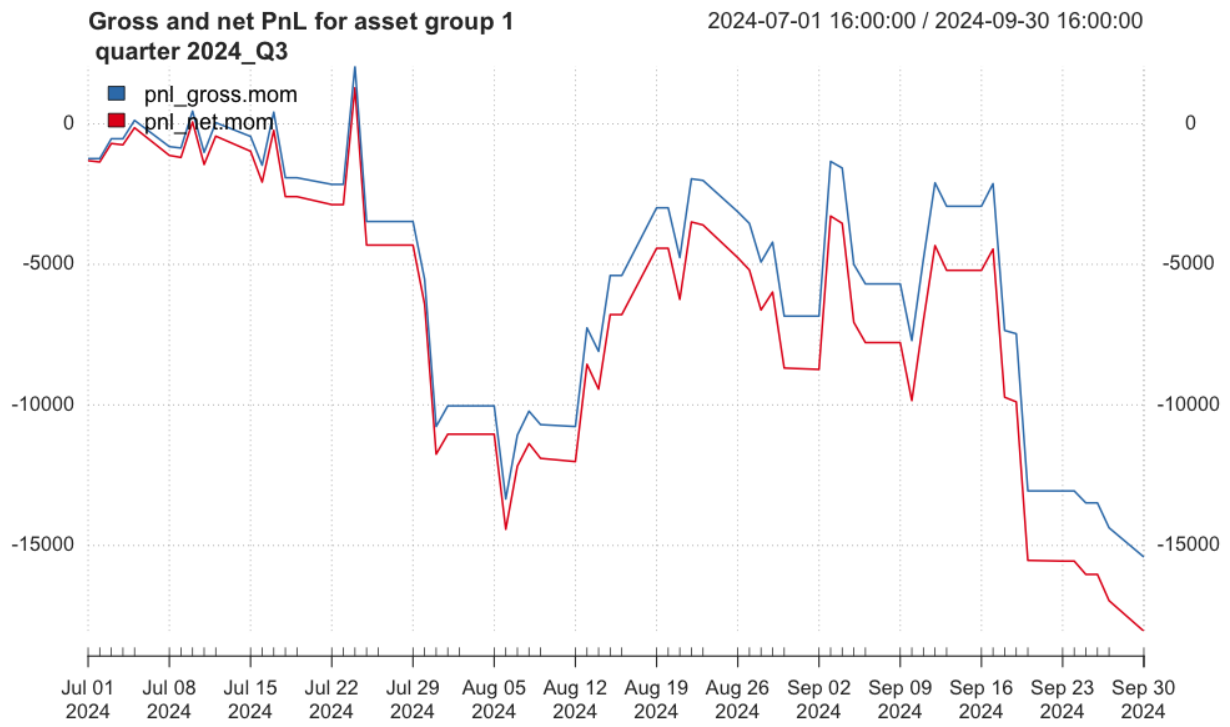
2024_Q1 exhibits volatile performance, with sharp swings in both gross and net PnL. Despite some strong gains, the strategy struggles to maintain consistent upward momentum, indicating sensitivity to market fluctuations. The divergence between gross and net PnL highlights the impact of transaction costs during periods of frequent trades.

PnL of results for group 1 – quarter 2024Q2



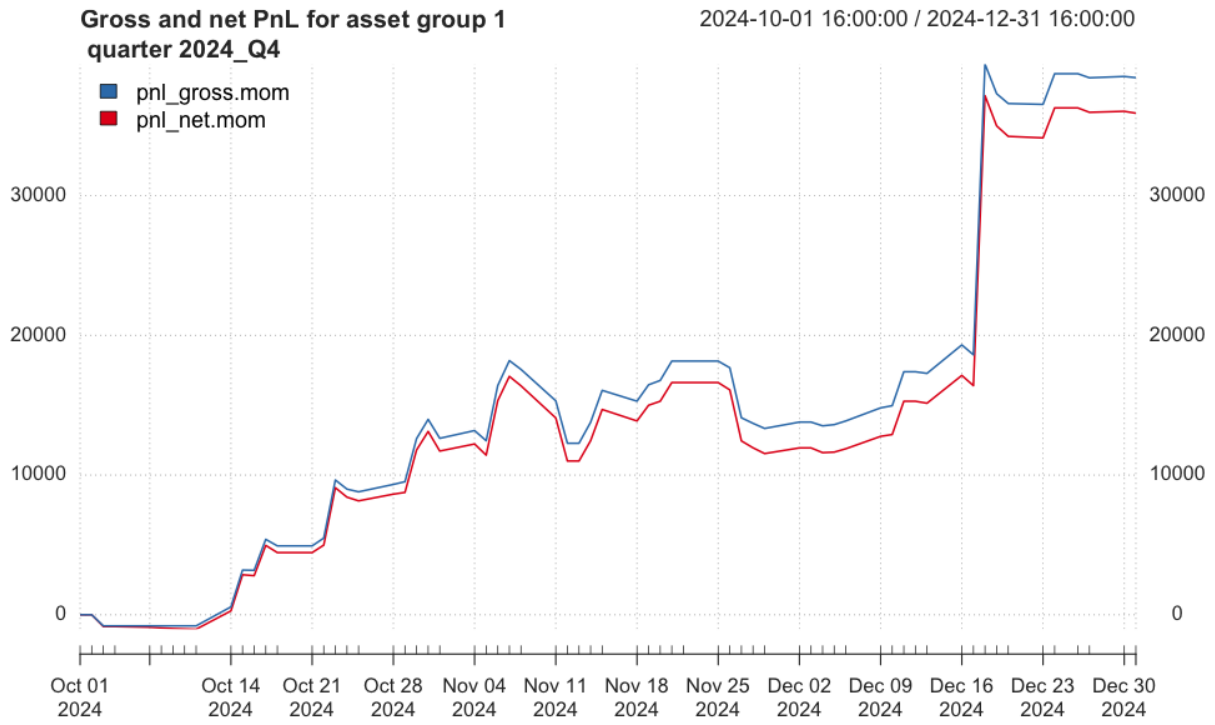
2024_Q2 shows a promising start with a significant peak early in the quarter, followed by periods of volatility and drawdowns. Again, the freuent trades mid-quarter influence our netPnL by the end of period.

PnL of results for group 1 – quarter 2024Q3



PnL for 2024_Q3 shows a consistent downward trend with a sharp decline in late September, ending with significant losses

PnL of results for group 1 – quarter 2024Q4



After experiencing dramatic losses in the previous quarter, the strategy demonstrates a steady increase throughout the quarter, culminating in a sharp surge in mid-December and stabilizing at high levels

Group 2

Approach to strategy search

The approach to finding parameters of entry is the following:

- First of all, consider combinations of strategies (momentum, mean-reverting), overall 16 combinations for four instruments.
- For each combination (for example, all mean-reverting strategies), analyze each quarter separately.
- In each quarter, iterate through the space of strategy parameters.
  - For a given set of parameters, create a strategy with entry separately for each instrument.
  - Aggregate daily results for strategies in one portfolio (sum up gross/net pnl and number of transactions). For example, add daily gross pnl values of EMA(10, 60) for AUD, CAD, XAU, XAG.
  - Calculate statistics for this combination and remember it, combining all statistics for each set parameters and each quarter in one data frame.
- Select such a set of parameters that the sum of cumNetPnL across all quarters is the largest. Output this set as "the best strategy". I decided to maximize cumNetPnL instead of target metric, because sometimes target metric can be positive even when PnL is negative.

Firstly, I searched for best parameters for 2EMA-crossover, and the best parameters were for the case when all strategies are mean-reverting. Parameters have been searched for in a larger space, with slow EMA being in range of 100-700, and fast EMA reaching 100.

Then, I decided to test volatility-breakout strategies, but only when all strategies are mean-reverting, to save time and on the grounds of 2EMA-crossover parameter search results.

Volatility-breakout strategy uses signal EMA to check for the breaches of the bands, defined by slow EMA and running volatility (standard deviation), multiplied by some number. So, each set consists of four parameters.

Strategy parameters

CAD	AUD	XAU	XAG	fast_ema	slow_ema	cum_net_pnl
mrev	mrev	mrev	mrev	105	500	33947.69

CAD	AUD	XAU	XAG	signal_ema	slow_ema	vol_sd	mult	cum_net_pnl
mrev	mrev	mrev	mrev	110	620	180	1.5	124788.7

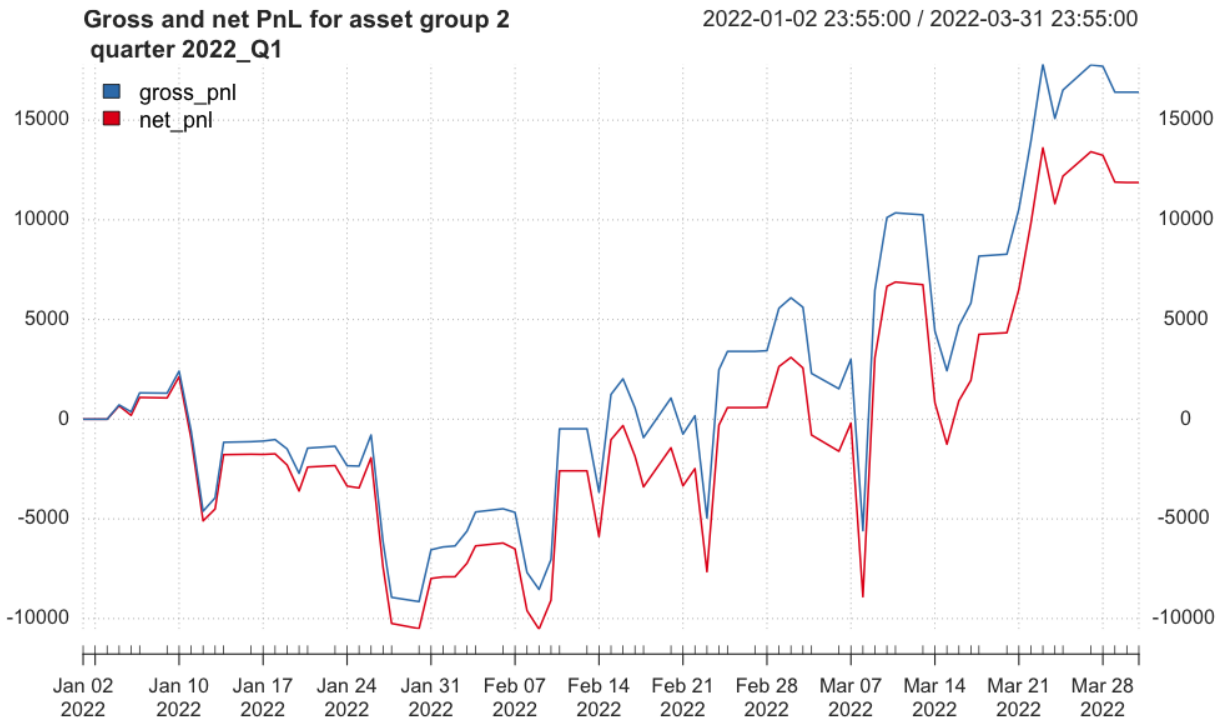
Volatility-breakout strategy is chosen as the best.

Summary of results for group 2

quarter	gross_sr	net_sr	gross_cr	net_cr	av_n_trades	cum_gross_pnl	cum_net_pnl	target_metric
2022_Q1	1.19	0.86	4.60	3.07	5.25	16403.50	11873.50	7.59
2022_Q2	-0.46	-0.86	-0.54	-0.96	5.10	-5004.10	-9459.10	-2.15
2022_Q3	2.20	1.85	7.15	5.63	5.27	29877.68	25177.68	18.15
2022_Q4	2.47	2.09	4.93	3.89	5.51	32236.58	27356.58	12.86
2023_Q1	0.37	0.03	0.74	0.06	5.36	5013.00	463.00	0.00
2023_Q2	1.35	0.96	4.13	2.72	5.14	15330.93	10900.93	6.50
2023_Q3	-2.47	-2.92	-2.24	-2.45	5.41	-25362.20	-30102.20	-8.34
2023_Q4	1.03	0.67	3.38	2.14	5.10	12791.42	8391.42	4.55
2024_Q1	1.29	0.90	2.08	1.41	4.99	14355.55	9960.55	3.24
2024_Q2	1.56	1.37	4.26	3.64	5.17	35638.06	31128.06	12.52
2024_Q3	0.04	-0.30	0.12	-0.71	5.30	604.73	-4140.27	-1.01
2024_Q4	-0.53	-0.80	-1.38	-1.89	5.44	-9487.77	-14297.77	-5.03

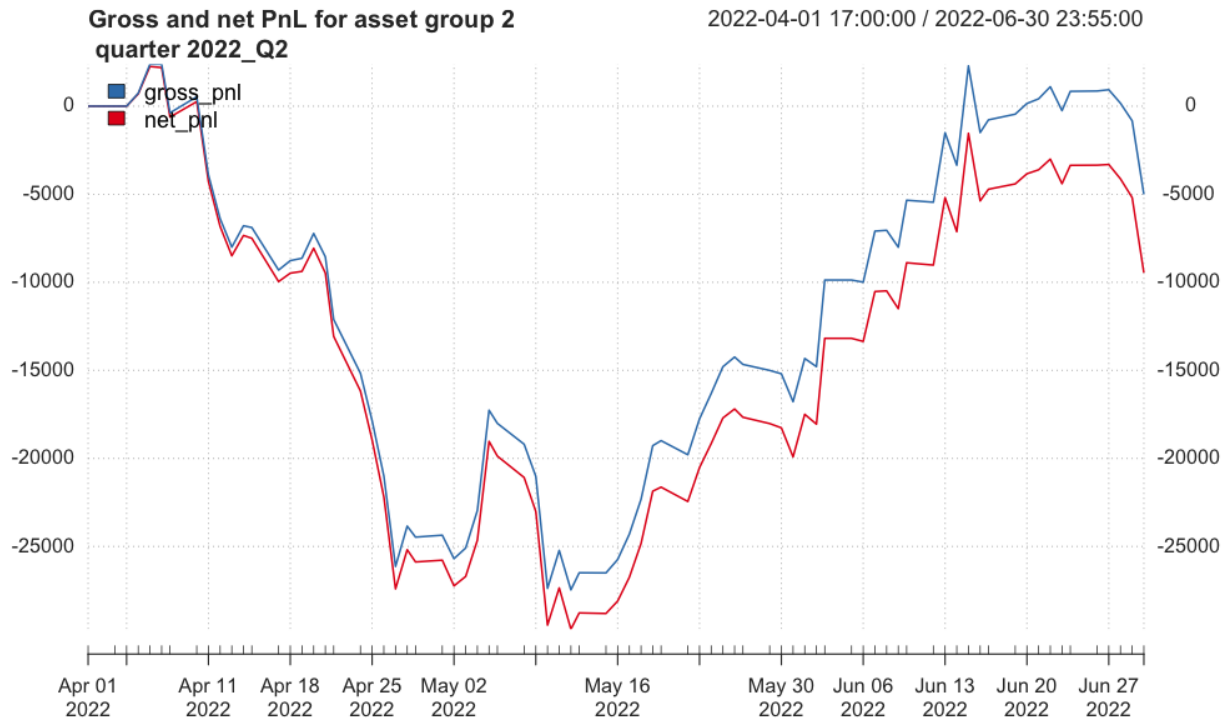
Overall, the strategy managed to achieve positive net PnL in every in-sample quarter without trading too much, while out-of sample quarters performed rather poorly, which may suggest overfitting.

PnL of results for group 2 – quarter 2022Q1



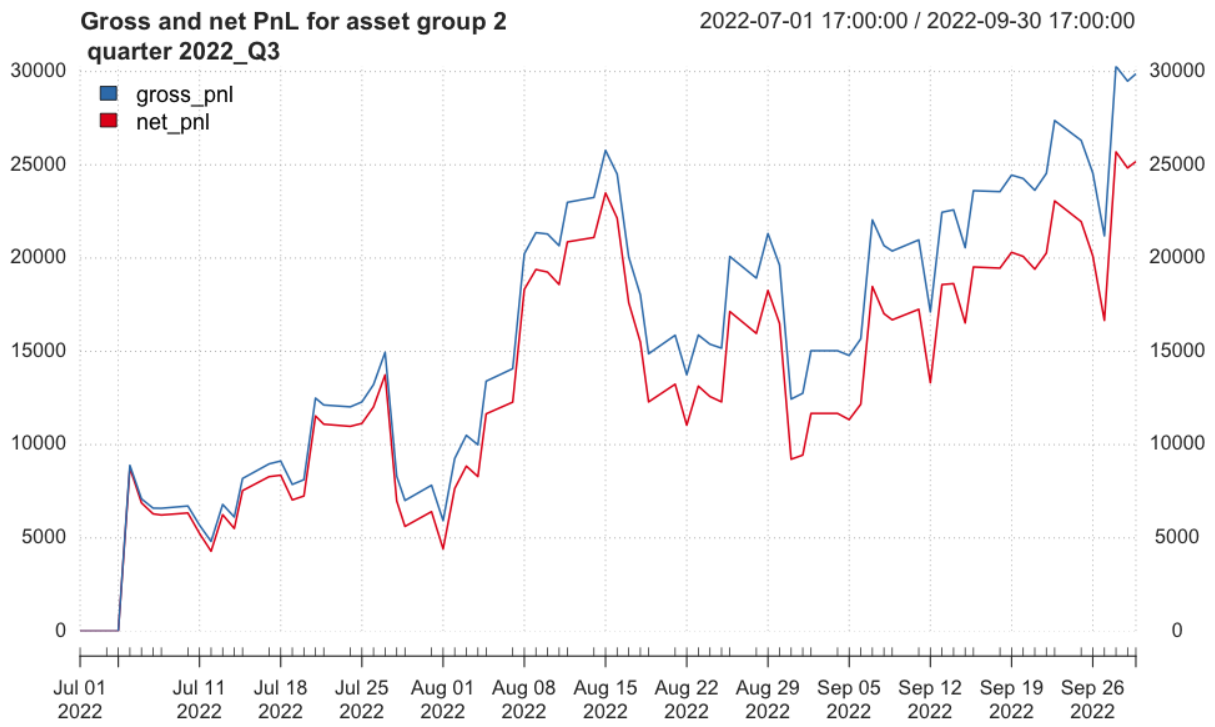
In Q1 2022, we see high volatility and several drawdowns, but strategy gained traction at the end of the quarter.

PnL of results for group 2 – quarter 2022Q2



Q2 2022 shows large drawdown, which was mostly reverted back till the end of the quarter. Perhaps, in this period of instability, mean-reverting strategies cannot perform well.

PnL of results for group 2 – quarter 2022Q3

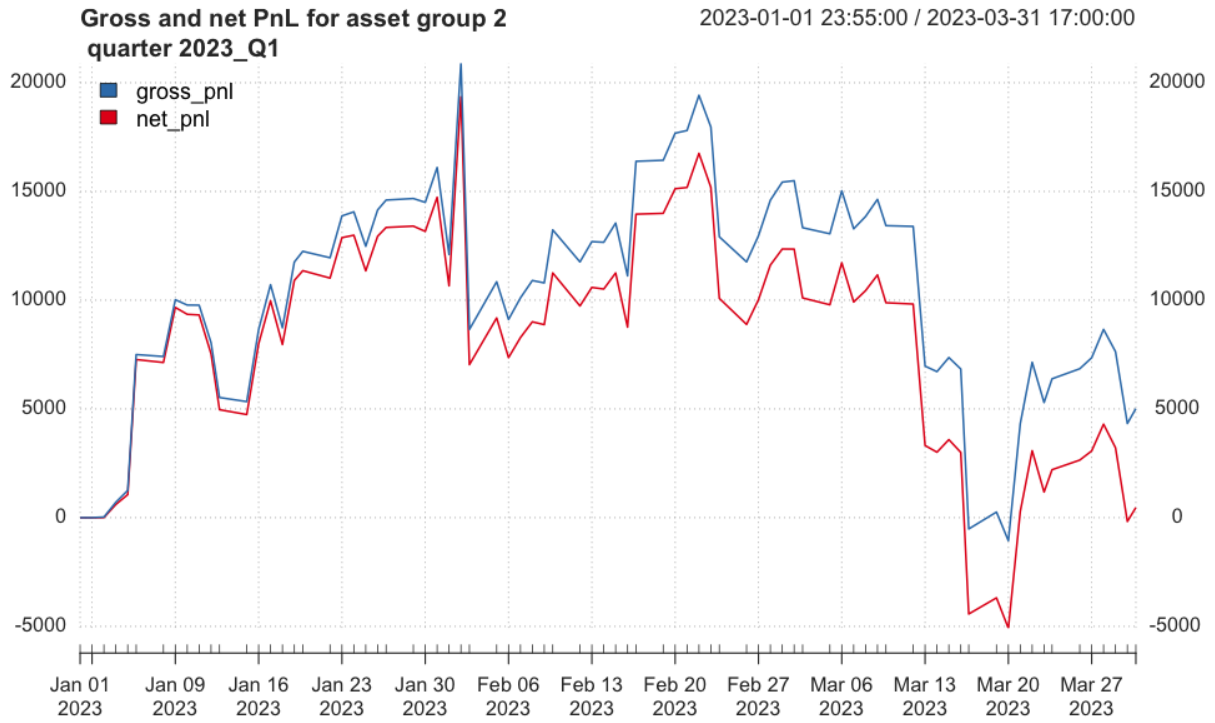


In Q3 2022, equity curve is increasing, but, again, with high volatility and several drawdowns.

PnL of results for group 2 – quarter 2022Q4

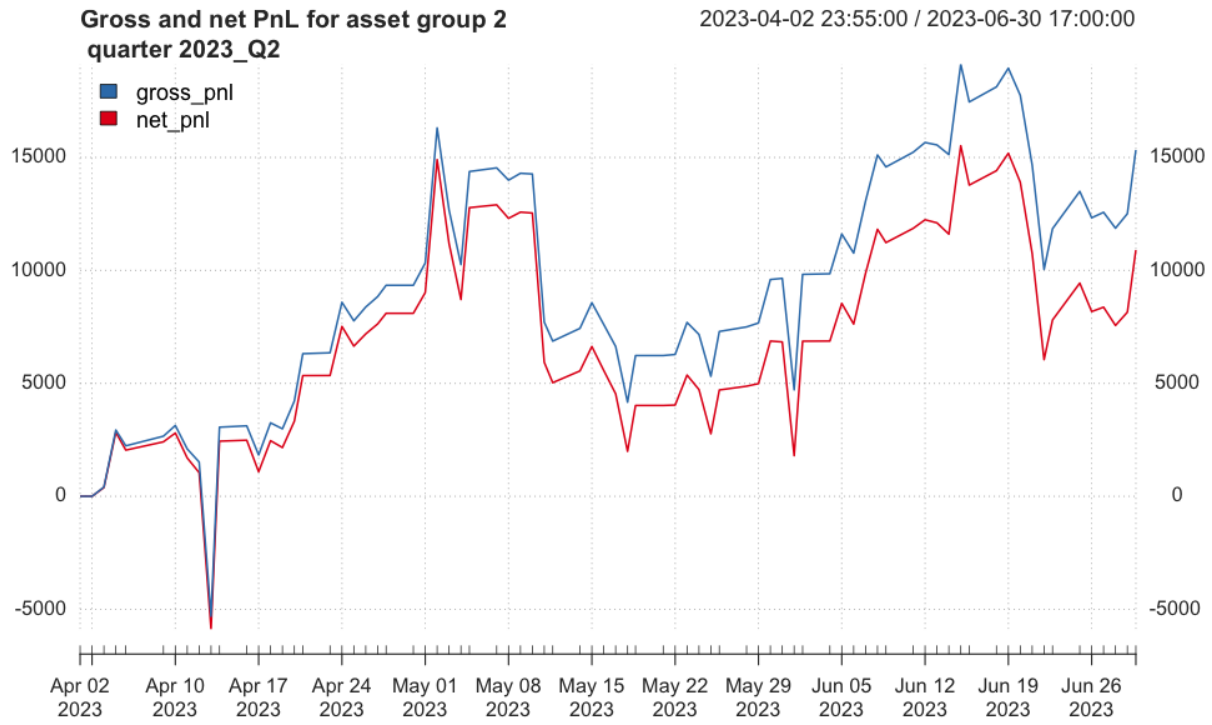
For Q4 2022, only last month brought increase in PnL; in earlier month it's rather stale with exception of the beginning of November.

PnL of results for group 2 – quarter 2023Q1



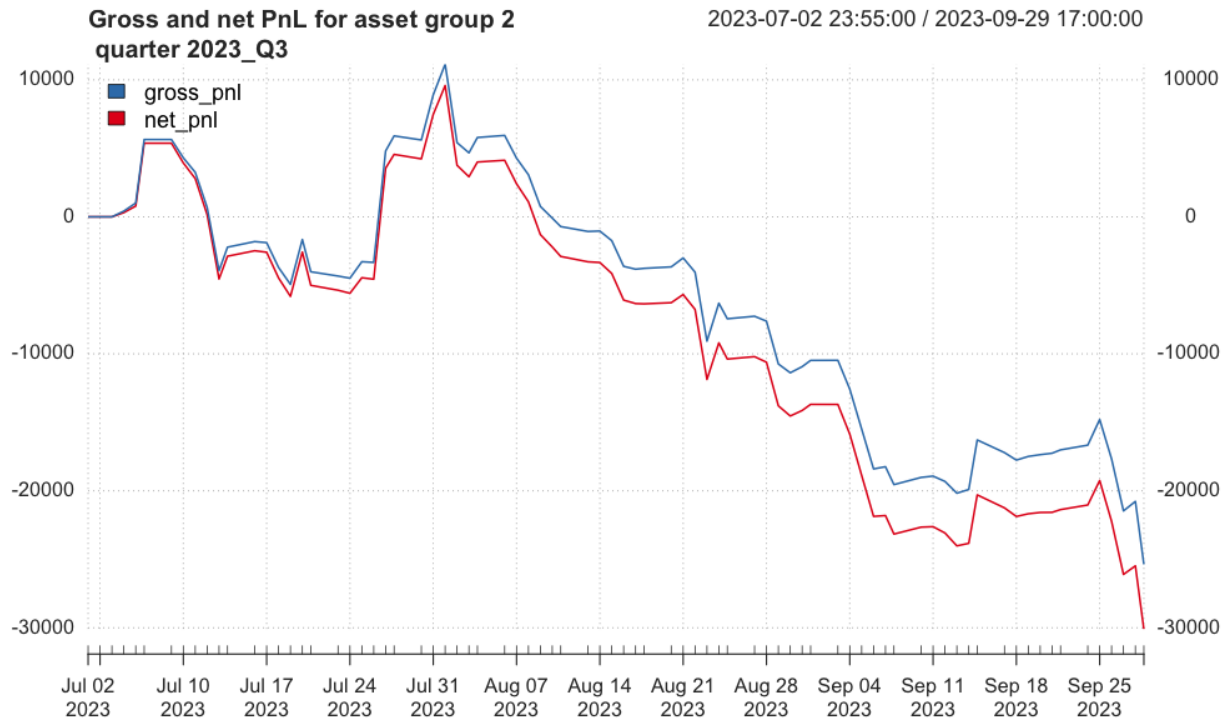
For Q1 2023, although strategy showed growth in the middle of the quarter, at the end all of it was turned to zero. Volatility is present as well.

PnL of results for group 2 – quarter 2023Q2



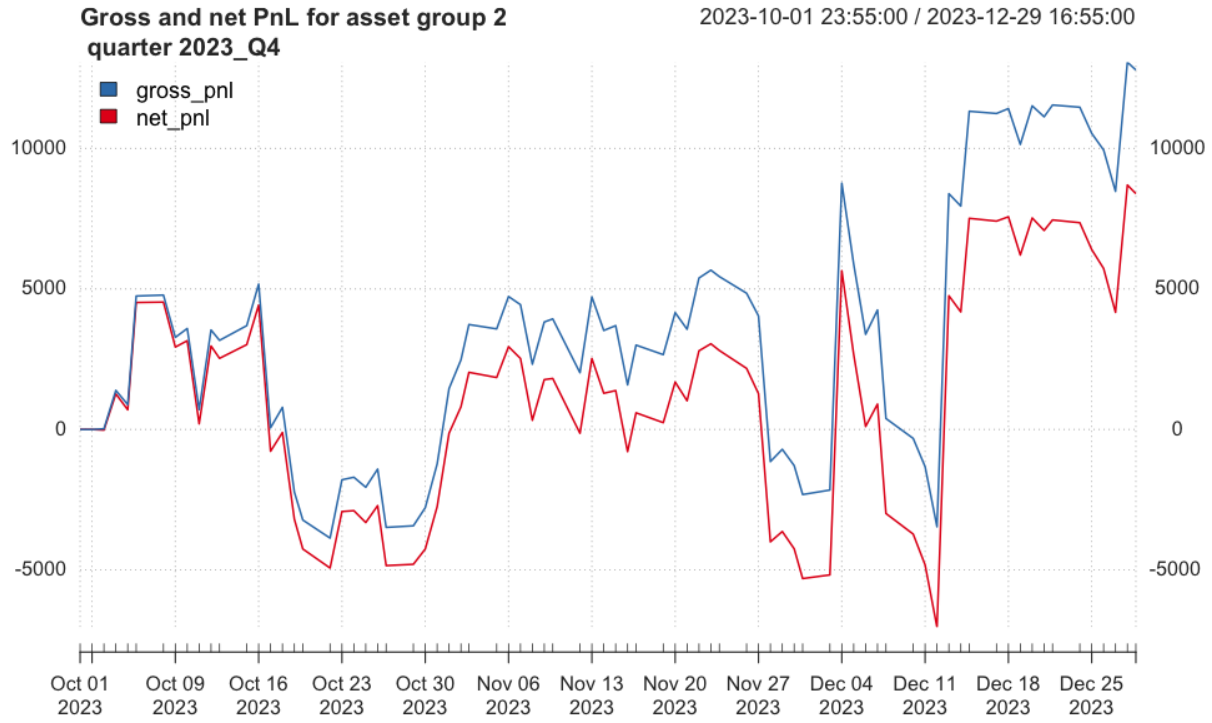
In Q2 2023, PnL mostly increased, but with a setback in the middle of the quarter. As usual, high volatility is present.

PnL of results for group 2 – quarter 2023Q3



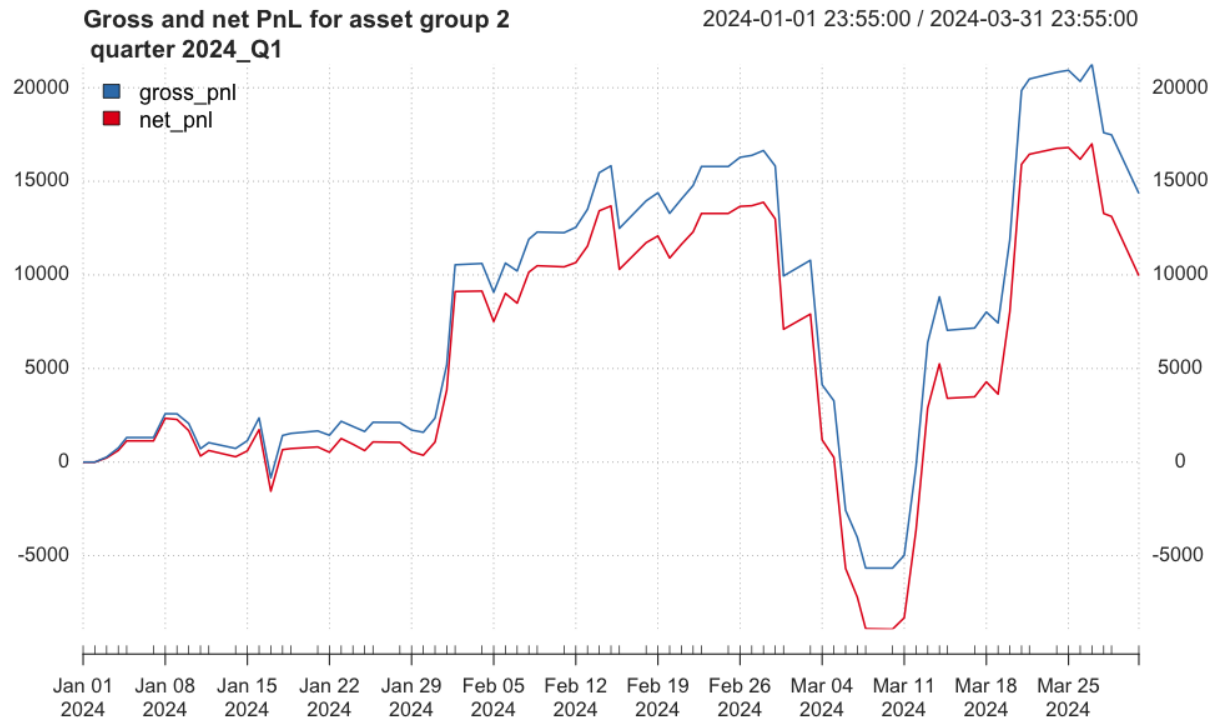
Q3 2023 shows one of the worst results, in August and September equity curve is simply declining, without much volatility. I think, in this period momentum strategy would have performed better.

PnL of results for group 2 – quarter 2023Q4



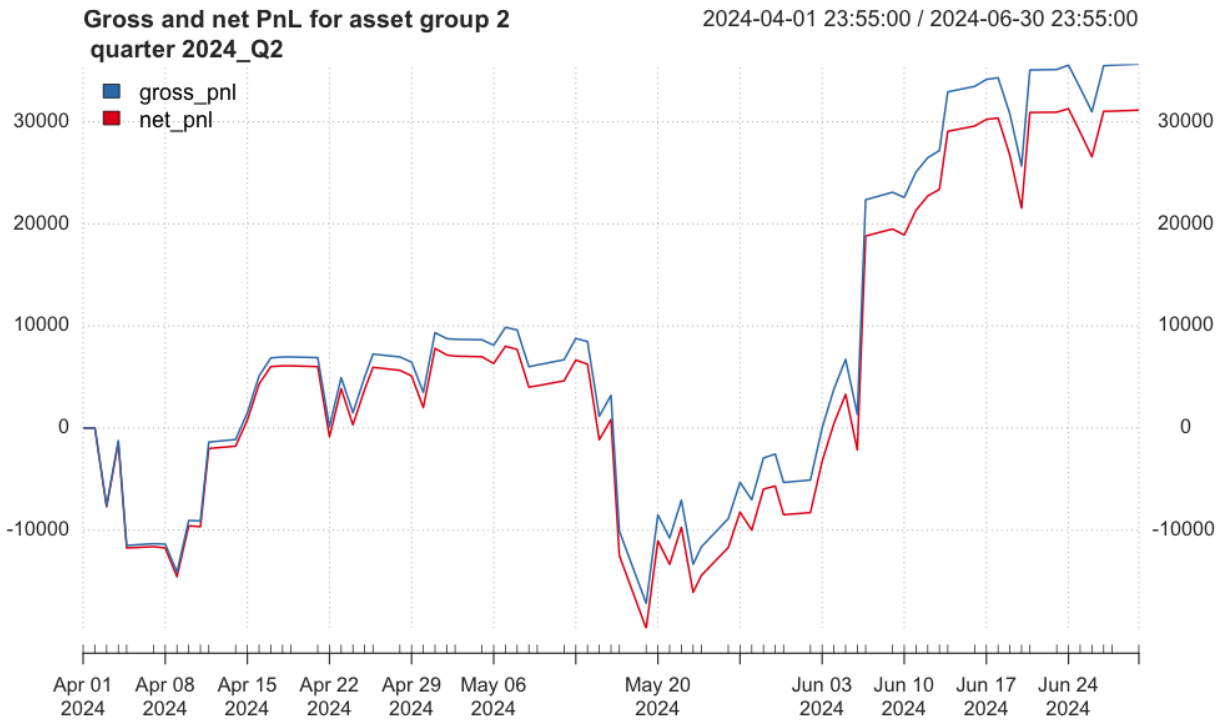
For Q4 2023, we have mostly high volatile equity curve oscillating around PnL=0, with gains at the end of the quarter only. Also two huge drawdowns in two weeks, both of them have been reverted.

PnL of results for group 2 – quarter 2024Q1



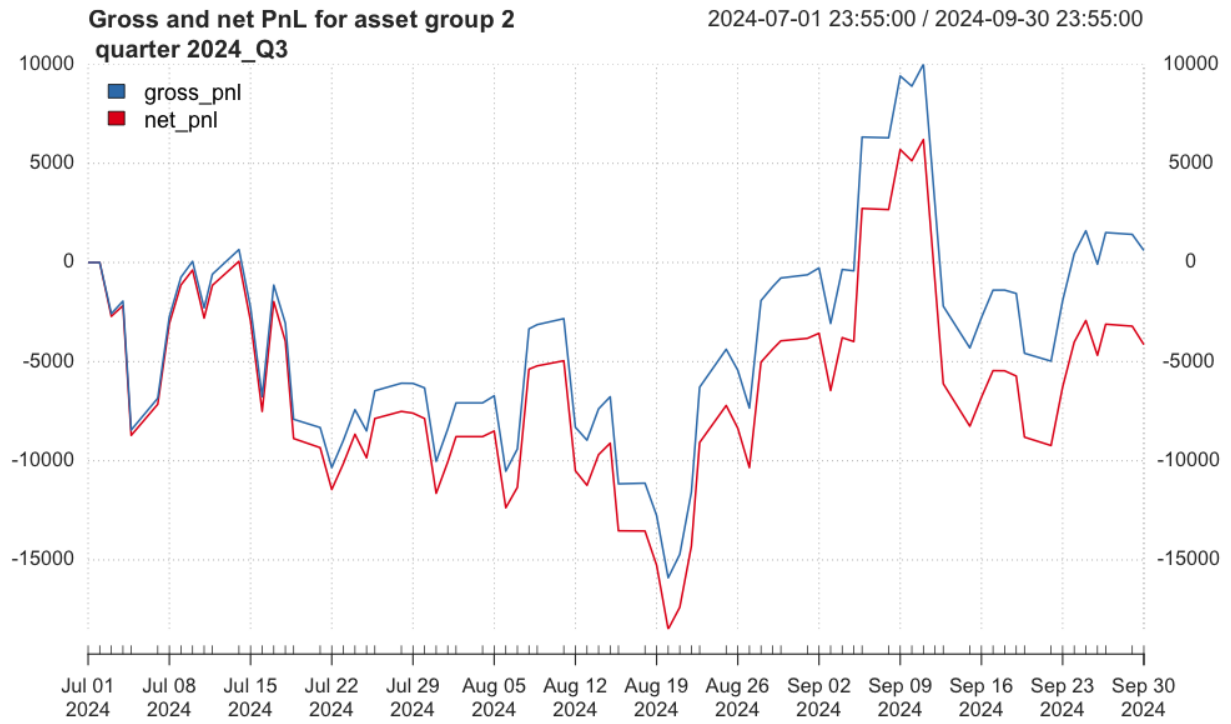
Q1 2024 shows less pronounced volatility, except for a huge drawdown in March.

PnL of results for group 2 – quarter 2024Q2



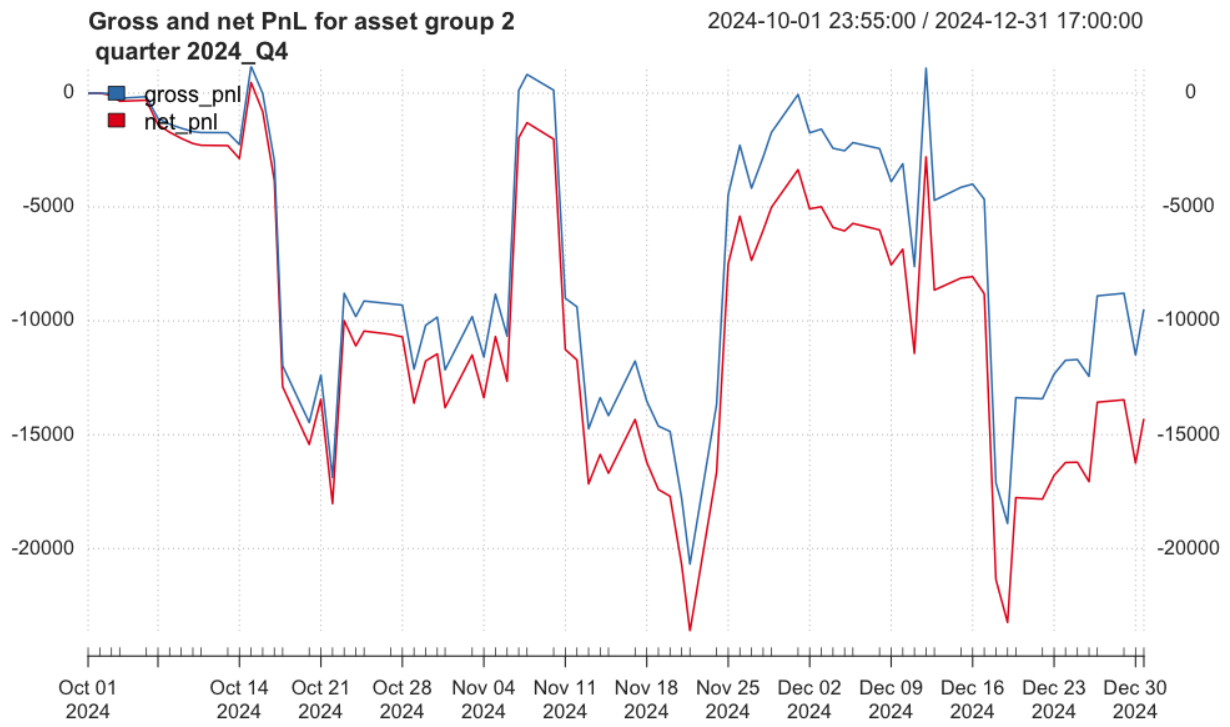
In Q2 2024, again, volatility is less pronounced, and again a drawdown, now in the middle of the quarter.

PnL of results for group 2 – quarter 2024Q3



For Q3 2024, I would say it stayed around the same value of negative PnL reached at the beginning of the quarter. High volatility is present.

PnL of results for group 2 – quarter 2024Q4



Q4 2024 shows the most erratic behavior out of all the quarters, because not only does it achieve bad negative PnL, but also does that with huge volatility and drawdowns.

Summary and conclusions

The Volatility Breakout Momentum Strategy for group1 demonstrated robust performance across multiple quarters, leveraging breakout signals derived from volatility measures combined with moving averages. The strategy proved particularly effective during trending market conditions, showing consistent growth in gross and net PnL. Overall, this momentum-based approach provided a reliable framework for capturing breakout opportunities, delivering solid returns over the analyzed period while highlighting areas for further refinement.

For group 2, the volatility-breakout strategy showed decent results on in-sample data, while out-of-sample results suggest overfitting. The main features of the strategy are: rather high values of signal EMA and slow EMA; high volatility; large drawdowns are possible.