2-RSI v.2

Investment Strategy Testing Summary

The 2-RSI strategy is a swing trading investment technique that uses **the short-term RSI (Relative Strength Index)** and a downward correction of an instrument that is in **an uptrend** (quotes above **the long-term moving average)**. The key assumption of the strategy is **to open long positions during a correction** and then **close them after the price increases.**

In this strategy, **compared to version 2-RSI v.1, the RSI Exit Threshold parameter,** used to determine the moment of closing the position, **has been replaced with a short-term moving average,** and the signal **to close the position has become the crossing of this average.**

The optimal optimization window for WFA tests is **1095/365 days,** and the results for the period **01/01/1995 – 31/12/2024** were:

- **Item size:** corresponding to the risk of 2.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening point;
- **CAGR:** 9.7%;
- **MAR:** 0.37;
- **Maximum drawdown:** 26.1%.

[An analysis](#) **showed** that in the next period (2025) **the optimal parameters** for the strategy are:

- **Moving Average Length (SMA-L):** 76 days;
- **Length of the moving average (SMA-S; take profit):** 6 days;
- **RSI Length:** 3 days;
- **RSI Entry Threshold:** 15.

It is worth noting that **at a position size of 2.0% of capital, the drawdown in 99% of the Monte Carlo simulations was 51.5% or less,** which is **average** compared to **the in-sample and out-of-sample data,** where **the drawdown was 21.4%.** Ultimately, **the position size should be adjusted to an acceptable level of drawdown consistent with the individual risk profile.**

The strategy passed both the stability tests as well as the Walk-Forward Analysis (WFA) tests, which indicates that the strategy can be **considered as one of the swing trading strategies in an investment portfolio.** However, **it has some significant limitations** that should be taken into account:

- **Relatively low MAR** compared to the trend-following strategy. However, the goal of this strategy is different than in the case of the trend-following strategy.
- **Large drawdown during a period of strong declines on the stock market (COVID),** which means susceptibility to sudden market changes.

- **Weaker results in the post-COVID period,** which may suggest some change in market characteristics.

Despite these limitations, the 2-RSI v.2 strategy **can be an effective tool for investors who prefer swing trading strategies,** as it remains stable in a variety of market conditions and a wide range of parameters. <u>I cannot</u> emphasize enough that for **the strategy to work** in real conditions, it must also work on **suboptimal parameters** and in **suboptimal conditions.** In short – **it must be stable** to changing market conditions.

I don't know who said these words, but they perfectly reflect the problem of many optimizations:

"I've never seen a strategy that didn't work in backtests."

We don't know the future, we don't know future market conditions, but if we know that our strategy **has historically generated acceptable results** in various market conditions and across various parameter ranges, then we are **one step ahead of other** market participants.

Contents

Step 1: Formulate an investment strategy

The 2-RSI v.2 strategy is **a short-term mean-reversion system** that uses **extreme readings of the short-term RSI indicator.** In this approach, the strategy takes **only long positions** in markets that have a **historical tendency to quickly recover,** i.e. major stock indices, Treasury bond futures, gold, US dollar index.

The aim of the strategy is **to join a pullback after a short-term, sharp price drop** within a dominant uptrend.

In this strategy, **compared to version 2-RSI v.1, the RSI Exit Threshold parameter,** used to determine the moment of closing the position, **has been replaced with a short-term moving average,** and the signal **to close the position has become the crossing of this average.**

The strategy uses:

- **Extreme RSI oversold** – the indicator value below the established threshold signals a potential rebound;
- **SMA Direction Filter** – positions are only taken when the price closes above the long-term moving average;
- **Pre-defined exit point** – the trade lasts until it crosses the short-term moving average.

Characteristics of the strategy and its strengths and weaknesses:

- **Simple, quantitative logic** – two main conditions (RSI & SMA) simplify testing and automation;
- **Natural mean-reversion environment** – the indicated asset classes historically rebound after short corrections;
- **Small number of transactions** – clear filters reduce commission costs;
- **Risk during violent bear markets** – during heavy sell-offs, the price may fall significantly before recovering (2020);
- **Less activity during periods of low volatility** – extreme RSI values are rare then.

The 2-RSI strategy, while simple to implement, requires caution due to its susceptibility to false signals and **lack of stop losses.** Its application requires careful optimization and risk management, especially in volatile market conditions.

Step 2: Define investment principles

Below is **the pseudocode** for the **2-RSI v.2 strategy** on daily data:

1. **Calculating Indicators:**
   a. **X-Day RSI:** Used to identify short-term oversold market conditions.
   b. **YY-day SMA-L:** Determines the long-term trend of the market. If the price is above the SMA, it is considered to be in an uptrend.
   c. **AA-day SMA-S:** Specifies short-term signals to close a position.
2. **Generating Entry Signals – Long Position:**
   a. It is opened only when the market is in an uptrend (Price > SMA-L) and the RSI drops below ZZ, which indicates an oversold condition.
   b. A position is opened at the opening of the next day on which the conditions are met.
3. **Generating Output Signals:**
   a. A position is closed when the closing price rises above the short-term moving average SMA-S.
   b. The close occurs at the opening price of the next day, after the signal is generated.
4. **Stop Loss Management:**
   a. The strategy does not use Stop Loss orders, which means that potential losses are not limited by automatic closing of positions.
   b. This is an important consideration for risk management and requires the trader to be disciplined and possibly introduce their own capital protection mechanisms.
5. **Daily Monitoring:**
   a. RSI, SMA-L, SMA-S values are calculated every day.
   b. The system checks whether the entry or exit conditions are met and takes appropriate action the next day upon opening.
6. **Additional Notes:**
   a. **No Short Positions:** The strategy focuses only on long positions in an uptrend.
   b. **Financial Instruments:** For the purposes of this test, **long positions** on **stock indices, bonds, gold** and **the dollar index were used.**

The above rules have been described in a way that allows them to be directly converted into a script in the chosen testing platform, which ensures the accuracy of the historical simulation and the reliability of the test results.

The tests are carried out assuming that the risk of one position is **2.0% of the total capital,** with **a hypothetical stop loss order located 2 x ATR (40 days)** away from the position opening point.

Step 3: Conduct a preliminary test of the investment strategy

Below are some purchase and sale transactions that allow you to verify the following aspects:

- **Correctness of generated signals;**
- **Direction of opening position;**
- **Moment of opening a position;**
- **Position opening price;**
- **Moment of closing the position;**
- **Closing price of the position;**
- **Compliance of the transaction with the theoretical assumptions of the investment strategy.**

At this stage **it does not matter** whether the transactions are **profitable,** what **instrument was used** or whether they took place **recently** or **in the distant past.** The key is **to check whether the transactions are generated correctly** and in accordance with the assumptions described in the previous step.

The first transaction was made on a futures contract for the Nasdaq100 index. At the end of June 2018, the quotes were above **the 100-day moving average,** and the value of the **3-day indicator RSI fell below the level of 15,** which generated a signal to open a long position (**the first candle in the rectangle on the left**). The position was opened the next day at the opening price (**the second candle in the rectangle on the left**).

After several days of sideways movement, in early July 2018 the market rose and **the closing price fell above the 6-day moving average,** which signaled the closing of the position (**first candle in the rectangle on the right**). The position was closed the next day at the opening price (**second candle in the rectangle on the right**). **The system worked correctly.**
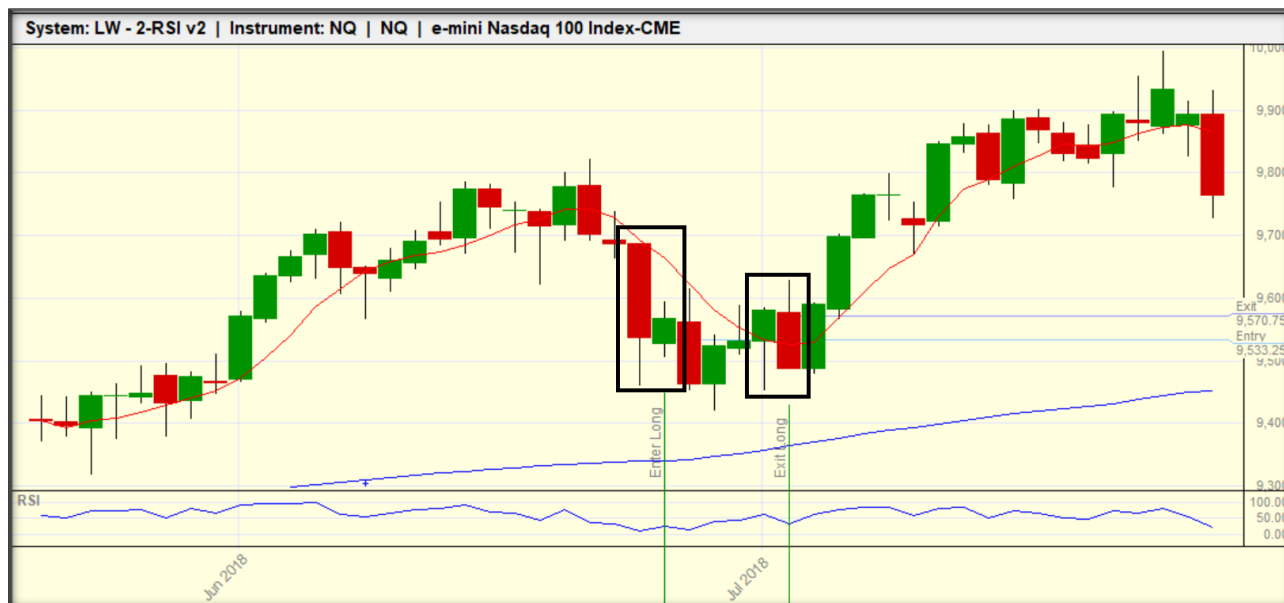
Once we are sure that the trades are generated correctly, we can proceed to the first test of the strategy on the full **in-sample data set.** These tests are performed on **the basic parameters,** which – according to my assessment – should correspond to the assumed goals of the strategy.

First of all, **we reject strategies that linearly lose capital.** If a strategy exhibits such a pattern, it is a clear signal that any parameter optimization does not make sense.

Our basic expectation is that the strategy generates **positive results,** even if they are at a low level.

Tested base parameters:

- **Moving Average Length (SMA-L):** 100 days;
- **Length of the moving average (SMA-S; take profit):** 6 days;
- **RSI Lengths:** 3 days;
- **RSI Entry Threshold:** 15;
- **Stop loss:** none;
- **Method of opening a position:** at the opening price of the next day;
- **Position size:** corresponding to the risk of 2.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening position;
- **Position direction:** long positions (buy) only.

The test result is shown below.
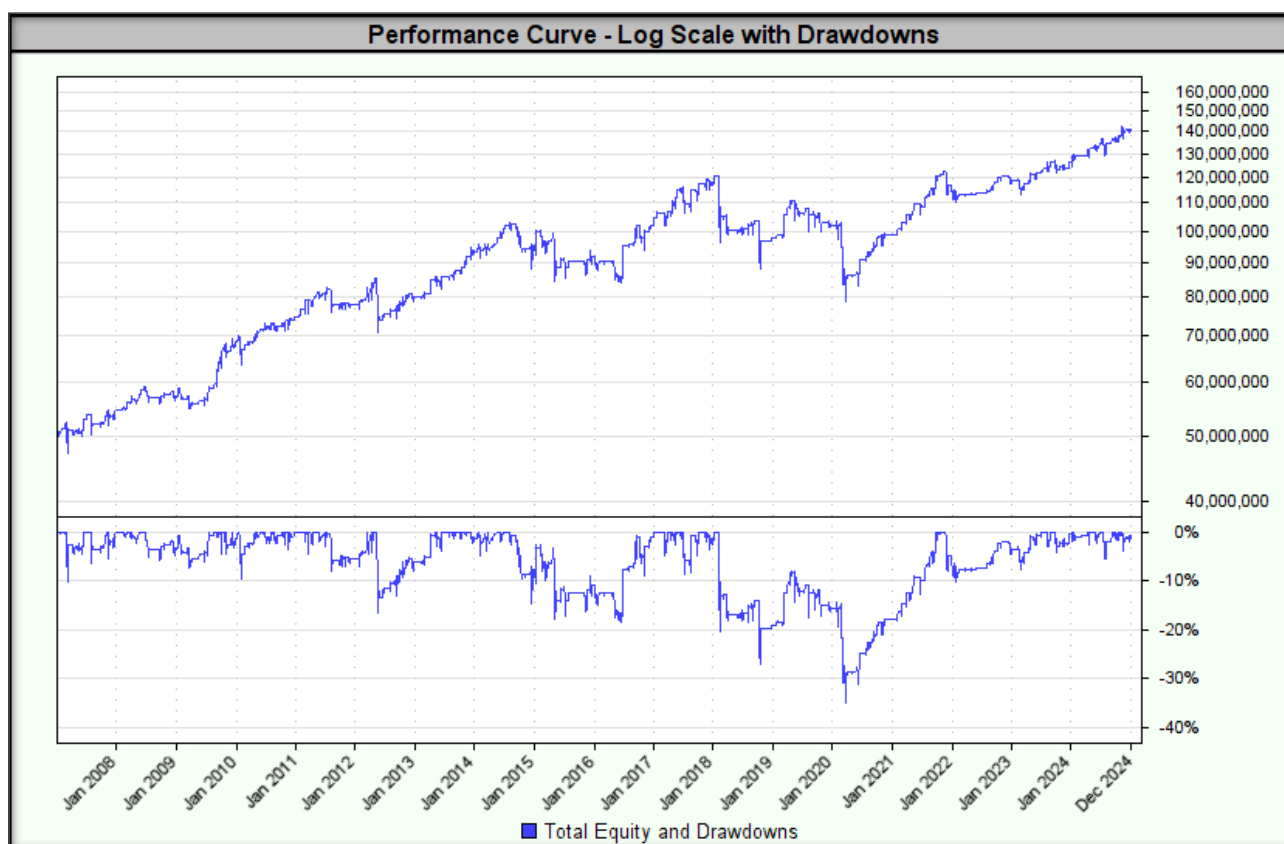
Indicators/Measures	Concluding a transaction at the opening price
CAGR%	5.9%
MAR Ratio	0.17
RAR%	4.8%
R-Cubed	0.16
Robust Sharpe Ratio	0.45
Max Drawdown	34.8%
Wins	68.4%
Losses	31.6%
Average Win%	0.89%
Average Loss%	1.35%
Win/Loss Ratio	0.63
Average Trade Duration (days)	7
Percent Profit Factor	1.44
SQN	-
Number of transactions	607

In summary, the system works properly and generates signals as expected. Additionally, tests on basic parameters have yielded satisfactory results. We can therefore move on to the most interesting stage of creating an investment strategy – **optimization.**

Step 4: Optimization and assessment of investment strategy stability

This stage of strategy creation and testing is **crucial,** as it determines how **effective** the strategy will be in **real conditions. I cannot** emphasize enough that for **a strategy to work** in real conditions, it must also work on **suboptimal parameters** and in **suboptimal conditions.** In a word – **it must be stable** to changing market conditions.

I don't know who said these words, but they perfectly reflect the problem of many optimizations:

"I've never seen a strategy that didn't work in backtests."

My goal is not to find **optimal parameter values** – **my goal** is to find **a wide range of parameters** for which the strategy will generate **acceptable results. We don't know the future,** we don't know future market conditions, but if we know that our strategy **has historically generated acceptable results** in various market conditions and across various parameter ranges, then we are **one step ahead of other** market participants.

What **parameters to choose** for the next period is the subject of consideration in **Step 5 of the "Walk-Forward Analysis,"** but before we get to that, **we need to know whether our strategy is stable** at all.

1. **Stability across a wide range of optimized parameters**

The 2-RSI v.2 strategy in this version assumes **the optimization of parameters using The Grid Search** method. It consists in **the full optimization of all indicated parameters by creating a wide range of possible combinations.** Our goal is to find such **parameter ranges** that **the strategy remains stable (robust),** which will allow us to assess its usefulness in real market conditions.

The key criterion for assessing stability is that all test results must show a positive MAR value and the maximum drawdown must not exceed 250% of the drawdown value for the result with the highest MAR. If any test generates a negative MAR value or if the drawdown exceeds 250% of the drawdown value for the result with the highest MAR, the strategy is rejected completely.

In the first step, we test the stability of parameters on **in-sample** data. For this purpose, we determine **the ranges of parameter values** so that **the quotient of the highest and lowest value of the range is at least 150%.**

In the tested strategy, the ranges defined in this way are:

- **Moving average lengths (SMA-L):** range **60-100 days (step: 2);**
- **Moving average lengths (SMA-S; take profit):** range **6-9 days (step: 1);**
- **RSI Lengths:** 3 days;
- **RSI Entry Threshold:** range **14-22 (step: 1).**

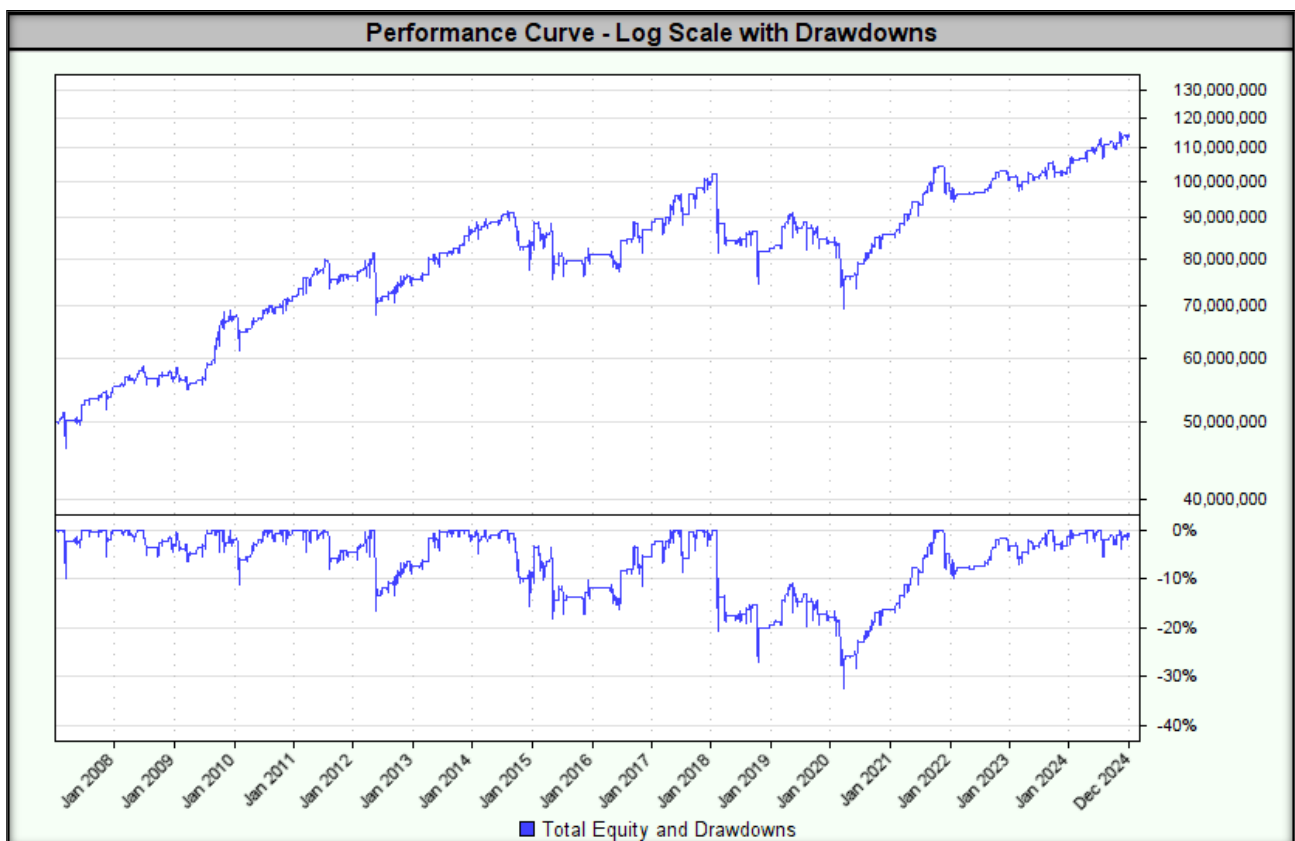**The lowest MAR value of 0.15** was achieved for the following parameters:

- **Moving Average Length (SMA-L):** 100;
- **Moving average lengths (SMA-S):** 6;

- **RSI Entry Threshold:** 14.

Test	Moving Average Long (bars)	Moving Average Short (bars)	RSI Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3
721	100	6	14	$114,124,490.97	4.69%	0.15	0.52	0.57	32.2%	43.7	540	0.12
685	98	6	14	$115,476,828.88	4.76%	0.15	0.54	0.61	32.1%	43.7	531	0.14
1	60	6	14	$96,239,266.79	3.71%	0.16	0.50	0.55	23.4%	41.9	398	0.16
649	96	6	14	$117,688,224.54	4.87%	0.16	0.56	0.62	30.5%	43.7	523	0.15
722	100	6	15	$141,002,808.86	5.93%	0.17	0.59	0.70	34.8%	43.7	607	0.16
686	98	6	15	$142,308,938.56	5.98%	0.17	0.61	0.72	34.7%	45.3	598	0.18
723	100	6	16	$138,815,111.73	5.84%	0.17	0.56	0.68	33.8%	42.5	674	0.14
687	98	6	16	$139,787,655.99	5.88%	0.17	0.57	0.73	33.7%	42.5	666	0.15
73	64	6	14	$103,793,138.54	4.14%	0.18	0.56	0.61	23.5%	41.6	415	0.19

Below is a graph of the equity curve for **the strategy with the lowest MAR.**

Performance Curve - Log Scale with Drawdowns

The highest MAR value of 0.60 was achieved for the following parameters:

- **Moving Average Length (SMA-L):** 74;
- **Moving average lengths (SMA-S):** 8;
- **RSI Entry Threshold:** 19.

The highest MAR value was accompanied by **a drawdown of 20.6%.**

Test	Moving Average Long (bars)	Moving Average Short (bars)	RSI Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3
276	74	8	19	$409,253,680.08	12.39%	0.60	1.05	1.19	20.6%	33.6	768	0.66
204	70	8	19	$382,473,834.06	11.97%	0.58	1.03	1.19	20.6%	32.9	746	0.69
240	72	8	19	$380,850,952.72	11.94%	0.58	1.02	1.15	20.6%	33.6	754	0.67
168	68	8	19	$350,587,927.74	11.43%	0.55	0.99	1.18	20.6%	32.9	741	0.65
528	88	8	19	$389,534,104.05	12.08%	0.55	0.98	1.13	21.9%	32.9	826	0.54
312	76	8	19	$415,863,098.52	12.49%	0.55	1.05	1.12	22.9%	34.1	778	0.60
203	70	8	18	$339,352,444.88	11.23%	0.54	1.02	1.15	20.6%	31.3	678	0.65
648	94	9	22	$636,863,316.91	15.19%	0.54	0.98	1.02	28.1%	34.1	1041	0.67
348	78	8	19	$403,271,717.92	12.30%	0.54	1.03	1.15	23.0%	38.2	785	0.58

Below is a graph of the equity curve for **the strategy with the highest MAR.**
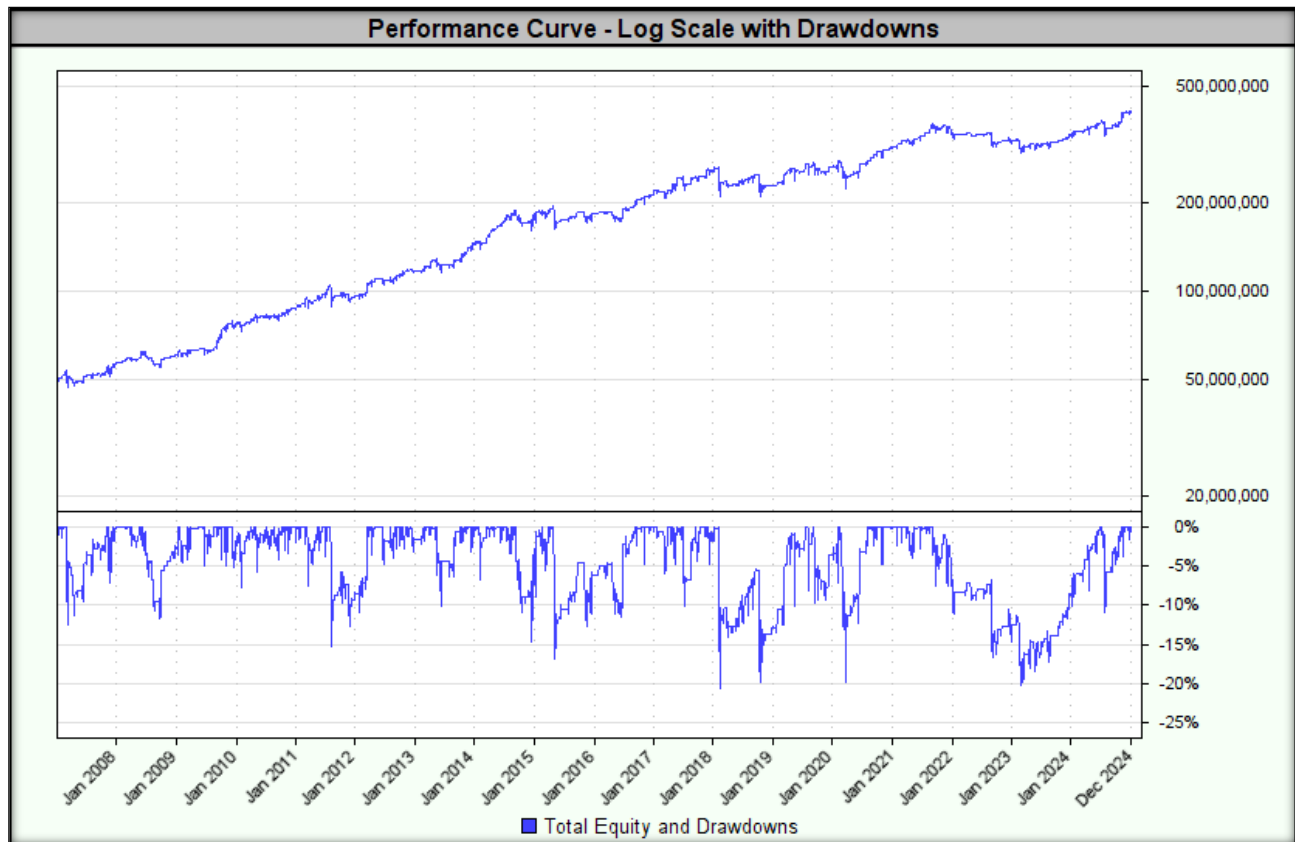
For all combinations of tested parameter ranges, **the highest drawdown was 45.5%.**

Test	Moving Average Long (bars)	Moving Average Short (bars)	RSI Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD ▽	Longest DD	Trades	R3
738	100	7	22	$371,638,477.18	11.79%	0.26	0.79	0.82	45.5%	43.3	1100	0.25
702	98	7	22	$341,240,963.79	11.26%	0.25	0.76	0.79	45.4%	43.3	1093	0.24
180	68	9	22	$405,508,509.92	12.33%	0.28	0.84	0.74	44.3%	40.0	945	0.47
144	66	9	22	$436,041,376.51	12.79%	0.29	0.88	0.80	44.3%	40.0	937	0.38
666	96	7	22	$326,309,965.63	10.98%	0.25	0.75	0.79	43.9%	43.1	1083	0.24
35	60	9	21	$335,497,948.95	11.16%	0.25	0.80	0.77	43.8%	40.0	848	0.40
36	60	9	22	$374,261,784.37	11.83%	0.27	0.83	0.82	43.7%	40.0	919	0.37
737	100	7	21	$347,154,678.47	11.37%	0.26	0.78	0.86	43.6%	43.1	1023	0.25
701	98	7	21	$329,384,367.27	11.04%	0.25	0.77	0.85	43.6%	43.1	1018	0.26

In summary, the strategy **passed the stability test** over a wide range of optimized parameters on in-sample data because:

- **All test results showed a positive MAR value** – which indicates the stability of the strategy in various market conditions.
- **The maximum drawdown did not exceed 250% of the drawdown value** for the result with the highest MAR (**45.5% vs. 20.6%**) – which means an acceptable risk of deep capital drawdowns.

Heatmaps for the tested ranges are presented below.

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

MAR as Moving Average Long (bars) Varies

MAR as Moving Average Short (bars) Varies

MAR as RSI Threshold Varies
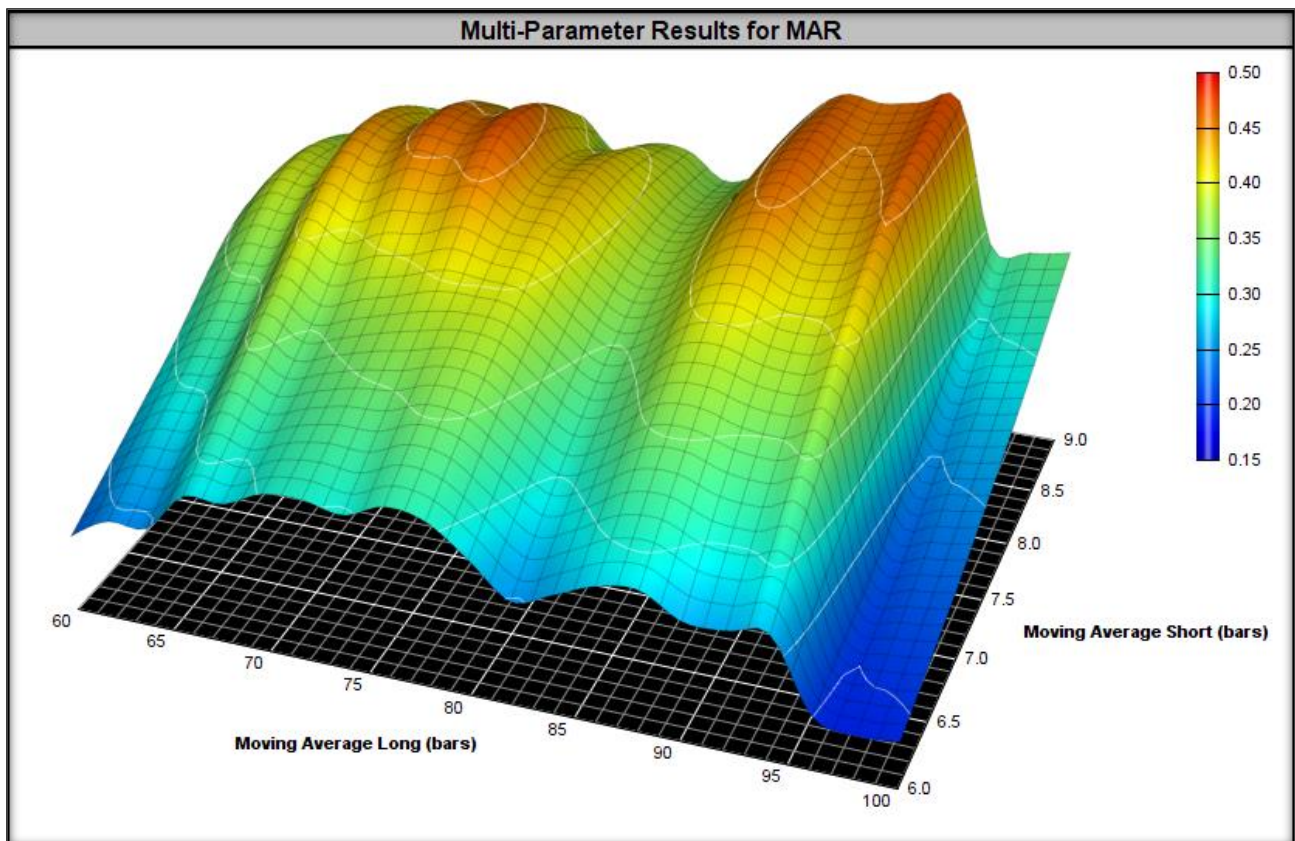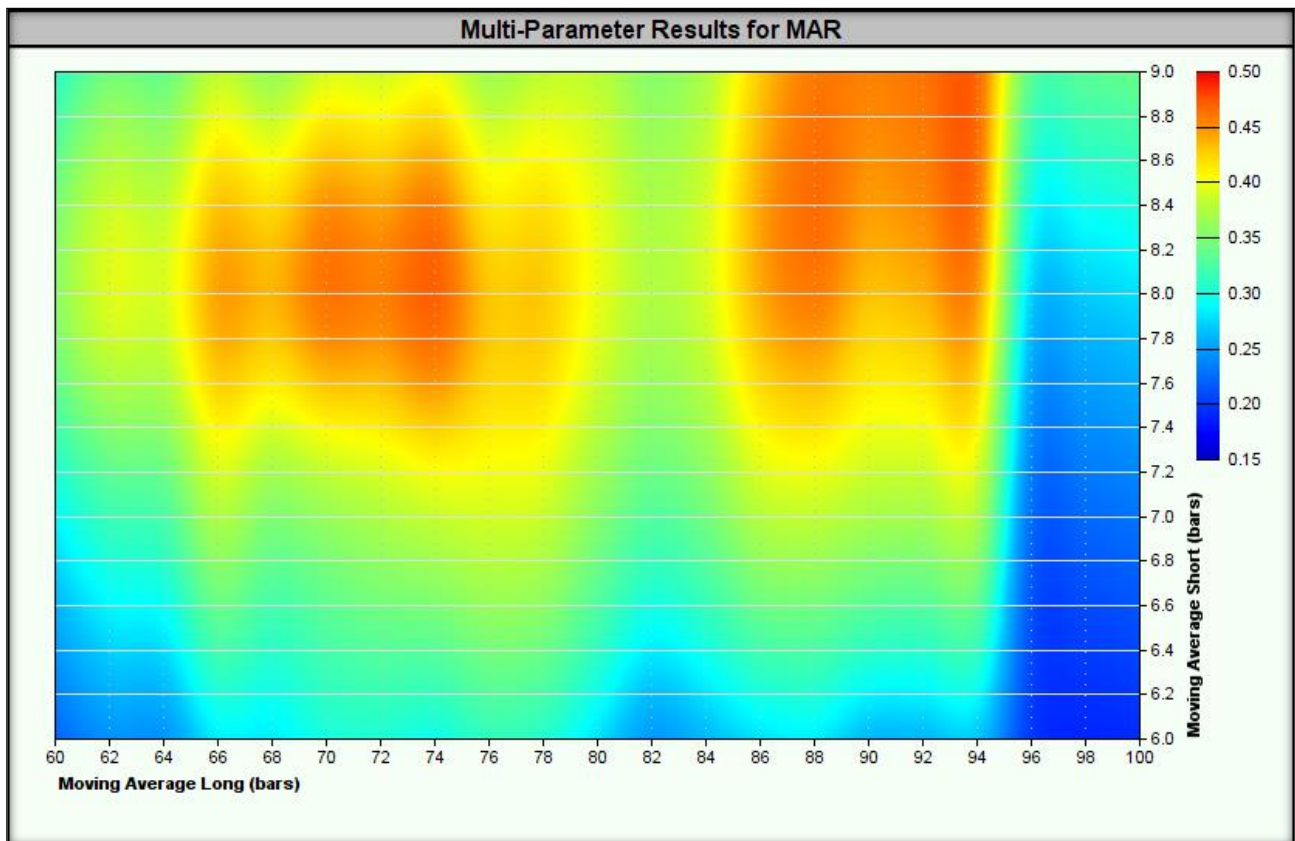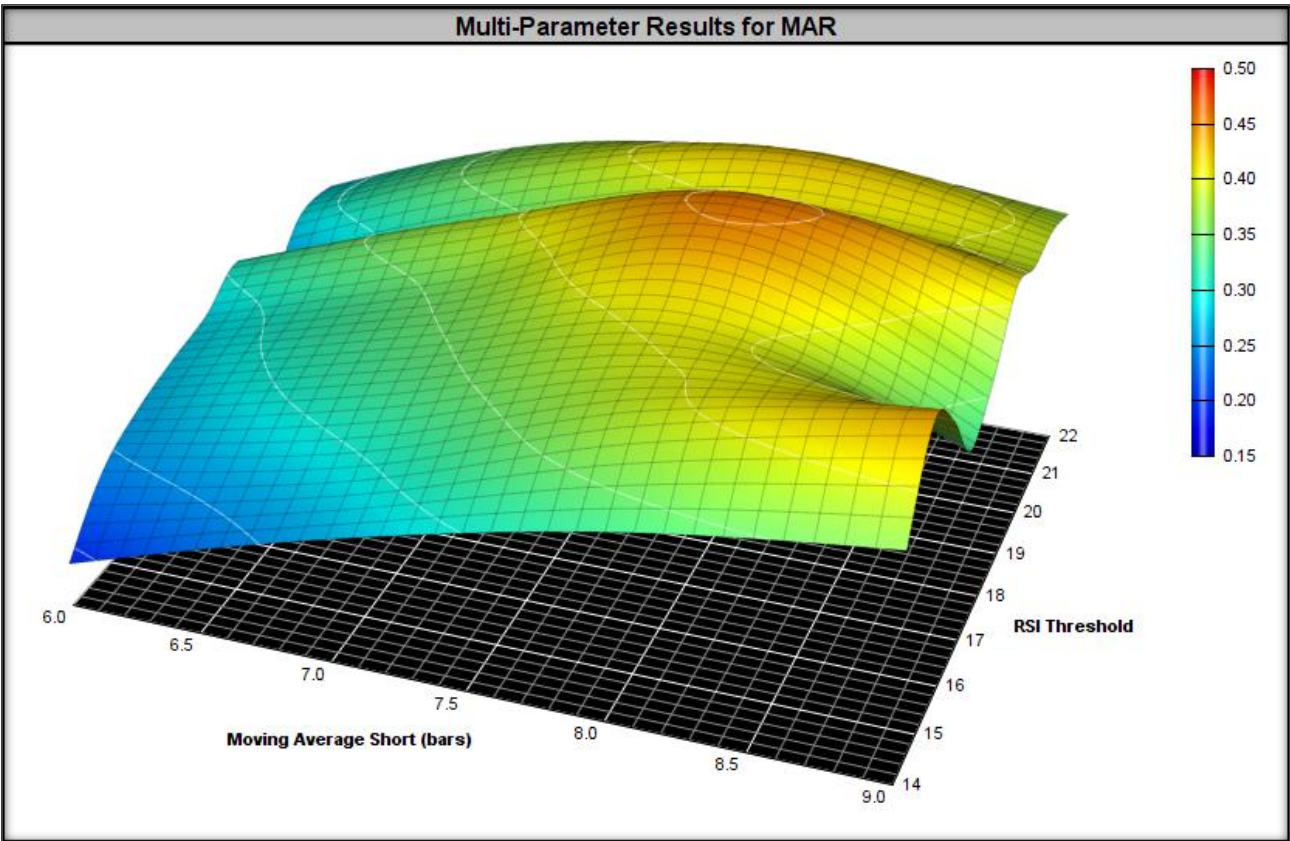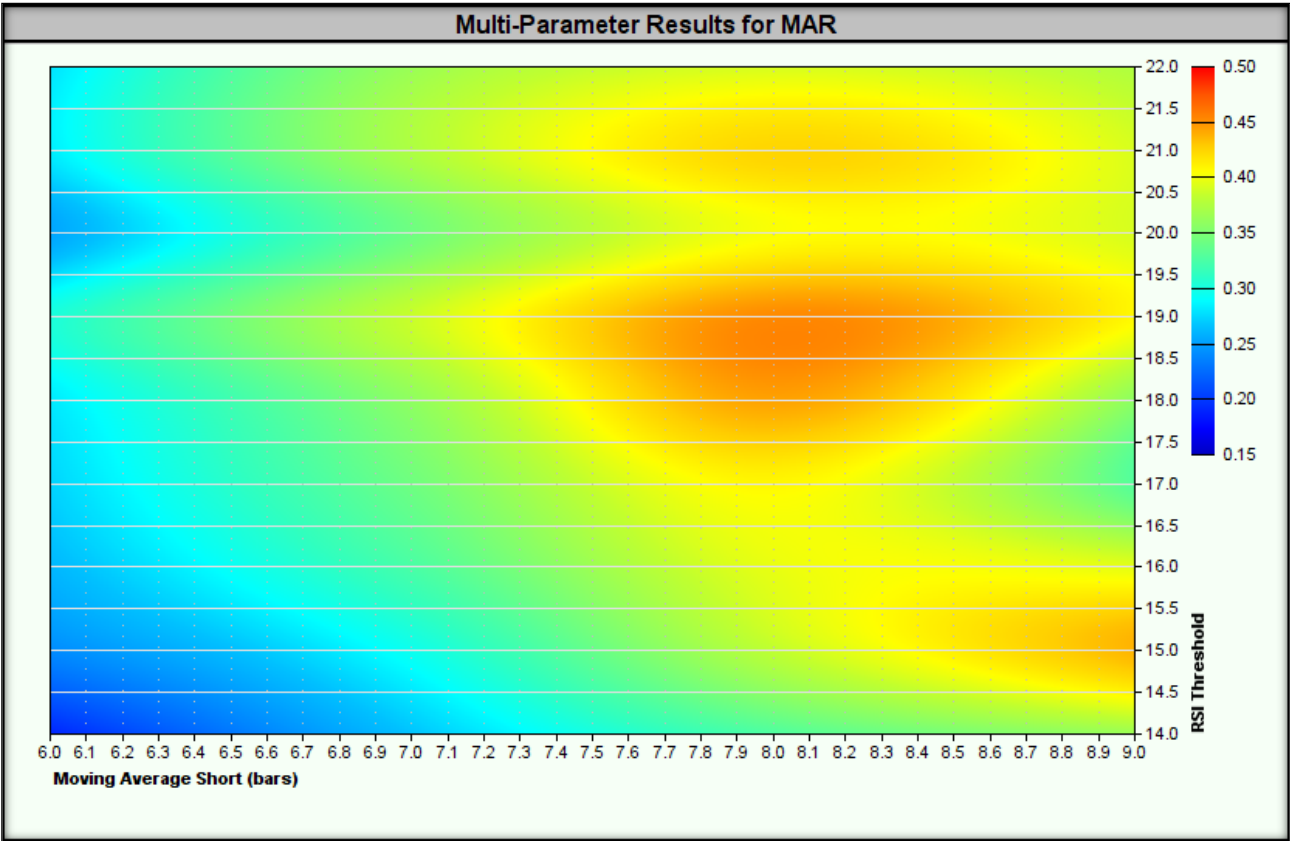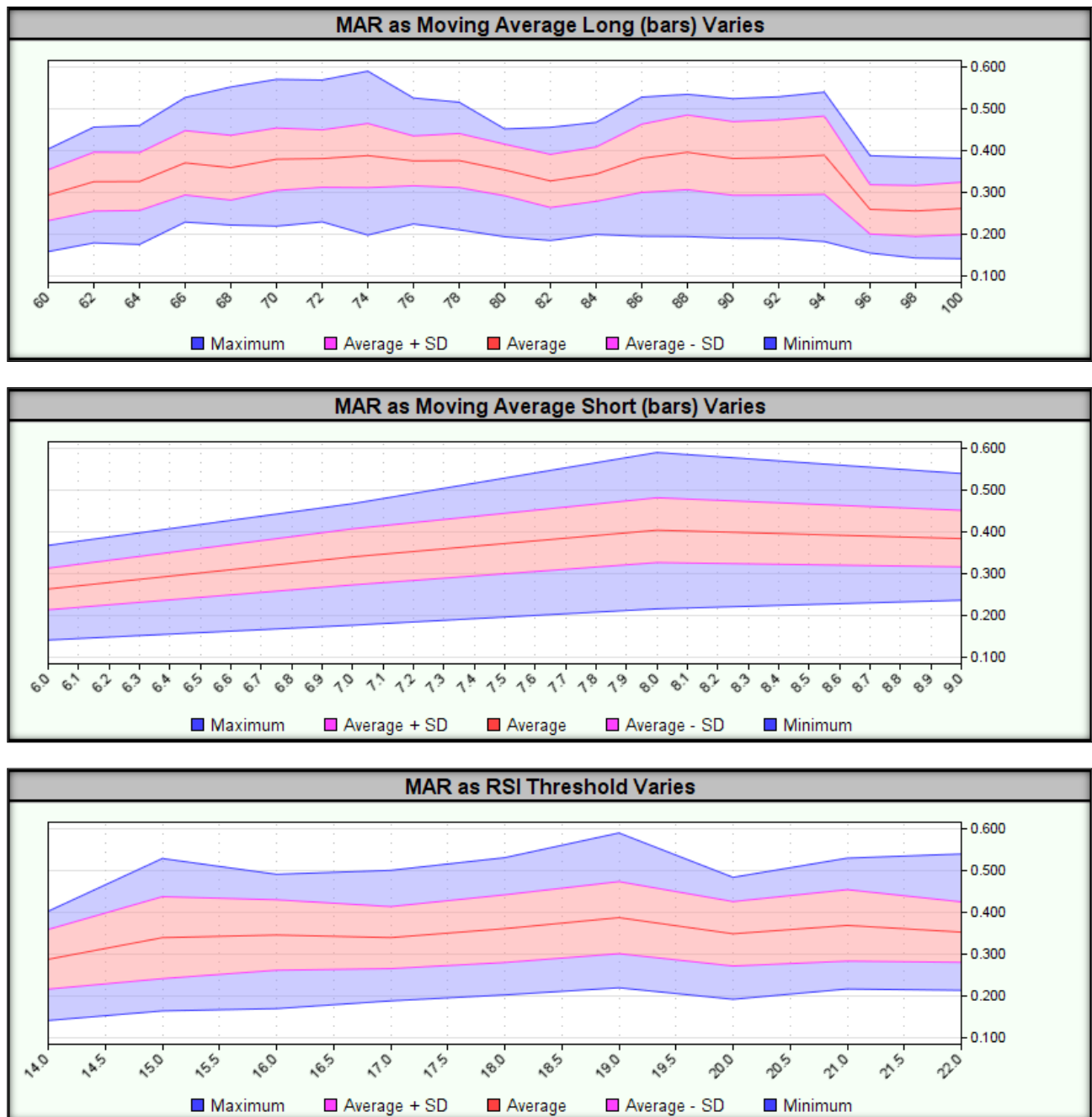
After passing the stability tests on **in-sample data,** it is time perform the same on **out-of-sample data.** For this purpose, we use **the same range of parameters** as on in-sample data:

- **Moving average lengths (SMA-L):** range **60-100 days (step: 2);**
- **Moving average lengths (SMA-S; take profit):** range **6-9 days (step: 1);**
- **RSI Lengths:** 3 days;
- **RSI Entry Threshold:** range **14-22 (step: 1).**

The lowest MAR value of 0.15 was achieved for the following parameters:

- **Moving Average Length (SMA -L):** 76;
- **Moving average lengths (SMA-S):** 6;
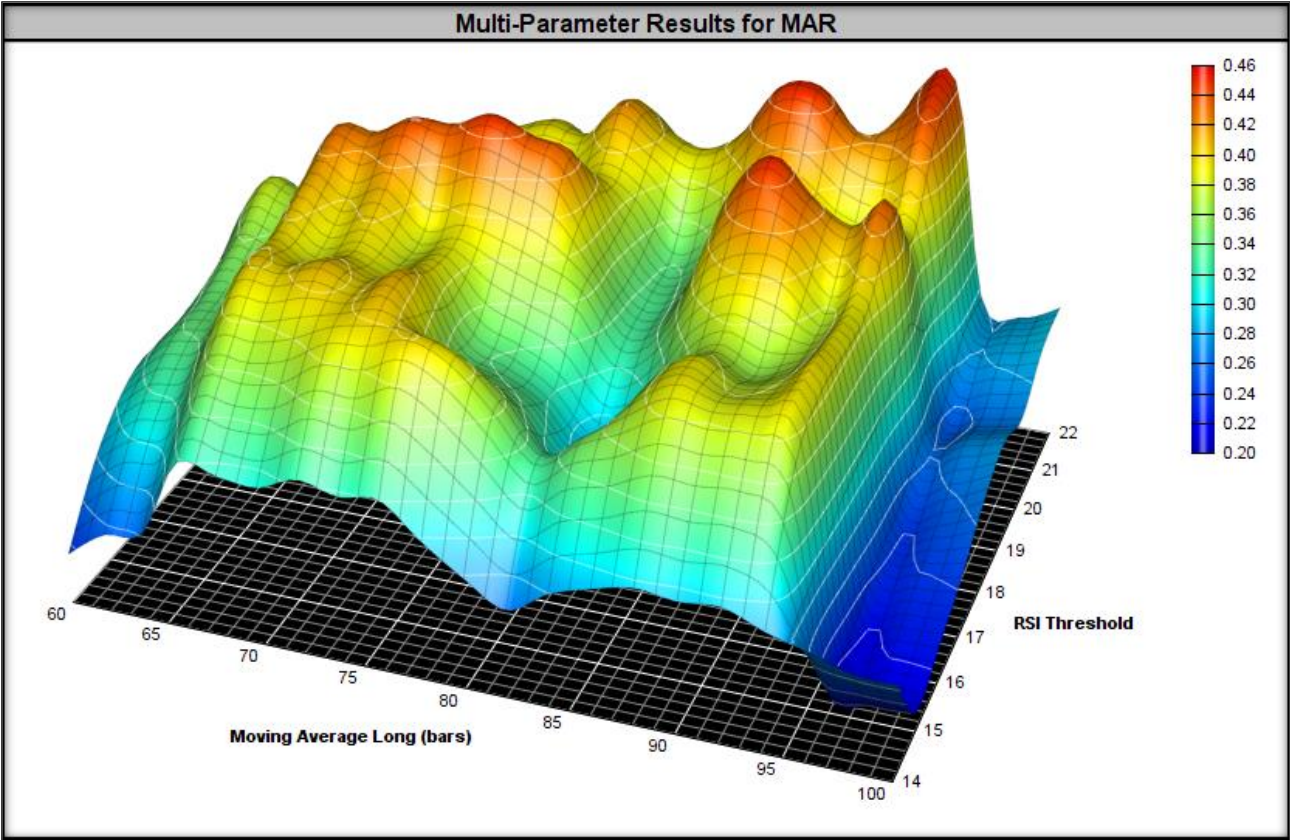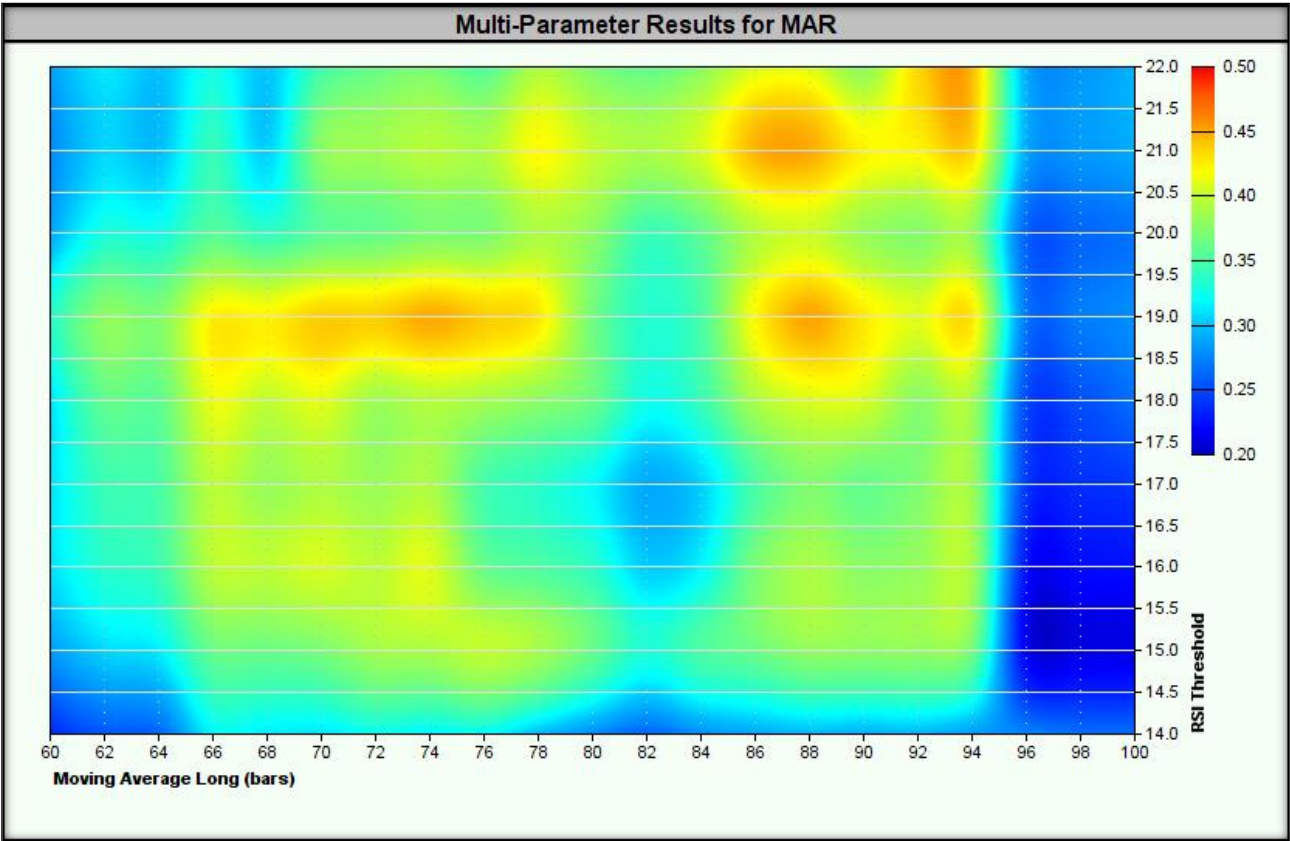- **RSI Entry Threshold:** 18.

Test	Moving Average Long (bars)	Moving Average Short (bars)	RSI Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3
293	76	6	18	$71,058,532.14	3.99%	0.15	0.39	0.42	26.7%	35.6	328	0.13
294	76	6	19	$68,728,774.44	3.60%	0.15	0.35	0.40	24.0%	28.3	353	0.10
336	78	7	16	$69,245,142.96	3.69%	0.15	0.37	0.58	24.3%	57.0	272	0.11
329	78	6	18	$71,955,737.34	4.13%	0.15	0.40	0.43	26.8%	35.5	328	0.15
330	78	6	19	$69,447,679.84	3.72%	0.16	0.36	0.42	24.0%	28.3	352	0.11
303	76	7	19	$69,736,355.82	3.77%	0.16	0.35	0.44	24.0%	53.7	349	0.17
541	90	6	14	$67,820,402.16	3.45%	0.16	0.40	0.54	21.9%	47.4	227	0.08
327	78	6	16	$69,898,907.11	3.80%	0.16	0.39	0.59	23.6%	57.0	275	0.09
300	76	7	16	$71,711,488.09	4.09%	0.16	0.40	0.64	25.3%	57.0	271	0.13

Below is a graph of the equity curve for **the strategy with the lowest MAR.**

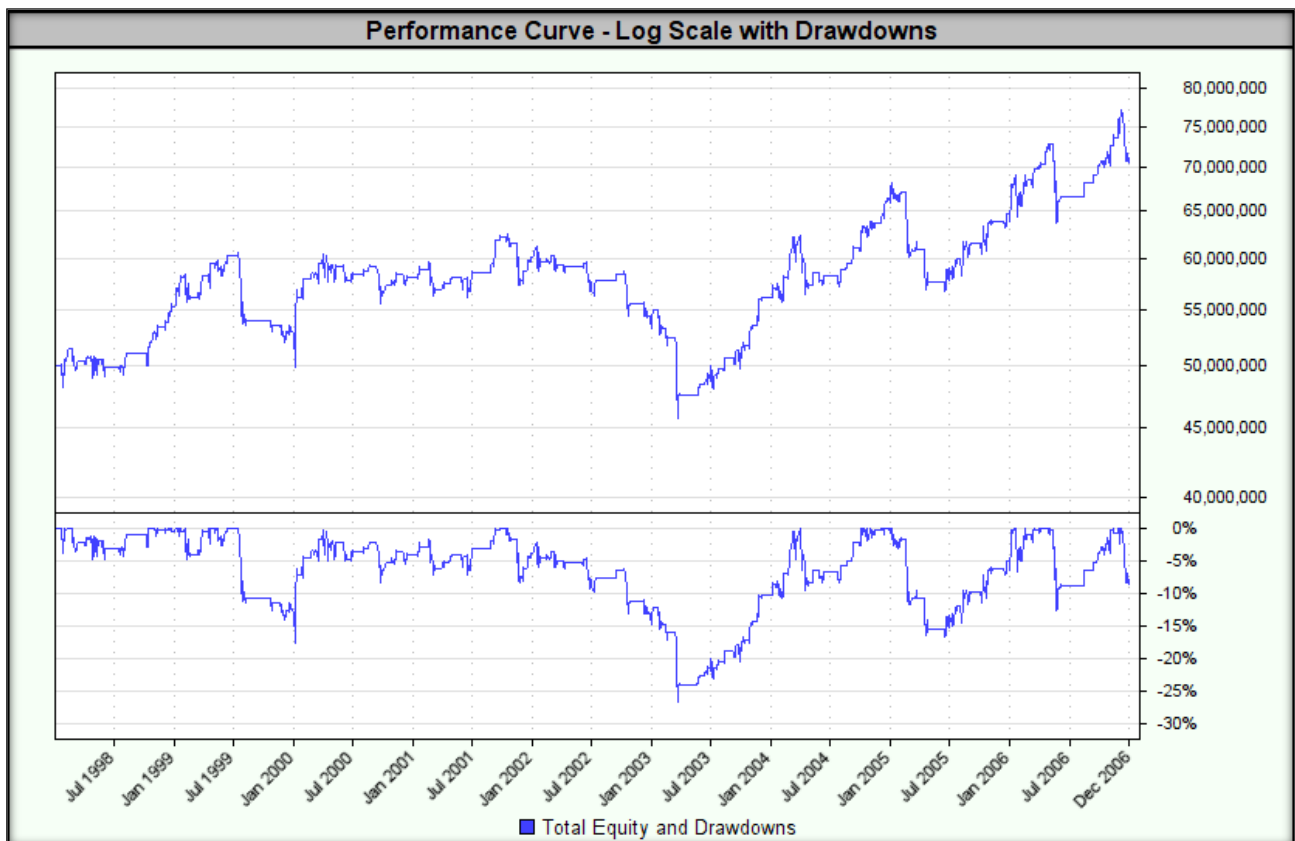The highest MAR value of **0.52** was achieved for the following parameters:

- **Moving Average Length (SMA-L):** 64;
- **Moving average lengths (SMA-S):** 8;
- **RSI Entry Threshold:** 15.

The highest MAR value was accompanied by **a drawdown of 14.9%.**

Test	Moving Average Long (bars)	Moving Average Short (bars)	RSI Threshold	End Balance	CAGR%	MAR ▽	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3
92	64	8	15	$97,368,930.25	7.69%	0.52	0.80	1.24	14.9%	13.2	212	0.90
56	62	8	15	$95,744,070.89	7.49%	0.50	0.79	1.20	14.9%	13.2	211	0.87
200	70	8	15	$101,335,389.15	8.17%	0.50	0.83	1.31	16.3%	13.2	227	0.82
20	60	8	15	$95,258,578.18	7.43%	0.50	0.79	1.13	14.9%	13.2	207	0.89
94	64	8	17	$101,813,056.02	8.23%	0.50	0.75	1.02	16.6%	20.8	267	0.88
26	60	8	21	$108,831,809.25	9.04%	0.49	0.72	0.92	18.3%	11.2	378	0.97
202	70	8	17	$105,691,693.53	8.68%	0.49	0.77	1.07	17.6%	13.6	283	0.83
236	72	8	15	$99,954,962.77	8.01%	0.49	0.80	1.44	16.3%	14.2	232	0.73
97	64	8	20	$104,069,698.92	8.49%	0.49	0.72	1.01	17.3%	11.6	346	0.97

Below is a graph of the equity curve for **the strategy with the highest MAR.**

Performance Curve - Log Scale with Drawdowns

Total Equity and Drawdowns
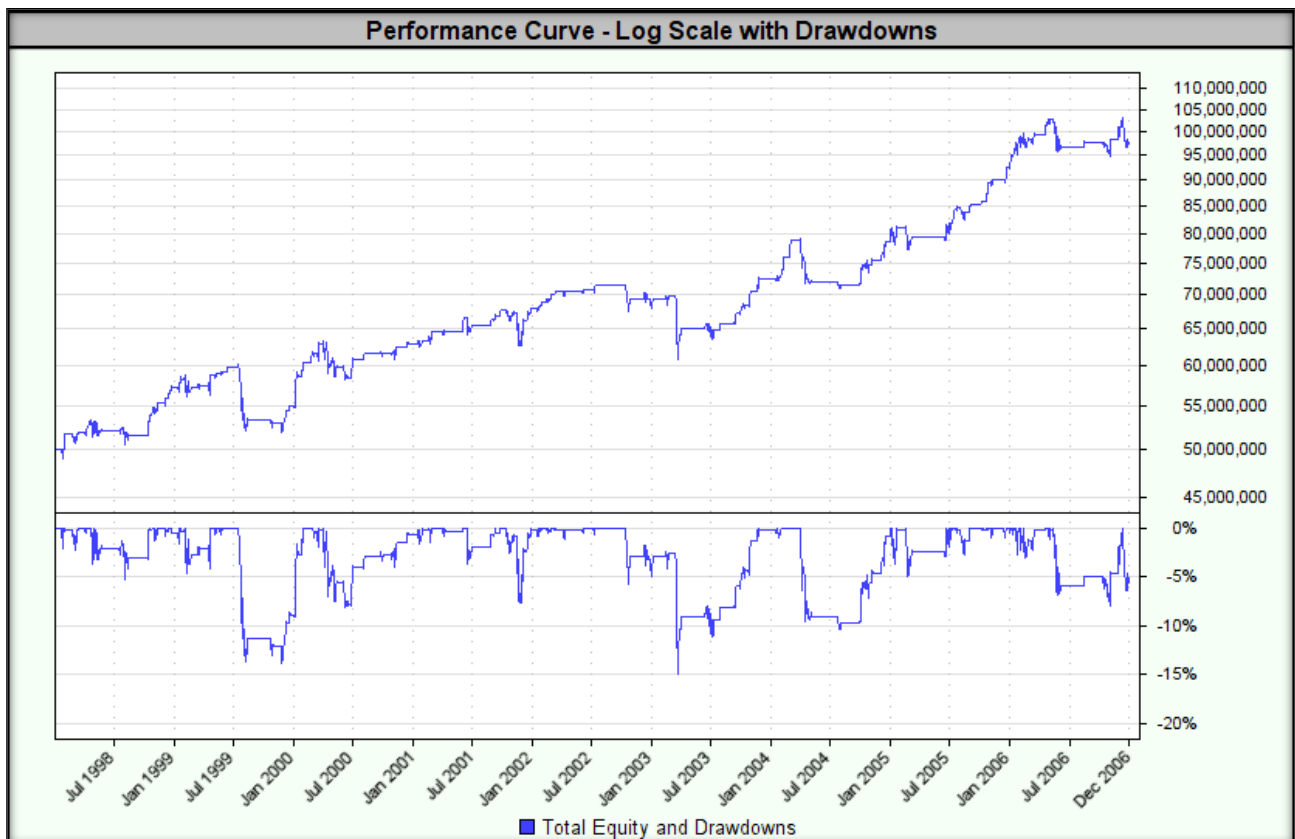
For all combinations of tested parameter ranges, **the highest drawdown was 29.4%.**

Test	Moving Average Long (bars)	Moving Average Short (bars)	RSI Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD ▽	Longest DD	Trades	R3
594	92	7	22	$81,983,201.34	5.65%	0.19	0.45	0.60	29.4%	54.2	452	0.17
630	94	7	22	$83,045,571.80	5.81%	0.20	0.46	0.63	28.9%	53.7	458	0.18
558	90	7	22	$81,258,338.07	5.55%	0.20	0.45	0.62	27.9%	53.1	454	0.18
234	72	7	22	$82,605,370.06	5.74%	0.21	0.47	0.62	27.7%	52.8	436	0.22
306	76	7	22	$77,397,297.16	4.98%	0.18	0.42	0.53	27.4%	52.8	443	0.18
522	88	7	22	$79,655,633.14	5.32%	0.19	0.44	0.58	27.3%	52.8	449	0.19
738	100	7	22	$84,712,131.50	6.04%	0.22	0.48	0.70	27.1%	52.8	461	0.20
270	74	7	22	$81,855,465.25	5.64%	0.21	0.46	0.64	27.0%	52.7	441	0.23
666	96	7	22	$84,339,612.62	5.99%	0.22	0.48	0.67	26.9%	52.8	457	0.21

In summary, the strategy **passed the stability test** over a wide range of optimized parameters on out-of-sample data because:

- **All test results showed a positive MAR value** – which indicates the stability of the strategy in various market conditions.
- **The maximum drawdown on out-of-sample data did not exceed 150% of the maximum drawdown value on in-sample data (29.4% vs. 45.5%)** – which means an acceptable risk of capital drawdown.

- **The decrease in the maximum MAR value on out-of-sample data was less than 50% relative to the in-sample test results (0.60 vs. 0.52)** – indicating that the strategy can perform well in a variety of market conditions.

Heatmaps for the tested ranges are presented below.

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

Multi-Parameter Results for MAR

MAR as Moving Average Long (bars) Varies

■ Maximum ■ Average + SD ■ Average ■ Average - SD ■ Minimum
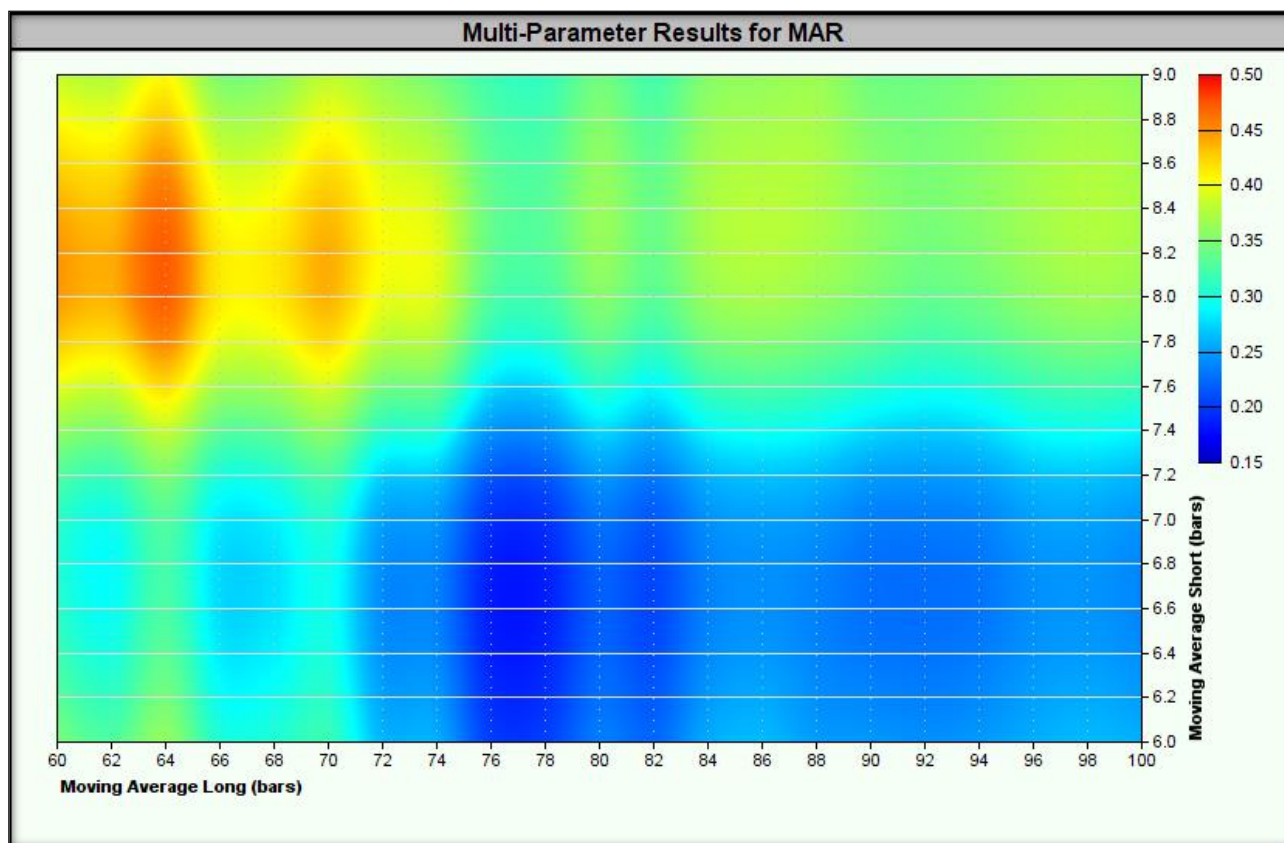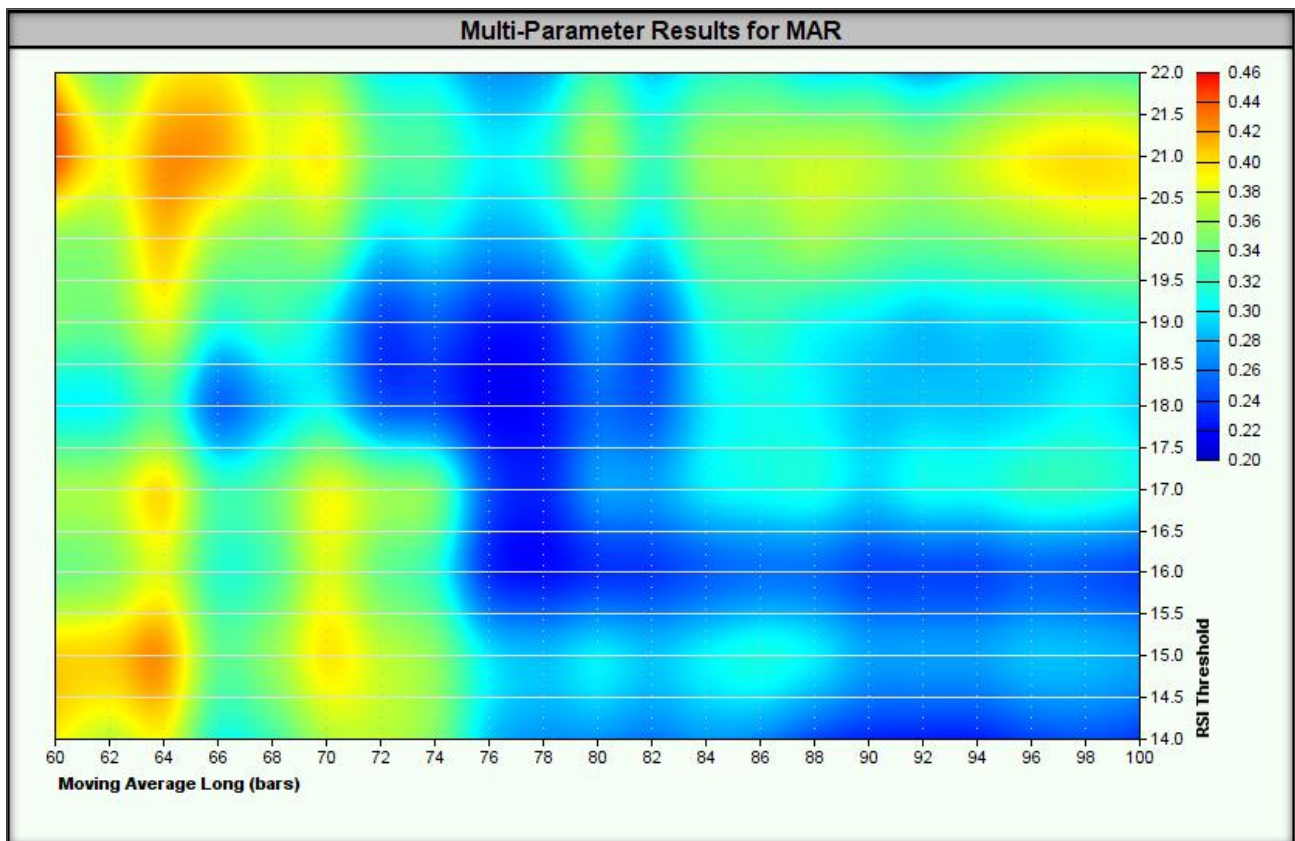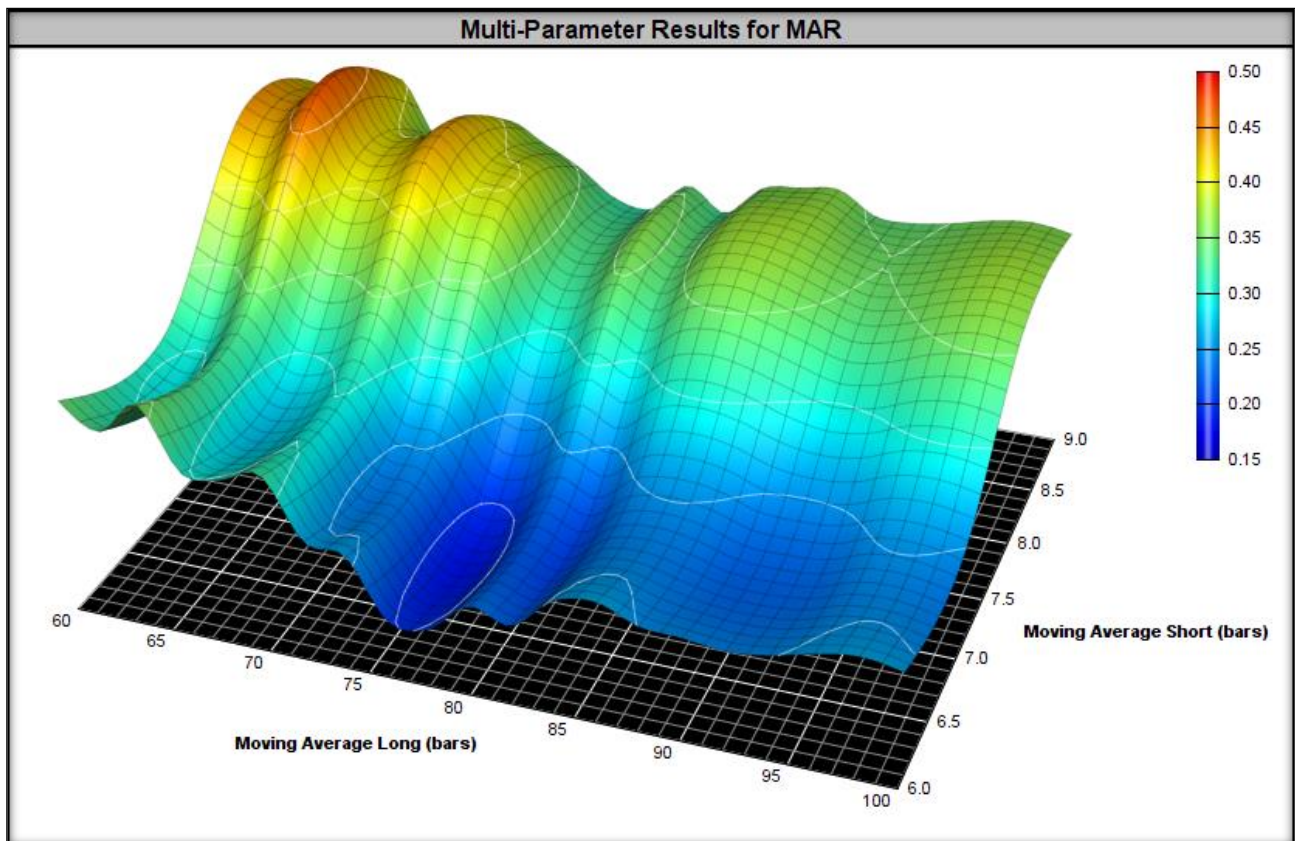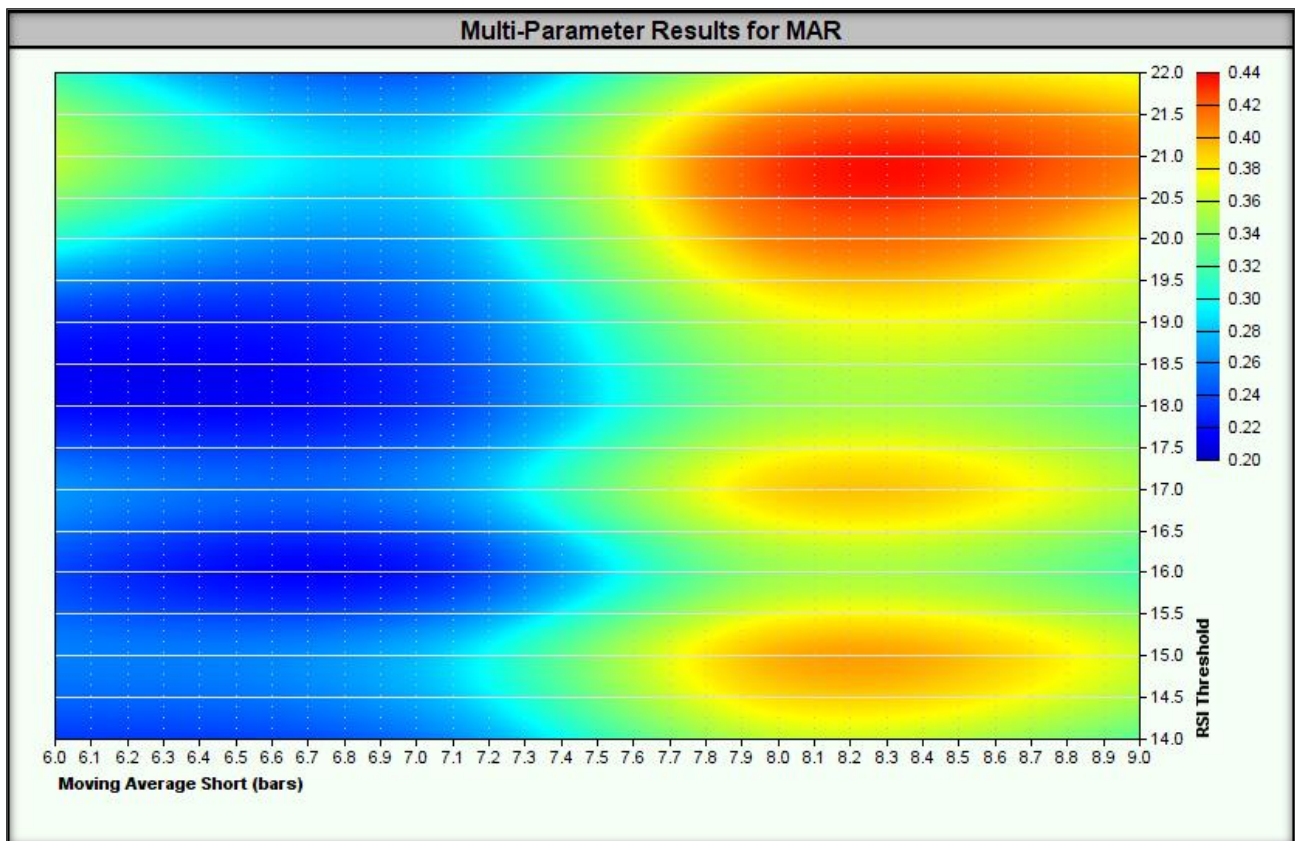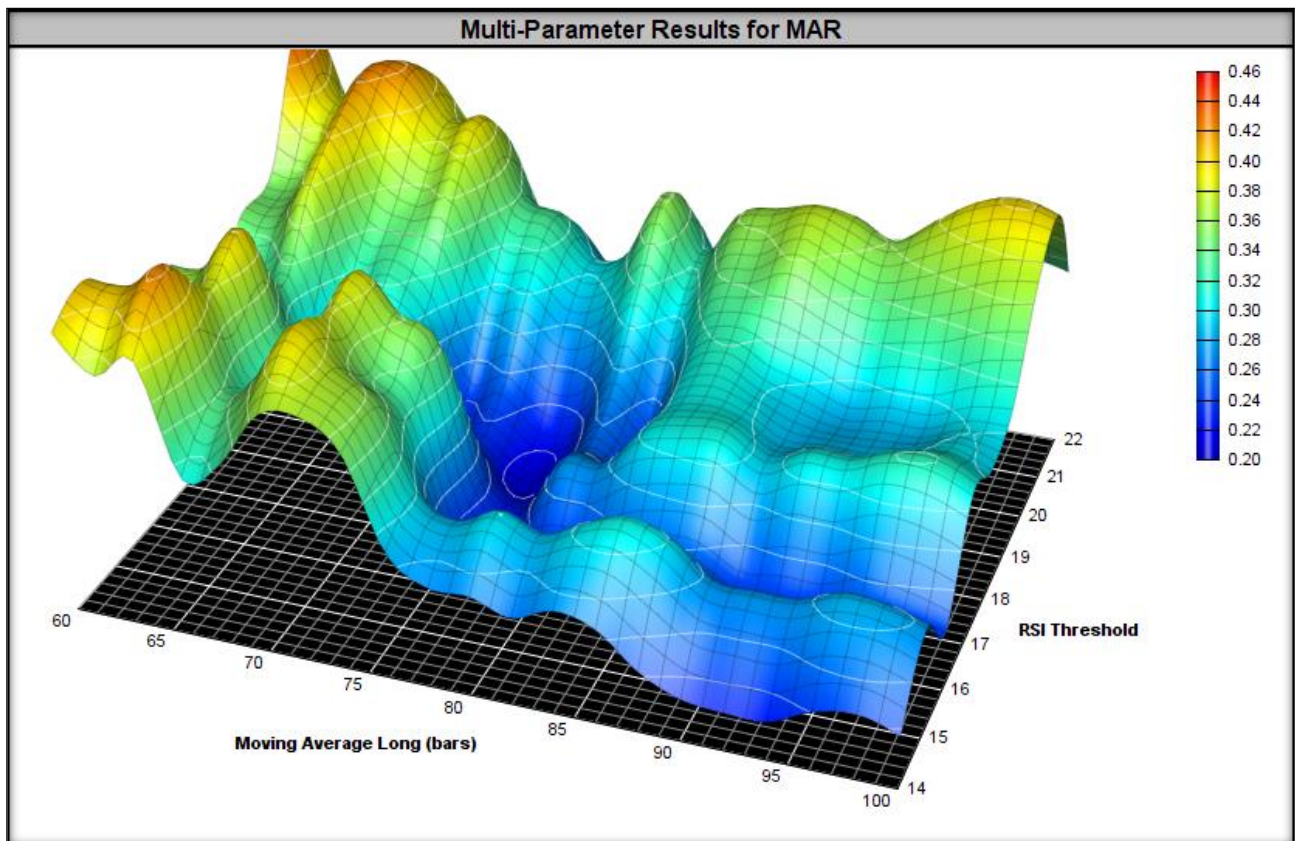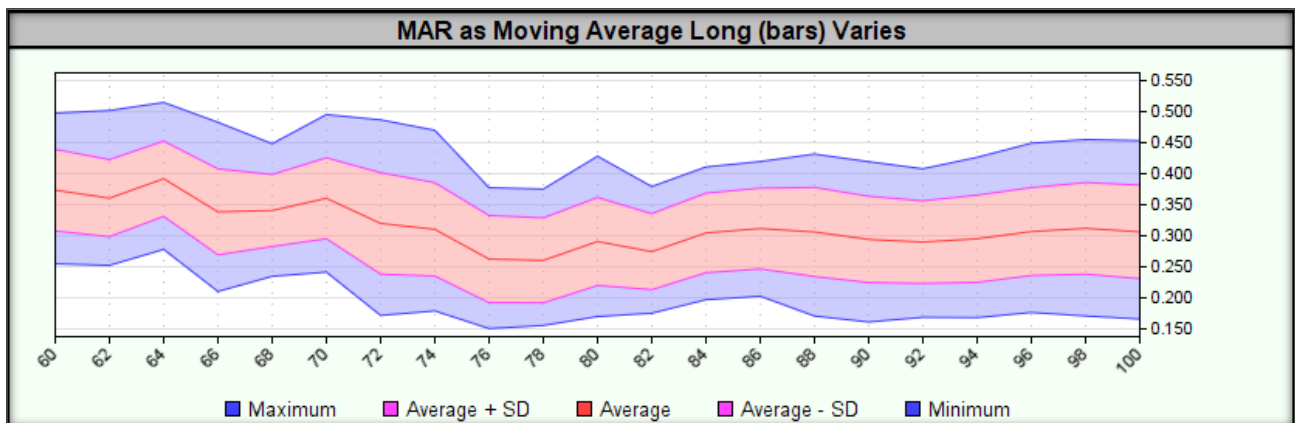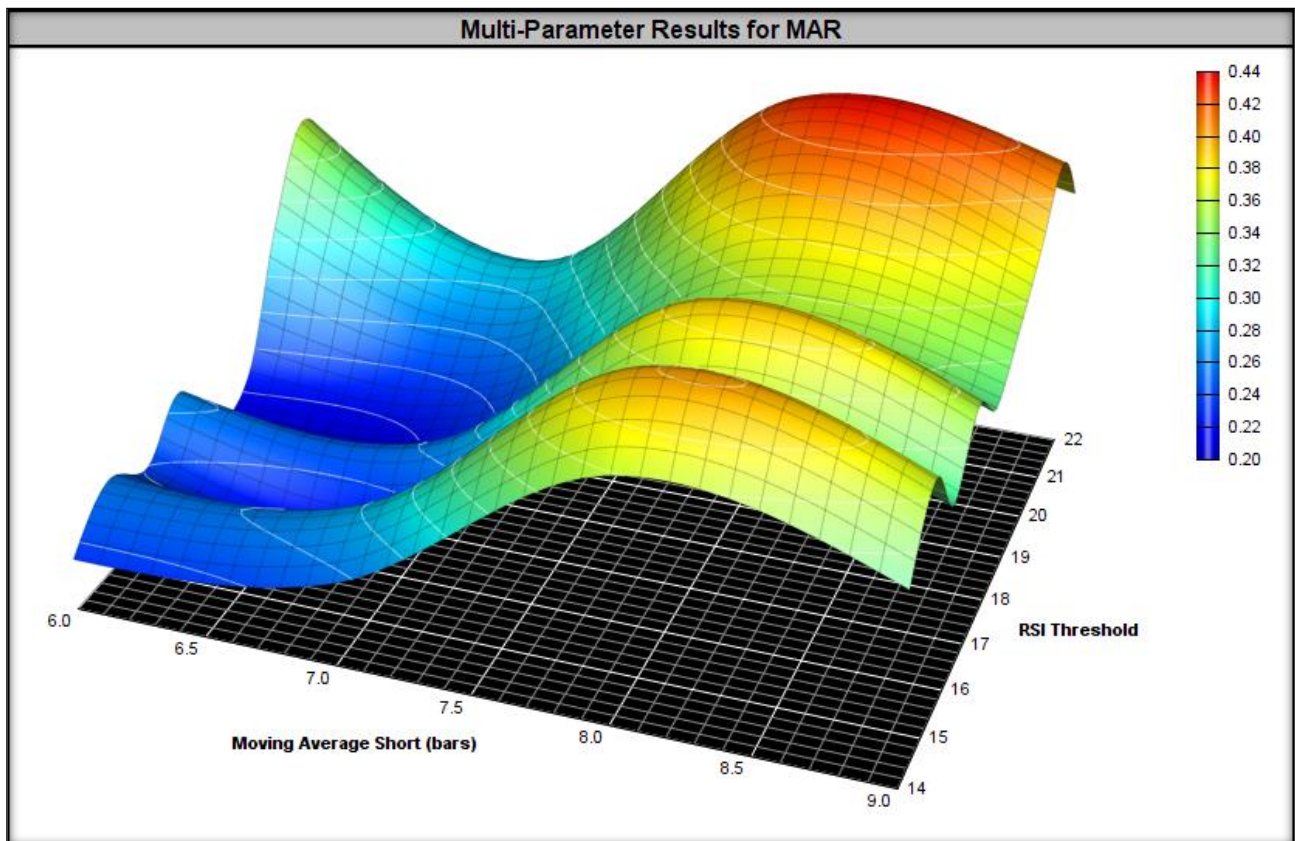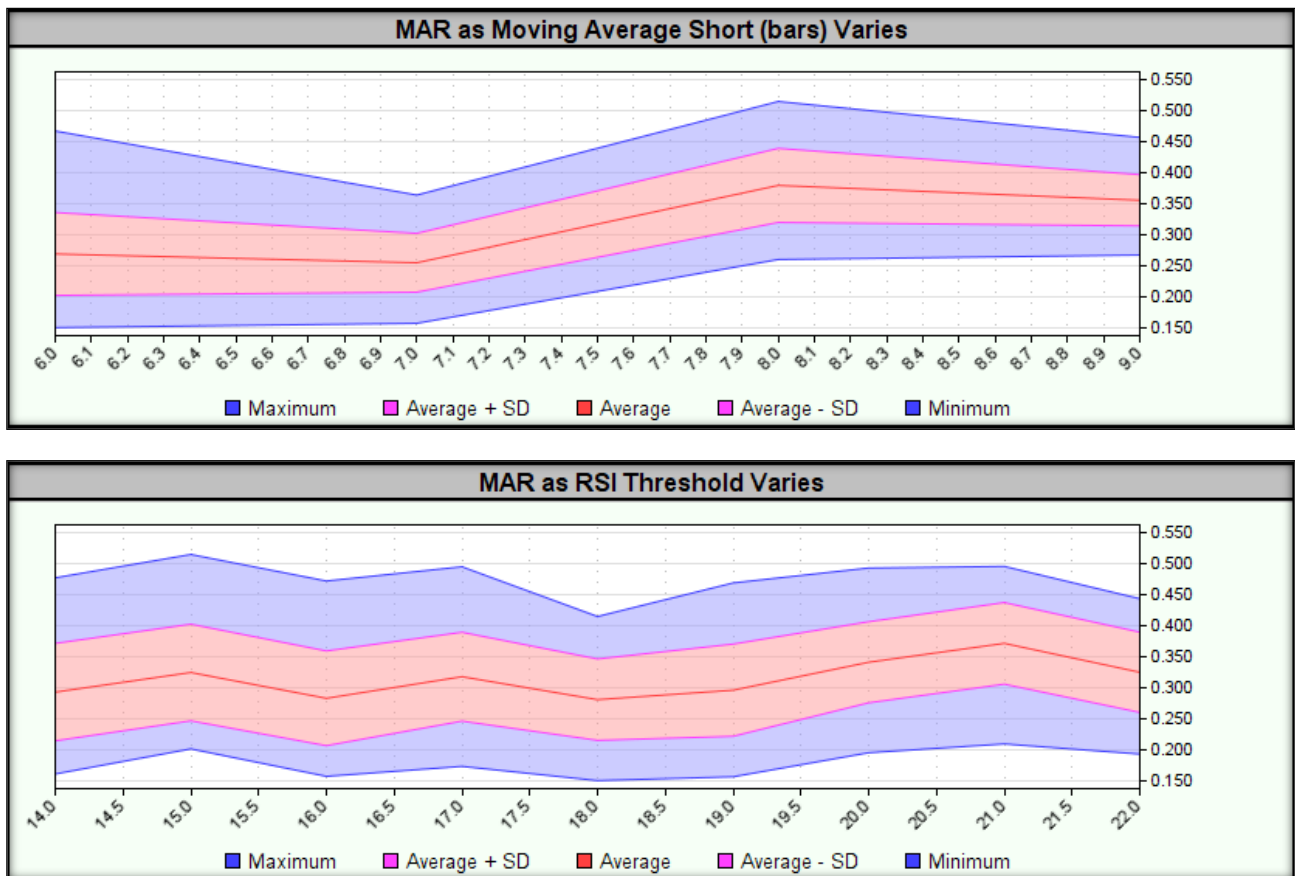
After passing **the stability test in a wide range of optimized parameters,** we can proceed to **stability testing using Monte Carlo simulation.** The conditions for passing this test are similar to those required in the above step.

2. **Monte Carlo simulation**

Monte Carlo simulation involves running multiple simulations to examine how a strategy might perform in different market scenarios. The key objective of this method is to assess the potential **drawdown** of an optimized strategy. **Monte Carlo simulation** better reflects the possible swings of the equity curve and the depth of the potential **drawdown,** allowing for a more realistic risk assessment. It is also an ideal opportunity to compare **the drawdown** obtained in tests on optimized parameter ranges with the results of **the Monte Carlo simulation,** using **a 99% confidence interval.**

A strategy considered to be **stable (robust)** should achieve **a drawdown in a Monte Carlo simulation** that does not exceed **250% of the drawdown** size **from total tests in-sample and out-of-sample** (for parameters optimized on IS data). Furthermore, the **MAR indicator** should remain positive within the chosen confidence interval.

For data covering the period from **01.01.1998 to 31.12.2024, a Monte Carlo simulation** was performed on **optimal strategy parameters.** The Monte Carlo simulation was performed **100,000 times,** testing **the variant with replacement (more conservative),** and **the confidence interval was set to 99%.**

Test results for **the simulation with sample replacement are presented below.**

Monte Carlo Equity Curve - Log Scale

Monte Carlo CAGR%

Monte Carlo Drawdowns
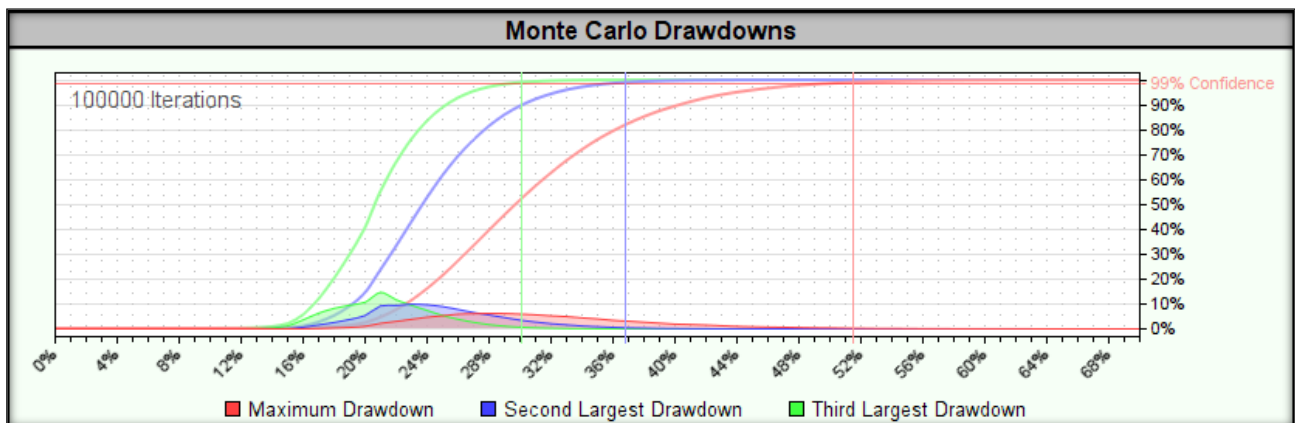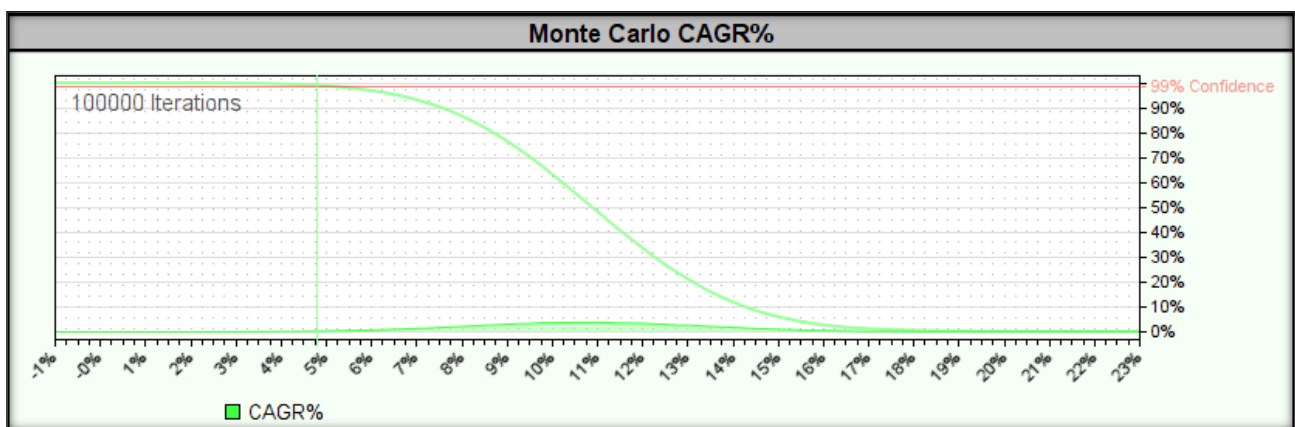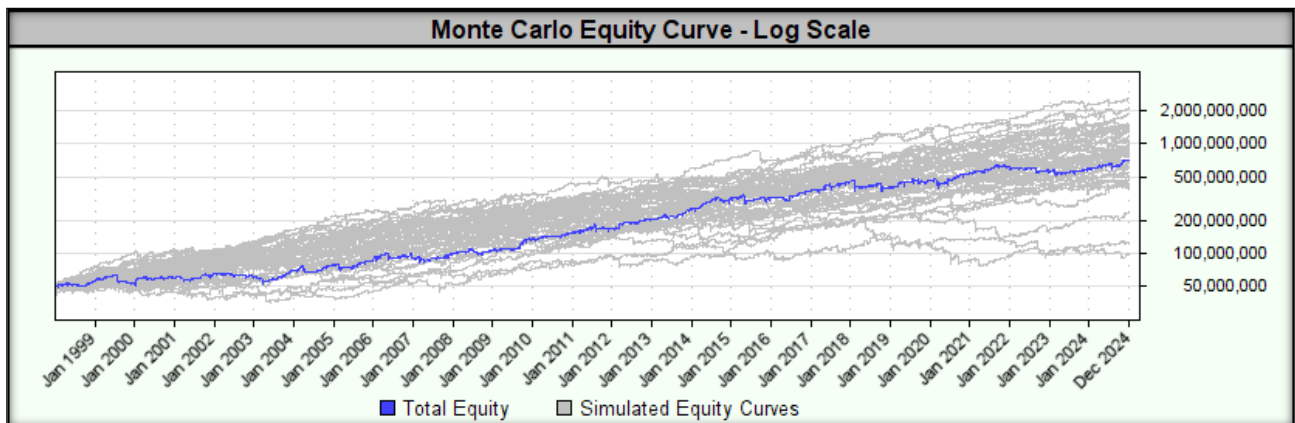
- **CAGR%** – In 99% of simulations achieved **a rate of return equal to or higher than 4.75%.**
- **Drawdown** – in 99% of simulations, **drawdown equal to or lower than 51.5% was achieved.** For parameters optimized on in-sample data, drawdown was 21.4%.

The strategy stability criteria **were met,** as **the drawdown** in **the Monte Carlo simulation** did not exceed **250% of the drawdown** value from tests on optimized parameters. Moreover, the **MAR indicator** remained positive in **99%** of tests, which was also a condition for the strategy stability.

Now that we know the strategy is **stable** across **wide data ranges** and **a changing environment,** it's time to test its **stability** over **different time periods.**

3. Stability over a moving time window

Rolling window stability testing involves **evaluating one-year and three-year returns in time windows that move one year** apart (for both in-sample and out-of-sample data). This process involves **applying strategy parameters optimized for the in-sample data,** setting a one-year or three-year trading window, and moving it forward by one year.

We then analyze what portion of these one- and three-year periods showed positive returns. **A strategy considered stable (robust) should achieve profitable results in at least 70% of the one- and three-year periods.**

For data covering the period from **01/01/1998 to 31/12/2024, testing of optimized parameters** was performed on **a moving data window.**

Two variants of test windows were tested:

- **Annual testing window (365 days),** tested **every 365 days** – this means that **we measure the annual rate of return every year.**
- **Three-year testing window (1095 days),** tested **every 365 days** – this means **we measure a three-year rate of return every year.**

A one-year (365/365) testing window are shown below.

/	Test Start Date	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF	Expectancy
1	19980101	$55,327,945.21	10.66%	1.49	1.50	2.00	7.1%	6.7	33	9.86	4.03	1.82	0.00
2	19990101	$47,712,161.56	-4.59%	-0.26	-0.25	NA	17.5%	5.6	32	-14.87	-9.97	0.86	0.00
3	20000101	$57,164,971.87	14.51%	1.78	1.08	NA	8.1%	9.0	39	12.09	3.82	1.92	0.00
4	20010101	$53,952,196.39	7.91%	0.88	0.61	2.00	9.0%	6.5	33	13.68	7.51	1.45	0.00
5	20020101	$45,989,574.33	-8.03%	-0.81	-1.12	-2.00	10.0%	11.5	26	-12.70	-6.00	0.54	0.00
6	20030101	$56,433,373.55	12.88%	0.80	1.02	2.00	16.1%	8.7	40	36.75	14.46	1.80	0.00
7	20040101	$58,251,397.33	16.51%	1.27	1.05	NA	13.0%	8.8	44	11.64	6.68	1.83	0.00
8	20050101	$53,043,754.27	6.16%	0.48	0.55	NA	12.7%	6.5	48	20.60	13.65	1.30	0.00
9	20060101	$51,603,982.22	3.22%	0.25	0.27	1.99	13.0%	8.0	48	7.48	3.82	1.16	0.00
10	20070101	$57,151,043.67	14.31%	1.15	1.19	2.00	12.4%	8.0	43	23.11	9.87	1.86	0.00
11	20080101	$53,044,832.47	6.09%	0.52	0.60	NA	11.7%	7.0	29	4.90	2.42	1.40	0.00
12	20090101	$63,716,007.60	27.45%	5.35	1.86	2.00	5.1%	3.0	57	111.33	29.21	3.00	0.00
13	20100101	$55,509,158.12	11.06%	1.58	1.06	NA	7.0%	2.2	43	50.00	12.81	1.78	0.00
14	20110101	$54,798,791.45	9.72%	0.63	0.70	NA	15.4%	5.1	47	17.69	9.53	1.45	0.00
15	20120101	$60,969,099.18	22.02%	4.57	2.12	NA	4.8%	1.6	43	124.50	22.64	3.31	0.00
16	20130101	$61,847,003.38	23.71%	2.36	1.93	2.00	10.1%	4.8	40	66.04	19.56	3.21	0.00
17	20140101	$63,242,737.28	26.51%	1.80	2.12	2.00	14.7%	3.9	52	74.47	26.20	2.52	0.00
18	20150101	$50,091,275.83	0.18%	0.01	0.07	2.00	16.9%	8.4	47	-4.48	-3.26	1.04	0.00
19	20160101	$57,878,346.51	15.81%	2.13	1.28	NA	7.4%	3.2	39	101.43	18.29	2.12	0.00
20	20170101	$59,753,944.43	19.58%	1.95	1.60	2.01	10.1%	3.4	51	44.35	20.47	1.96	0.00
21	20180101	$44,823,789.03	-10.36%	-0.50	-0.57	-2.00	20.6%	11.0	36	-11.14	-6.65	0.64	0.00
22	20190101	$57,832,212.55	15.68%	1.63	1.20	2.00	9.6%	3.8	45	33.05	12.21	2.02	0.00
23	20200101	$58,323,480.24	16.66%	0.84	1.29	NA	19.8%	5.7	47	37.85	21.44	1.90	0.00
24	20210101	$55,610,000.34	11.26%	1.48	1.16	NA	7.6%	4.0	42	49.70	20.51	1.52	0.00
25	20220101	$46,753,195.00	-6.57%	-0.62	-0.80	NA	10.6%	4.8	20	-18.15	-5.84	0.60	0.00
26	20230101	$52,274,945.97	4.57%	0.45	0.46	2.01	10.1%	9.2	35	12.58	3.97	1.33	0.00
27	20240101	$59,908,175.10	19.83%	1.81	1.79	NA	10.9%	4.0	53	36.46	15.00	2.26	0.00

A three-year testing window (1095/365) are shown below.

/	Test Start Date	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF	Expectancy	^
1	19980101	$59,385,454.74	5.92%	0.28	0.56	0.77	20.8%	17.5	104	1.91	5.87	1.35	0.00	
2	19990101	$57,891,246.52	5.01%	0.24	0.43	0.70	20.8%	27.0	104	0.76	2.12	1.28	0.00	
3	20000101	$56,732,518.17	4.31%	0.43	0.41	0.46	10.0%	17.2	98	0.95	3.38	1.28	0.00	
4	20010101	$57,171,464.32	4.57%	0.21	0.45	0.53	21.4%	22.2	98	0.05	0.20	1.30	0.00	
5	20020101	$61,728,496.87	7.28%	0.34	0.63	0.65	21.4%	22.2	109	1.67	6.30	1.45	0.00	
6	20030101	$70,269,718.40	12.03%	0.75	0.91	3.02	16.1%	8.8	132	4.08	14.18	1.63	0.00	
7	20040101	$66,311,458.86	9.89%	0.76	0.70	2.14	13.0%	8.8	139	3.99	13.63	1.46	0.00	
8	20050101	$62,195,108.49	7.57%	0.42	0.59	2.09	18.0%	19.9	138	2.18	7.72	1.36	0.00	
9	20060101	$60,254,802.19	6.43%	0.36	0.54	2.30	18.0%	19.9	120	1.43	4.75	1.33	0.00	
10	20070101	$77,270,892.23	15.63%	1.26	1.28	1.78	12.4%	8.0	129	7.37	13.17	2.01	0.00	
11	20080101	$75,138,041.08	14.55%	1.25	1.23	1.60	11.7%	7.2	129	12.83	17.34	2.00	0.00	
12	20090101	$79,213,350.79	16.62%	1.08	1.25	2.21	15.4%	5.1	147	15.41	19.58	2.03	0.00	
13	20100101	$75,699,126.45	14.84%	0.97	1.23	2.98	15.4%	7.4	133	10.79	15.26	2.01	0.00	
14	20110101	$82,670,138.16	18.30%	1.19	1.47	2.91	15.4%	7.4	130	9.08	15.32	2.29	0.00	
15	20120101	$95,402,868.17	24.07%	1.64	2.13	12.83	14.7%	4.8	135	20.31	23.75	2.92	0.00	
16	20130101	$78,391,543.19	16.18%	0.96	1.39	1.29	16.9%	8.4	139	7.22	19.56	1.90	0.00	
17	20140101	$73,347,663.74	13.65%	0.81	1.18	1.26	16.9%	16.5	138	2.97	8.04	1.72	0.00	
18	20150101	$69,907,725.50	11.85%	0.70	1.04	1.36	16.9%	16.5	135	4.86	13.34	1.61	0.00	
19	20160101	$62,526,619.77	7.74%	0.38	0.61	0.57	20.6%	11.7	124	4.65	11.34	1.42	0.00	
20	20170101	$61,918,362.20	7.40%	0.36	0.58	0.61	20.6%	18.2	132	1.22	4.44	1.39	0.00	
21	20180101	$60,578,946.36	6.61%	0.32	0.52	0.53	20.6%	17.4	128	1.77	7.34	1.36	0.00	
22	20190101	$75,181,175.91	14.57%	0.74	1.24	6.03	19.8%	5.7	134	7.39	15.87	1.79	0.00	
23	20200101	$59,726,895.92	6.11%	0.31	0.61	0.58	19.8%	16.0	110	3.58	10.83	1.34	0.00	
24	20210101	$54,887,555.25	3.16%	0.16	0.36	0.43	20.2%	28.1	98	-0.73	-2.08	1.21	0.00	
25	20220101	$60,056,971.84	6.32%	0.44	0.65	0.59	14.5%	16.4	108	1.85	4.59	1.46	0.00	

In both cases, **success** is completing at least **70% of the periods** (both **365-day** and **1095-day) with positive returns.**

- **For the one-year test window (365/365): 23 out of 27 periods** ended with a positive rate of return (**85%**).
- **For the three-year test window (1095/365): 25 out of 25 periods** ended with a positive rate of return (**100%**).

Thus, **the test of the strategy's stability on a moving data window was passed.**

4. **Long/short stability**

In the case of many instruments, markets have **a natural tendency** to move in an upward direction (so-called **Long Bias)**, which makes investing in upside scenarios often easier than betting on downside. **Optimizing a strategy** for a downside scenario, which is usually implied by the data used for optimization, can lead to **problems** when markets enter **a long-term downward trend.** In such conditions, the strategy can generate **significant losses.**

To check if **a strategy** is prone to **Long Bias** or (less often) **Short Bias,** you need to look at **the distribution of historical** buys and sells. Ideally, this distribution should be around **50%/50%.** However, if one side is significantly favored (e.g. **70%/30%)**, the strategy may be **unstable** in a real market environment.

A strategy considered stable (robust) should show a maximum of **60% tendency (bias)** in one direction.

In the case of the 2-RSI v.2 strategy, testing **long/short stability** does not make sense, because **the strategy** assumes opening **only long positions.**

5. **Stability in the portfolio of financial instruments**

In this step, we want to examine **how the strategy's performance is distributed across different instruments in the portfolio.** Our goal is **to avoid a situation where the strategy's positive performance comes only from a small group of exceptionally well-performing instruments.**

To check this, for **both in-sample and out-of-sample data,** we analyze **what percentage of instruments achieved a profit factor value above 1** (which means a positive contribution to the strategy's result).

We expect that:

- **For the portfolio with the highest MAR** (obtained on IS data), the percentage of instruments with **profit factor > 1 will be at least 80%.**
- **For the portfolio with the lowest MAR** (obtained on IS data), the percentage of instruments with **profit factor > 1 will be at least 70%.**

If the above conditions are met, **we can consider that the strategy is stable on a wide basket of financial instruments.**

The profit factor for the instruments included in the portfolio using the highest MAR is presented below.

Instrument Performance Summary														
Symbol	Wins	%	Losses	%	Trades	Win Months	%	Loss Months	%	Avg. Win %	Avg. Loss %	Avg. Trade %	%	Profit Factor
DX	73	71.6%	29	28.4%	102	285	88.0%	39	12.0%	0.87%	1.40%	0.23%		1.57
EBL	71	62.8%	42	37.2%	113	266	82.1%	58	17.9%	0.92%	1.73%	-0.07%		0.90
ES	97	77.0%	29	23.0%	126	286	88.3%	38	11.7%	1.02%	1.15%	0.52%		2.98
FDX	84	75.0%	28	25.0%	112	288	88.9%	36	11.1%	0.98%	1.04%	0.47%		2.81
FLG	72	63.2%	42	36.8%	114	269	83.0%	55	17.0%	0.95%	1.49%	0.05%		1.09
GC	60	63.2%	35	36.8%	95	279	86.1%	45	13.9%	0.83%	1.35%	0.03%		1.06
HSI	78	68.4%	36	31.6%	114	277	85.5%	47	14.5%	1.16%	1.73%	0.25%		1.45
NIY	65	73.9%	23	26.1%	88	290	89.5%	34	10.5%	1.04%	1.82%	0.29%		1.62
NQ	97	72.4%	37	27.6%	134	280	86.4%	44	13.6%	1.04%	1.00%	0.48%		2.72
TY	73	65.8%	38	34.2%	111	278	85.8%	46	14.2%	0.91%	1.17%	0.19%		1.49

The profit factor for the instruments included in the portfolio **using the lowest MAR** is presented below.

Instrument Performance Summary														
Symbol	Wins	%	Losses	%	Trades	Win Months	%	Loss Months	%	Avg. Win %	Avg. Loss %	Avg. Trade %	%	Profit Factor
DX	45	64.3%	25	35.7%	70	295	91.0%	29	9.0%	0.72%	1.25%	0.02%		1.04
EBL	42	56.0%	33	44.0%	75	286	88.3%	38	11.7%	0.80%	1.44%	-0.19%		0.71
ES	75	75.8%	24	24.2%	99	292	90.1%	32	9.9%	1.04%	1.12%	0.52%		2.91
FDX	54	76.1%	17	23.9%	71	300	92.6%	24	7.4%	0.87%	1.09%	0.40%		2.55
FLG	45	56.2%	35	43.8%	80	279	86.1%	45	13.9%	0.85%	1.17%	-0.03%		0.94
GC	37	61.7%	23	38.3%	60	298	92.0%	26	8.0%	0.79%	1.06%	0.08%		1.21
HSI	54	63.5%	31	36.5%	85	289	89.2%	35	10.8%	1.15%	1.77%	0.08%		1.13
NIY	42	66.7%	21	33.3%	63	294	90.7%	30	9.3%	1.05%	1.97%	0.04%		1.06
NQ	73	76.0%	23	24.0%	96	299	92.3%	25	7.7%	0.94%	0.97%	0.48%		3.08
TY	44	62.9%	26	37.1%	70	297	91.7%	27	8.3%	0.76%	1.14%	0.06%		1.14

For our tested strategy:

- **the portfolio with the highest MAR** (obtained on IS data) has a percentage of instruments with **profit factor > 1 at the level of 90%.**
- **the portfolio with the lowest MAR** (obtained on IS data) has a percentage of instruments with **profit factor > 1 at the level of 80%.**

Thus, **the test of the stability of the strategy on the portfolio of financial instruments was passed.**

6. **Money Management (Position Sizing)**

Once **stability testing is complete,** we now know **what range of results we can expect from our strategy,** and more importantly – **what amount of capital loss (drawdown).**

Previous tests show that:

- **In-sample drawdown** for optimized parameters was **20.6%.**
- **in-sample and out-of-sample drawdown** for the optimized parameters was **21.4%.**
- **The highest in-sample drawdown** for the tested parameter range was **45.5 %.**
- **The largest out-of-sample drawdown** for the tested parameter range was **29.4 %.**
- **Drawdown in 99% of the Monte Carlo simulations** was equal to or lower than **51.5 %.**

Our investment strategy was tested assuming that **the risk of a single position (two units in total) is 2.0% of the total capital, with a hypothetical stop loss order placed 2 x ATR (40 days) away from the position opening point.**

With the above information in mind, you should consider **whether the risk of a single position is acceptable, taking into account the possible drawdown.**

At this stage, **this position size is acceptable to me personally, but I will make the final decision after conducting Walk-Forward Analysis tests.**

To summarize, at this point <u>**the strategy has been optimized to the following parameters:**</u>

- <u>**Moving Average Length (SMA-L):**</u> <u>100;</u>
- <u>**Moving Average Length (SMA-S):**</u> <u>6;</u>
- <u>**RSI length:**</u> <u>3;</u>
- <u>**RSI Entry Threshold:**</u> <u>14;</u>
- <u>**Stop loss:**</u> <u>none;</u>
- <u>**Method of opening a position:**</u> <u>at the opening price of the next day;</u>
- <u>**Position size:**</u> <u>corresponding to the risk of 2.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening position;</u>
- <u>**Position direction:**</u> <u>long positions (buy) only.</u>

7. **Strategy Risk Management**

In addition to defining **the maximum size of a single position,** we can implement additional mechanisms that **will improve risk control** in the investment strategy. Key elements include:

- **Maximum number of open positions in highly correlated instruments,**
- **Maximum number of open positions in moderately correlated instruments,**
- **Maximum number of open positions in one direction,**
- **Maximum risk value of all positions,**
- **Drawdown – position reduction mechanism.**

The optimal values for these parameters can be determined by **maximizing the MAR objective function.** However, based on experience and **awareness of the risk of** excessive **portfolio concentration in one**

direction (long/short) or **too much exposure to correlated instruments,** I adopt **certain arbitrary concentration limits.**

These are not the "best" optimal values for all market conditions – as with position size, sometimes **it is worth reducing it and sometimes increasing it.** However, the key goal is **to avoid a drawdown** that could force you **to end your strategy for financial or emotional** reasons.

Too much concentration in correlated instruments or in one market direction can undermine diversification, which is one of the strategy's key sources of advantage.

Therefore, **I assume the following concentration limits without optimization:**

- **Maximum number of open positions in highly correlated instruments: 3 positions (units),**
- **Maximum number of open positions in moderately correlated instruments: 6 positions (units),**
- **Maximum number of open positions in one direction: 12 positions (units).**

After this step, we have already **optimized all the elements of the investment strategy.** We can finally **analyze the results generated by the strategy in more detail.**

We haven't done this before because our goal **was not to optimize the parameters themselves and look for the "best" set,** but **to build a stable strategy.**

Importantly, **we will not use the parameters optimized in back-tests in the end,** because **they serve only as a reference point. The parameters used in real transactions will be determined during the Walk-Forward Analysis.**

Before we move on to this step, **let us summarize the results on the in-sample data and on the combined in-sample and out-of-sample data.**

Indicators/Measures	In-sample	In-sample & Out-of-sample
CAGR%	12.4%	10.3%
MAR Ratio	0.60	0.48
RAR%	12.7%	11.7%
R-Cubed	0.66	0.37
Robust Sharpe Ratio	1.07	0.95
Max Drawdown	20.6%	21.4%
Wins	70.7%	69.4%
Losses	29.3%	30.6%
Average Win%	0.95%	0.98%
Average Loss%	1.32%	1.39%
Win/Loss Ratio	0.72	0.68
Average Trade Duration (days)	8	8
Percent Profit Factor	1.74	1.60
SQN	-	-
Number of transactions	768	1109

Performance Curve - Log Scale with Drawdowns

Total Equity and Drawdowns

Monthly Returns

Losing Months Winning Months

Monthly Return Distribution

To summarize, at this point **the strategy has been optimized to the following parameters:**

- **Moving Average Length (SMA-L):** 100;
- **Moving Average Length (SMA-S):** 6;
- **RSI length:** 3;
- **RSI Entry Threshold:** 14;
- **Stop loss:** none;
- **Method of opening a position:** at the opening price of the next day;
- **Position size:** corresponding to the risk of 2.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening position;
- **Maximum number of open positions in different categories:**
    - **Highly correlated instruments:** 6 items (units);
    - **Moderately correlated instruments:** 12 items (units);
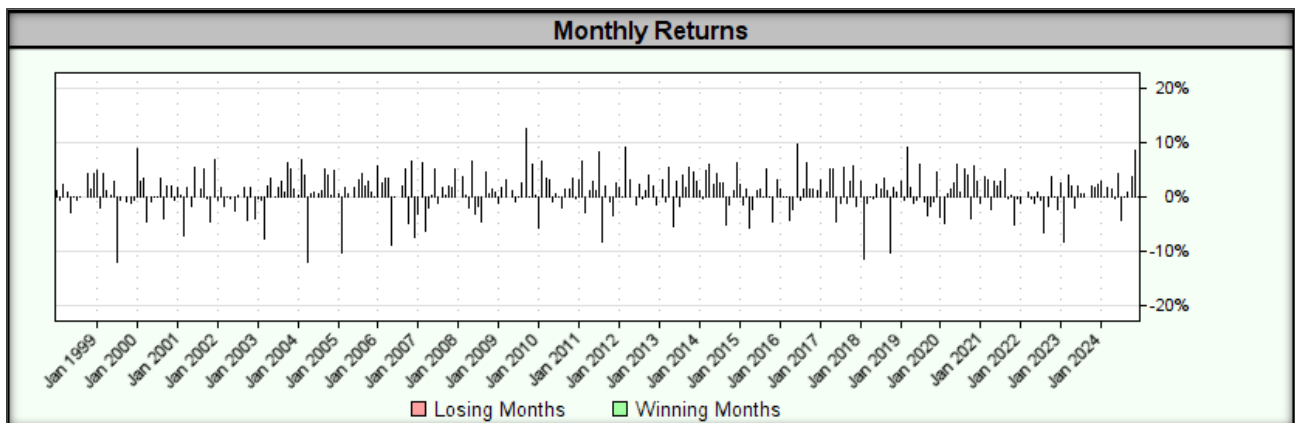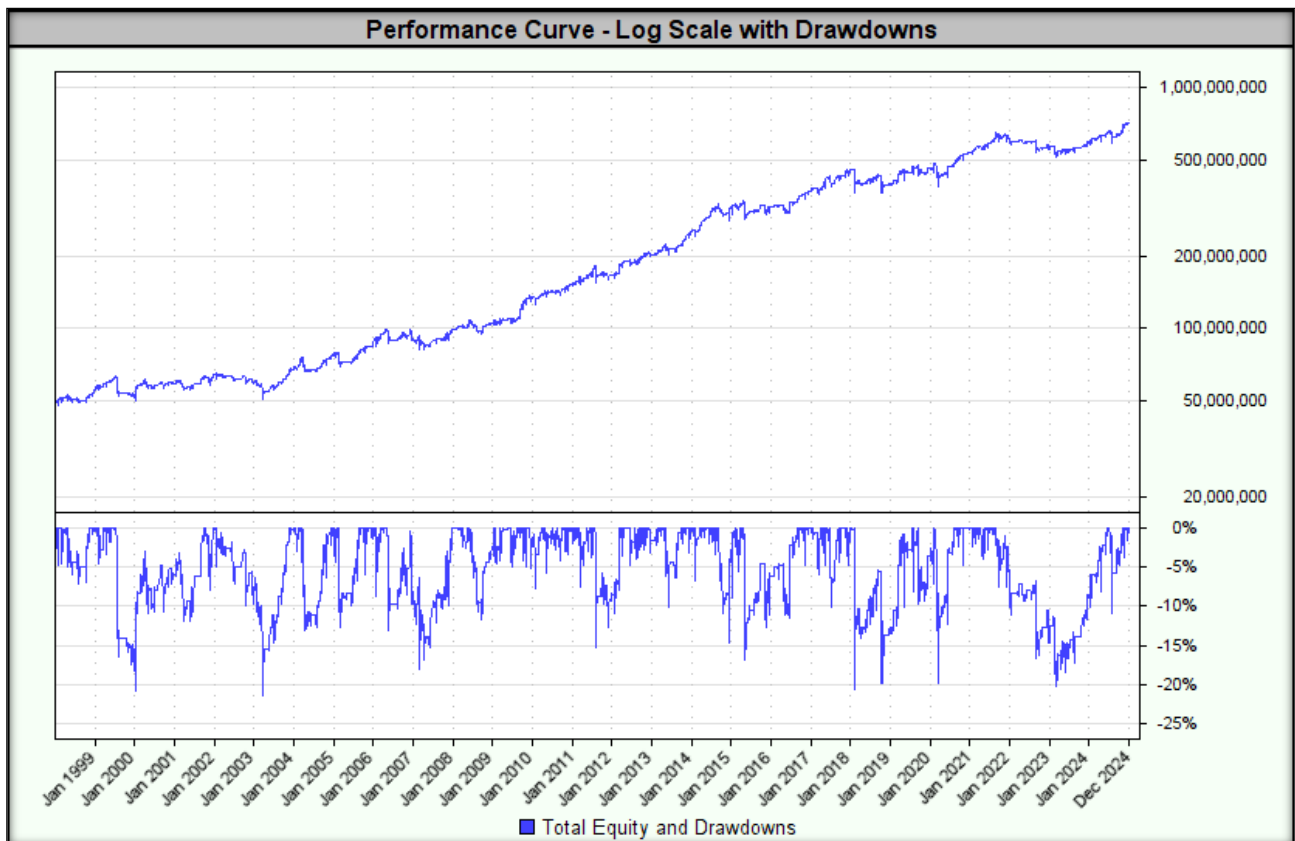   - **Maximum number of positions in one direction:** 24 positions (units);
- **Position direction:** long positions (buy) only.

Step 5: Walk-Forward Analysis

Walk-Forward Analysis (WFA) is a key tool for assessing **a strategy's ability to perform under real market conditions.** It provides **reliable measures of reward and risk** after the optimization process and allows us to answer several key questions:

1. **What rate of return can you expect from the strategy?**
   - The optimization result often overestimates the expected rate of return, which can lead to unrealistic forecasts.
   - WFA provides a more **reliable and realistic measure of return** by minimizing the impact of overfitting to historical data.
2. **What set of parameters should be used in the next period?**
   - Thanks to **WFA,** it is possible **to dynamically adjust the strategy parameters** to **the latest market changes,** increasing its adaptability.

WFA tests the strategy over multiple time periods, which helps **minimize the risk of overfitting** (overfitting the strategy to historical data). The WFA process consists of **two repeated steps:**

1. **Optimization (In-Sample):**
   - The strategy is optimized over a specific **training period** (**in-sample**).
   - In this step, parameters are adjusted to obtain **the best results.**
2. **Testing (Out-of-Sample):**
   - The strategy, using **the parameters optimized in Step 1,** is tested on **a test period** (out-of-sample).
   - This stage verifies the effectiveness of the strategy in new market conditions that **were not used** during optimization.

Walk-Forward Efficiency (WFE) is a key metric that assesses whether a strategy has the potential to perform under real market conditions. WFE compares:

- **The rate of return achieved in the in-sample window** (where parameters were optimized)
- **The rate of return in the out-of-sample window** (where the strategy was operating on unknown data)

Similarly, **for the drawdown value,** WFE checks whether the strategy does not lose significant stability outside the optimization period.

A strategy considered **stable (robust) should meet the following conditions:**

- **WFE ≥ 50% for the rate of return** – means that the strategy retains at least half of its effectiveness outside the optimization period.
- **WFE ≤ 150% for drawdown** – means that the drawdown outside the optimization period is not significantly higher than during the optimization period.

The WFA results and an assessment of the strategy's effectiveness according to the Walk-Forward Efficiency measure are presented below.

Walk-Forward Optimization (WFO) parameters:

- **Objective function:** MAR;
- **Position size:** corresponding to the risk of 2.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening position;
- **Range of optimized parameters:**
  - **Moving average length (SMA-L):** range **60-100 days (step: 2);**
  - **Moving average length (SMA-S; take profit):** range **6-9 days (step: 1);**
  - **RSI Length:** Range **2-3 days (step: 1);**
  - **RSI Entry Threshold:** range **14-22 (step: 1);**
- **Method of opening a position:** at the opening price of the next day;
- **Stop loss:** none;
- **Maximum number of open positions in different categories:**
  - **Highly correlated instruments:** 6 items (units);
  - **Moderately correlated instruments:** 12 items (units);
  - **Maximum number of positions in one direction:** 24 positions (units);
- **Position direction:** long positions only (buy);
- **Data period:** 01/01/1995 – 31/12/2024.

Below are the test results for different windows.

1. **Walk Forward Optimization: 1095 days; Walk Forward Out-of-sample: 365 days**

Below are **the results of Walk-Forward Analysis (WFA) for the 1095/365 day combination.**

Walk Forward Summary Performance						
Ending Balance	CAGR%	MAR	Annual Sharpe	Max Total Equity DD	Longest Drawdown	# Trades
609,836,520	9.70%	0.37	0.50	26.11%	55.46	1,226

Walk Forward Logarithmic Equity Curve

Walk Forward Equity Curve

Walk Forward Drawdown

Draw Down
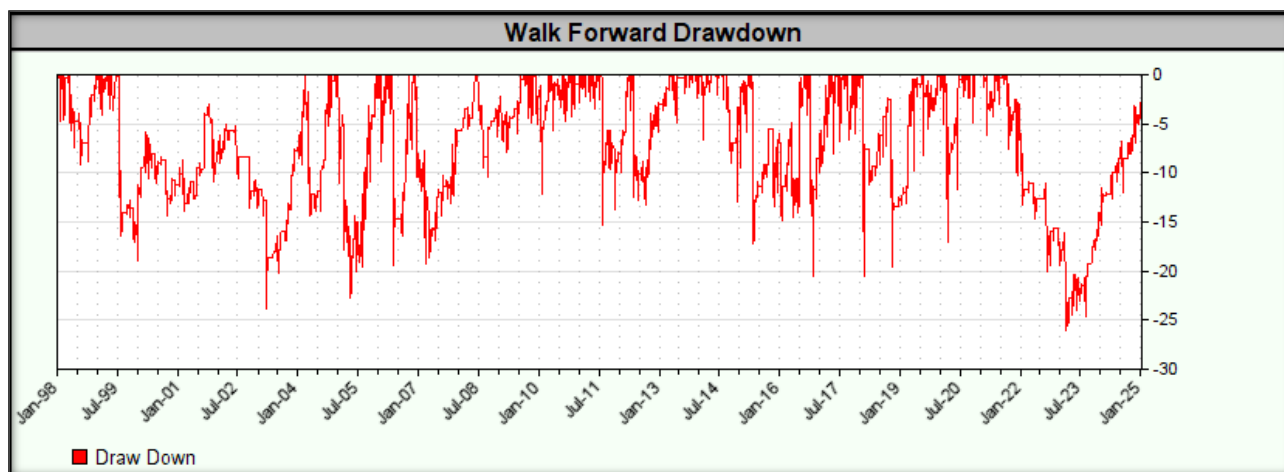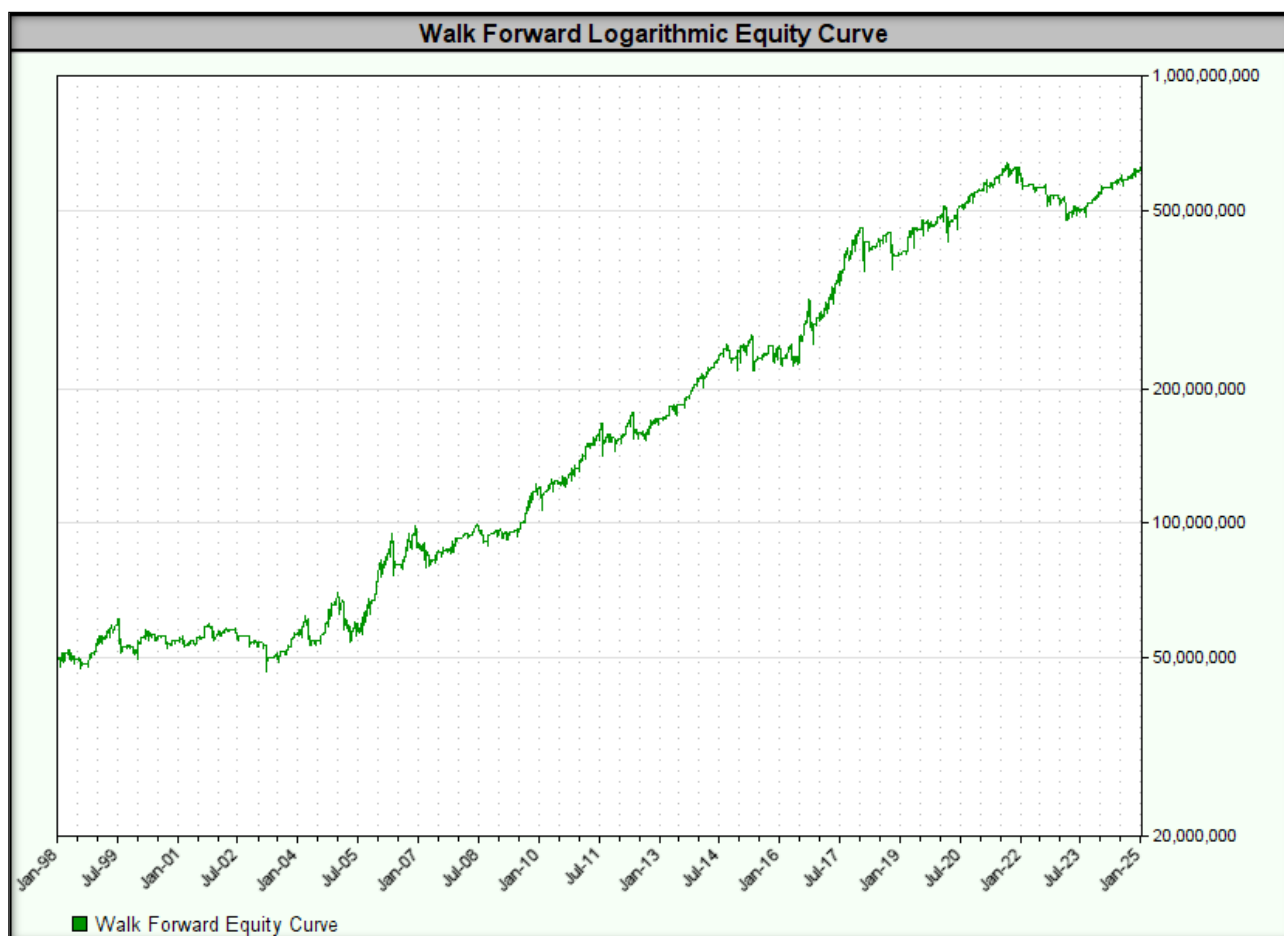
Optimization:	1095	CAGR%		Max DD		MAR	
WFA:	365	Projections	Real	Projections	Real	Projections	Real
19971231	19981230	23.3%	6.8%	7.3%	9.2%	3.17	0.74
19981231	19991230	17.5%	-4.0%	7.5%	17.0%	2.32	- 0.24
19991231	20001229	11.2%	6.4%	9.1%	8.9%	1.24	0.71
20010101	20011228	10.1%	3.6%	9.9%	8.2%	1.03	0.44

20011231	20021227	6.4%	-5.1%	9.9%	8.9%	0.65	- 0.57
20021230	20031229	9.6%	5.7%	8.9%	13.8%	1.08	0.41
20031230	20041228	11.9%	20.8%	17.7%	14.4%	0.68	1.45
20041229	20051228	19.7%	10.6%	19.4%	22.7%	1.02	0.47
20051229	20061228	25.3%	18.2%	18.2%	19.3%	1.39	0.94
20061229	20071228	12.9%	3.9%	9.5%	12.4%	1.35	0.31
20071231	20081226	13.7%	2.1%	10.8%	10.5%	1.28	0.20
20081229	20091225	10.5%	26.3%	10.8%	5.8%	0.98	4.51
20091228	20101227	26.4%	11.7%	12.4%	11.1%	2.12	1.05
20101228	20111227	19.3%	14.9%	8.1%	15.4%	2.38	0.97
20111228	20121226	19.6%	10.8%	7.8%	13.2%	2.52	0.82
20121227	20131226	15.5%	23.9%	7.7%	4.9%	2.02	4.84
20131227	20141226	19.6%	16.2%	7.8%	12.9%	2.52	1.25
20141229	20151225	25.2%	0.9%	13.4%	17.2%	1.88	0.05
20151228	20161223	29.9%	17.8%	18.0%	20.5%	1.67	0.87
20161226	20171225	30.2%	54.9%	17.5%	8.1%	1.73	6.80
20171226	20181225	14.6%	-11.0%	7.0%	20.5%	2.08	- 0.54
20181226	20191225	11.1%	21.3%	20.6%	9.5%	0.54	2.25
20191226	20201224	11.7%	15.3%	20.6%	17.1%	0.57	0.90
20201225	20211224	11.2%	10.2%	20.2%	10.3%	0.56	0.99
20211227	20221223	18.0%	-14.7%	13.6%	16.3%	1.32	- 0.90
20221226	20231222	11.5%	5.1%	20.0%	12.0%	0.57	0.43
20231225	20241223	8.4%	12.3%	10.0%	5.4%	0.85	2.27
Mean		**16.5%**	**10.6%**	**12.7%**	**12.8%**	**0.80**	**0.46**
		WFE:	**64.1%**	**WFE:**	**100.6%**	**WFE:**	**58.2%**

2. **Walk Forward Optimization: 1460 days; Walk Forward Out-of-sample: 365 days**

Below are **the results of the Walk-Forward Analysis (WFA) for the 1460/365 day combination.**

Walk Forward Summary Performance						
Ending Balance	CAGR%	MAR	Annual Sharpe	Max Total Equity DD	Longest Drawdown	# Trades
410,416,521	8.42%	0.21	0.39	39.48%	62.69	1,284

Walk Forward Logarithmic Equity Curve

■ Walk Forward Equity Curve

Walk Forward Drawdown

■ Draw Down
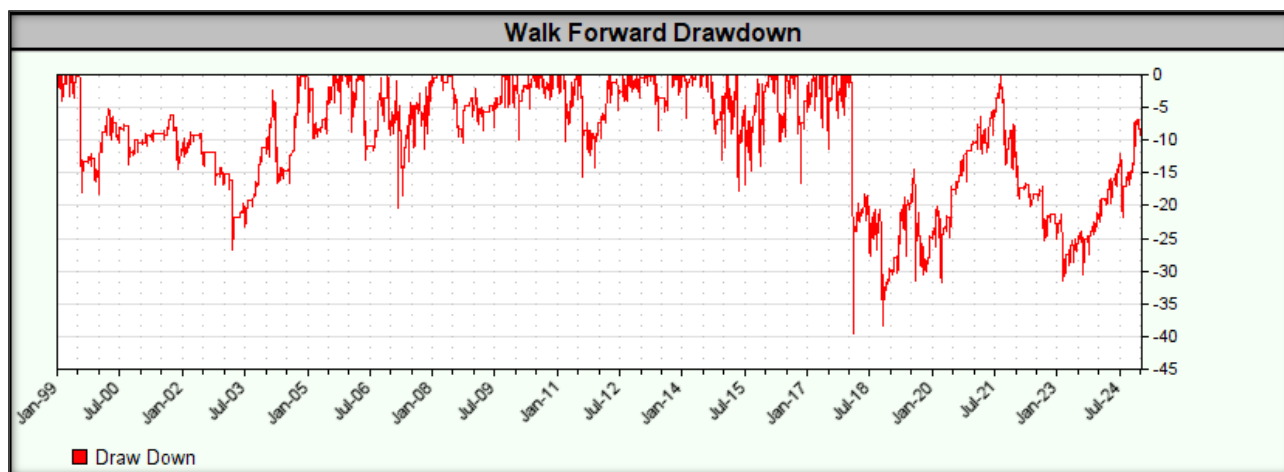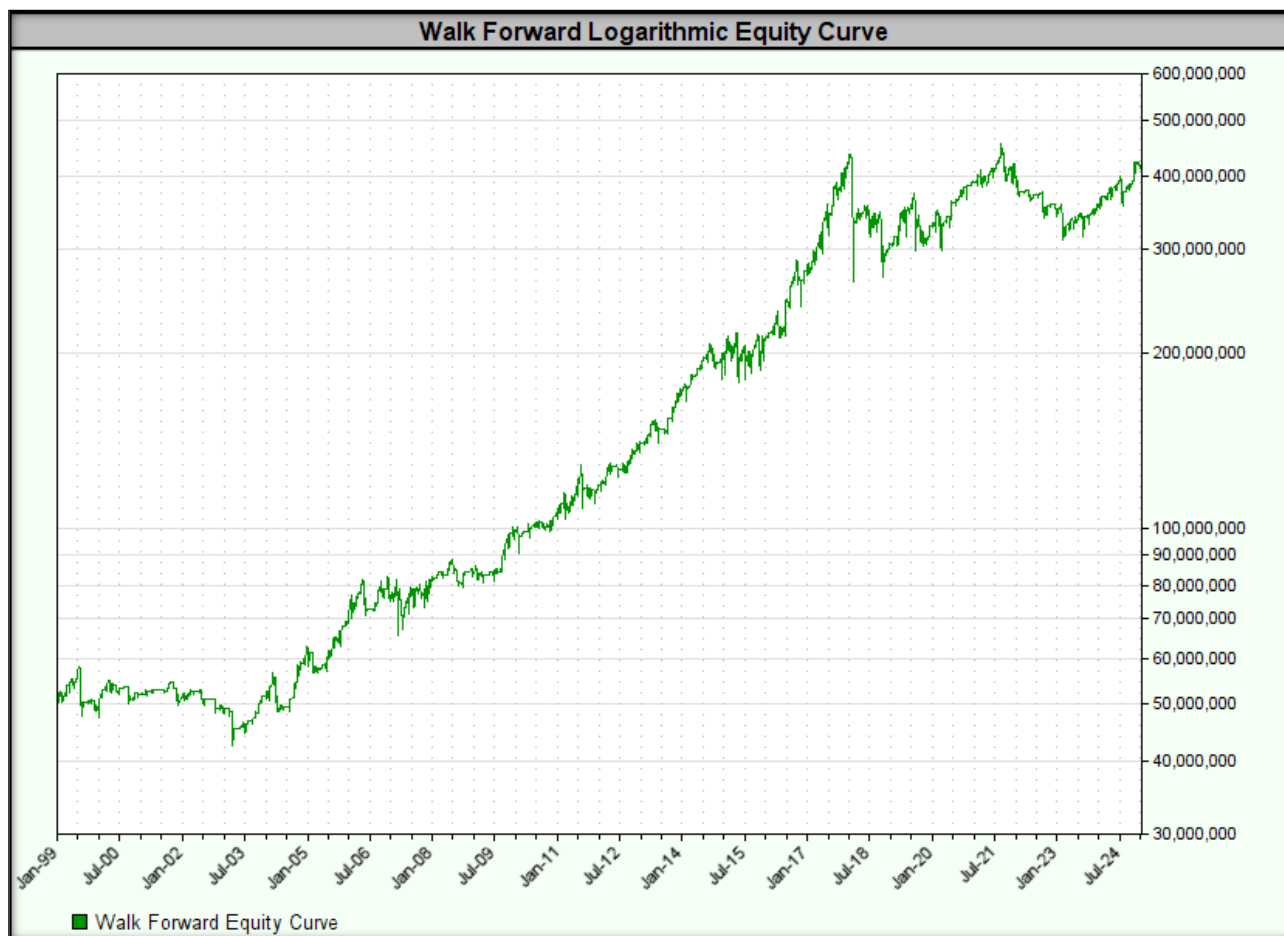
Optimization:	1460	CAGR%		Max DD		MAR	
WFA:	365	Projections	Real	Projections	Real	Projections	Real
19981231	19991230	20.1%	-2.2%	7.5%	18.0%	2.67	- 0.12
19991231	20001229	11.6%	6.4%	9.1%	8.9%	1.28	0.71
20010101	20011228	10.5%	-1.1%	9.1%	8.7%	1.16	- 0.13
20011231	20021227	8.4%	-5.1%	9.9%	8.9%	0.86	- 0.57

20021230	20031229	6.3%	5.7%	15.5%	13.8%	0.40	0.41
20031230	20041228	12.6%	18.6%	17.3%	14.4%	0.73	1.29
20041229	20051228	14.1%	14.8%	17.7%	9.8%	0.80	1.50
20051229	20061228	16.0%	8.1%	17.7%	12.9%	0.90	0.62
20061229	20071228	23.0%	7.5%	19.3%	19.6%	1.19	0.38
20071231	20081226	13.0%	3.2%	10.8%	10.5%	1.21	0.30
20081229	20091225	11.3%	17.6%	9.7%	6.5%	1.17	2.69
20091228	20101227	14.2%	7.7%	10.8%	9.7%	1.32	0.79
20101228	20111227	22.8%	11.1%	12.4%	15.7%	1.83	0.71
20111228	20121226	16.8%	16.9%	8.2%	5.5%	2.05	3.08
20121227	20131226	17.6%	25.1%	7.8%	8.6%	2.26	2.92
20131227	20141226	17.4%	16.2%	7.8%	12.9%	2.25	1.25
20141229	20151225	28.2%	5.3%	17.1%	17.7%	1.65	0.30
20151228	20161223	24.3%	31.7%	17.7%	16.6%	1.38	1.91
20161226	20171225	29.3%	52.5%	18.0%	11.4%	1.63	4.61
20171226	20181225	35.9%	-27.5%	17.5%	39.5%	2.05	- 0.70
20181226	20191225	11.8%	7.9%	28.0%	20.1%	0.42	0.39
20191226	20201224	13.6%	19.3%	20.6%	14.4%	0.66	1.34
20201225	20211224	13.4%	4.0%	20.6%	14.6%	0.65	0.27
20211227	20221223	11.0%	-15.1%	20.2%	16.7%	0.54	- 0.91
20221226	20231222	12.6%	3.3%	20.8%	13.0%	0.61	0.26
20231225	20241223	9.2%	16.1%	17.1%	10.9%	0.54	1.47
Mean		**16.3%**	**9.5%**	**14.9%**	**13.8%**	**0.58**	**0.24**
		WFE:	**58.3%**	**WFE:**	**92.7%**	**WFE:**	**41.4%**

3. **Walk Forward Optimization: 1825 days; Walk Forward Out-of-sample: 365 days**

Below are **the results of the Walk-Forward Analysis (WFA) for the 1825/365 day combination.**

Walk Forward Summary Performance						
Ending Balance	CAGR%	MAR	Annual Sharpe	Max Total Equity DD	Longest Drawdown	# Trades
375,152,341	8.38%	0.21	0.40	40.45%	48.43	1,216

Walk Forward Logarithmic Equity Curve

■ Walk Forward Equity Curve

Walk Forward Drawdown

■ Draw Down
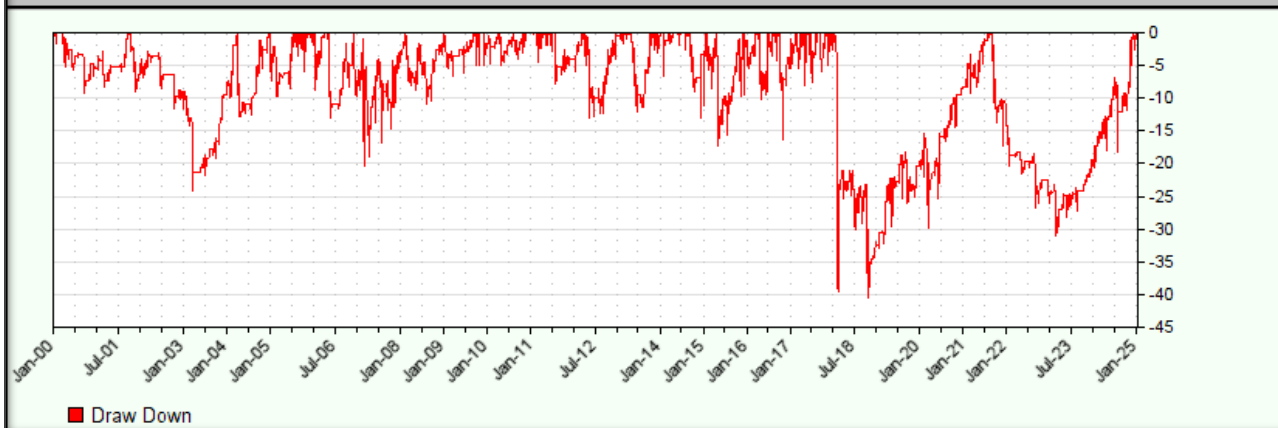
Optimization:	1825	CAGR%		Max DD		MAR	
WFA:	365	Projections	Real	Projections	Real	Projections	Real
19991231	20001229	12.7%	11.1%	9.1%	9.2%	1.40	1.20
20010101	20011228	11.3%	-0.6%	9.2%	8.7%	1.23	- 0.07
20011231	20021227	9.4%	-5.1%	9.9%	8.9%	0.95	- 0.57
20021230	20031229	5.6%	1.3%	10.9%	16.7%	0.51	0.08

20031230	20041228	7.1%	11.5%	17.4%	12.9%	0.41	0.89
20041229	20051228	13.8%	18.2%	17.3%	9.8%	0.80	1.85
20051229	20061228	14.0%	3.2%	17.3%	12.9%	0.81	0.25
20061229	20071228	17.8%	4.5%	20.9%	19.6%	0.85	0.23
20071231	20081226	21.3%	2.6%	21.5%	10.7%	0.99	0.24
20081229	20091225	11.3%	17.6%	10.9%	6.5%	1.04	2.69
20091228	20101227	12.5%	6.9%	9.7%	4.9%	1.29	1.41
20101228	20111227	12.9%	9.6%	10.8%	7.7%	1.20	1.24
20111228	20121226	18.0%	10.1%	11.7%	13.1%	1.53	0.77
20121227	20131226	16.8%	16.9%	8.2%	12.0%	2.05	1.40
20131227	20141226	18.4%	16.2%	7.8%	12.9%	2.37	1.25
20141229	20151225	28.5%	8.2%	17.7%	17.2%	1.61	0.47
20151228	20161223	23.9%	29.8%	18.0%	16.4%	1.33	1.82
20161226	20171225	25.7%	45.4%	17.7%	8.1%	1.45	5.63
20171226	20181225	33.8%	-29.2%	18.0%	40.4%	1.88	- 0.72
20181226	20191225	12.4%	18.2%	20.6%	9.6%	0.60	1.89
20191226	20201224	10.8%	15.3%	20.6%	17.1%	0.52	0.90
20201225	20211224	14.7%	4.5%	20.6%	17.2%	0.71	0.26
20211227	20221223	12.7%	-15.0%	20.9%	16.5%	0.61	- 0.91
20221226	20231222	5.4%	7.7%	20.6%	10.1%	0.26	0.76
20231225	20241223	11.7%	24.0%	22.2%	12.4%	0.53	1.94
Mean		**15.3%**	**9.3%**	**15.6%**	**13.3%**	**0.69**	**0.23**
		WFE:	**60.9%**	**WFE:**	**85.2%**	**WFE:**	**33.4%**

4. **Walk Forward Optimization: 1644 days; Walk Forward Out-of-sample: 548 days**

Below are **the results of Walk-Forward Analysis (WFA) for the 1644/548 day combination.**
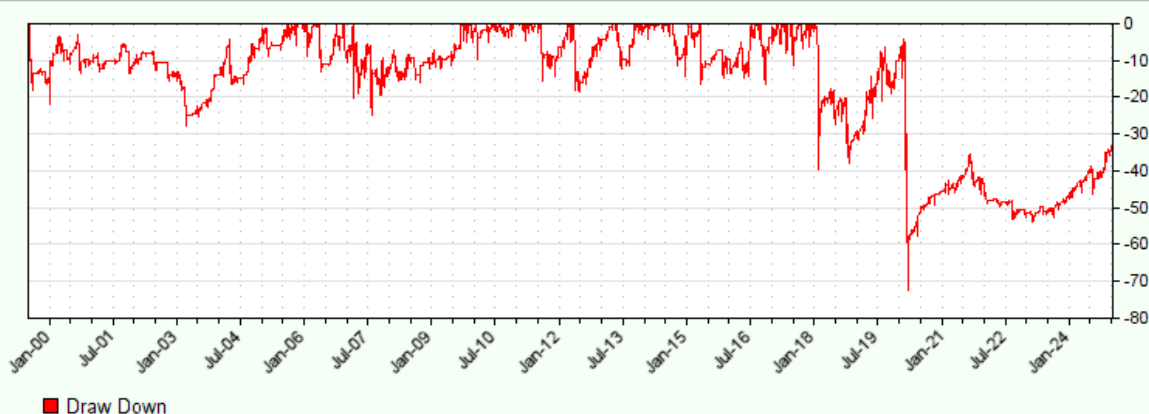
Walk Forward Summary Performance						
Ending Balance	CAGR%	MAR	Annual Sharpe	Max Total Equity DD	Longest Drawdown	# Trades
170,452,603	4.92%	0.07	0.19	72.24%	84.01	1,332

Walk Forward Logarithmic Equity Curve

■ Walk Forward Equity Curve

Walk Forward Drawdown

■ Draw Down

Optimization:	1644	CAGR%		Max DD		MAR	
WFA:	548	Projections	Real	Projections	Real	Projections	Real
19990705	20001229	21.5%	-6.7%	7.5%	21.9%	2.85	- 0.30
20010101	20020702	10.6%	-1.4%	9.2%	8.7%	1.15	- 0.16
20020703	20040101	7.0%	-1.2%	9.9%	19.0%	0.71	- 0.06
20040102	20050701	6.2%	7.0%	17.4%	12.9%	0.36	0.54

20050704	20070101	11.7%	17.6%	17.7%	12.9%	0.67	1.36
20070102	20080702	22.0%	-2.1%	21.0%	24.3%	1.05	- 0.09
20080703	20100101	12.5%	14.6%	10.8%	7.5%	1.16	1.95
20100104	20110701	15.8%	10.6%	10.8%	9.7%	1.47	1.09
20110704	20130101	21.9%	10.9%	12.4%	18.6%	1.76	0.59
20130102	20140703	17.2%	22.6%	8.2%	12.0%	2.09	1.88
20140704	20160101	18.6%	-1.7%	7.8%	16.6%	2.40	- 0.11
20160104	20170703	26.6%	30.7%	18.0%	16.4%	1.48	1.87
20170704	20190102	30.4%	-3.8%	18.0%	39.5%	1.69	- 0.10
20190103	20200703	18.0%	-20.8%	39.5%	71.0%	0.46	- 0.29
20200706	20211231	14.3%	7.5%	20.6%	17.2%	0.69	0.43
20220103	20230704	11.4%	-7.6%	20.9%	17.5%	0.55	- 0.43
20230705	20250102	13.7%	21.1%	27.2%	12.3%	0.50	1.71
Mean		**16.4%**	**5.7%**	**16.3%**	**19.9%**	**0.42**	**0.08**
	WFE:	**34.8%**	WFE:	**122.2%**	WFE:	**19.4%**	

5. **Walk Forward Optimization: 1918 days; Walk Forward Out-of-sample: 548 days**

Below are **the results of Walk-Forward Analysis (WFA) for the 1918/548 day combination.**
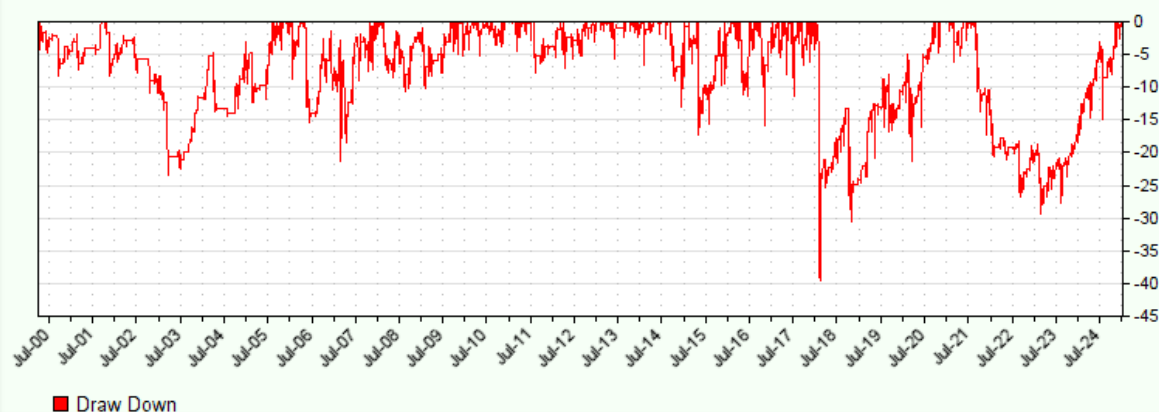
Walk Forward Summary Performance						
Ending Balance	CAGR%	MAR	Annual Sharpe	Max Total Equity DD	Longest Drawdown	# Trades
424,647,562	9.02%	0.23	0.44	39.47%	45.73	1,135

Walk Forward Logarithmic Equity Curve

Walk Forward Equity Curve

Walk Forward Drawdown

Draw Down

Optimization:	1918	CAGR%		Max DD		MAR	
WFA:	548	Projections	Real	Projections	Real	Projections	Real
20000403	20011001	15.4%	1.8%	9.1%	8.3%	1.70	0.21
20011002	20030402	11.2%	-14.1%	9.9%	23.6%	1.14	- 0.60
20030403	20041001	5.3%	6.6%	14.9%	10.3%	0.36	0.64
20041004	20060331	7.0%	23.3%	18.3%	9.4%	0.38	2.47

20060403	20071002	15.3%	1.1%	17.0%	21.2%	0.90	0.05
20071003	20090402	18.4%	3.9%	21.8%	10.7%	0.85	0.36
20090403	20101001	10.5%	17.5%	10.8%	5.2%	0.97	3.38
20101004	20120402	13.8%	16.2%	10.8%	7.7%	1.29	2.10
20120403	20131002	16.0%	12.3%	9.5%	7.1%	1.68	1.73
20131003	20150403	15.0%	18.4%	7.8%	12.9%	1.93	1.42
20150406	20160930	27.3%	23.0%	17.7%	17.2%	1.54	1.34
20161003	20180403	29.2%	8.6%	18.0%	39.5%	1.63	0.22
20180404	20191003	15.6%	8.2%	20.6%	19.9%	0.76	0.41
20191004	20210402	10.5%	16.1%	20.6%	17.1%	0.51	0.94
20210405	20221003	14.7%	-9.1%	20.6%	26.8%	0.71	- 0.34
20221004	20240403	10.0%	12.8%	28.0%	13.0%	0.36	0.98
20240404	20250110	12.7%	22.7%	22.2%	12.4%	0.57	1.84
Mean		**14.6%**	**10.0%**	**16.3%**	**15.4%**	**0.52**	**0.25**
		WFE:	68.3%	WFE:	94.5%	WFE:	48.5%

6. **Walk Forward Optimization: 2192 days; Walk Forward Out-of-sample: 548 days**

Below are **the results of Walk-Forward Analysis (WFA) for the 2192/548 day combination.**

Walk Forward Summary Performance						
Ending Balance	CAGR%	MAR	Annual Sharpe	Max Total Equity DD	Longest Drawdown	# Trades
365,176,872	8.63%	0.21	0.41	40.45%	42.25	1,124

Walk Forward Logarithmic Equity Curve

■ Walk Forward Equity Curve

Walk Forward Drawdown

■ Draw Down
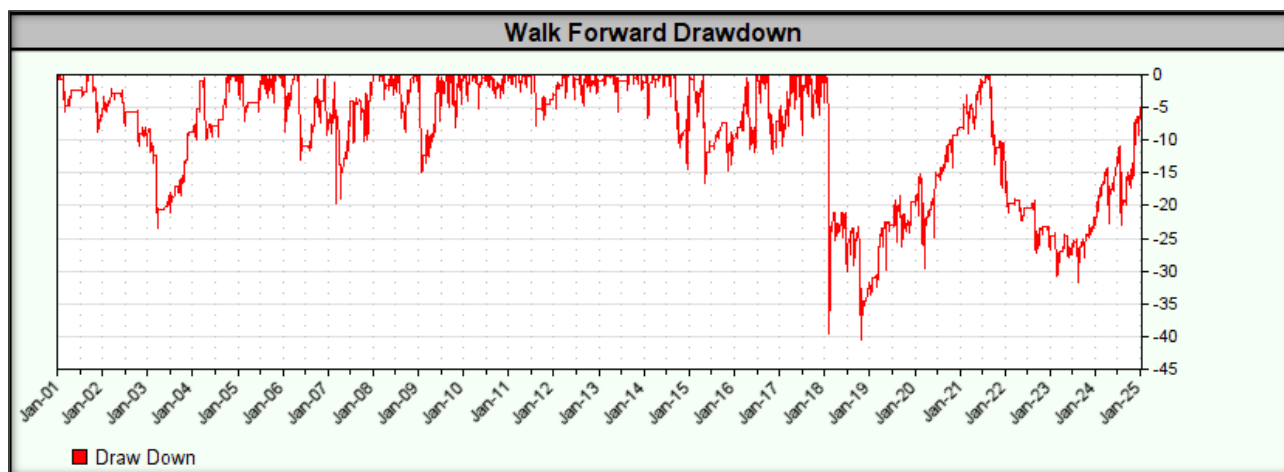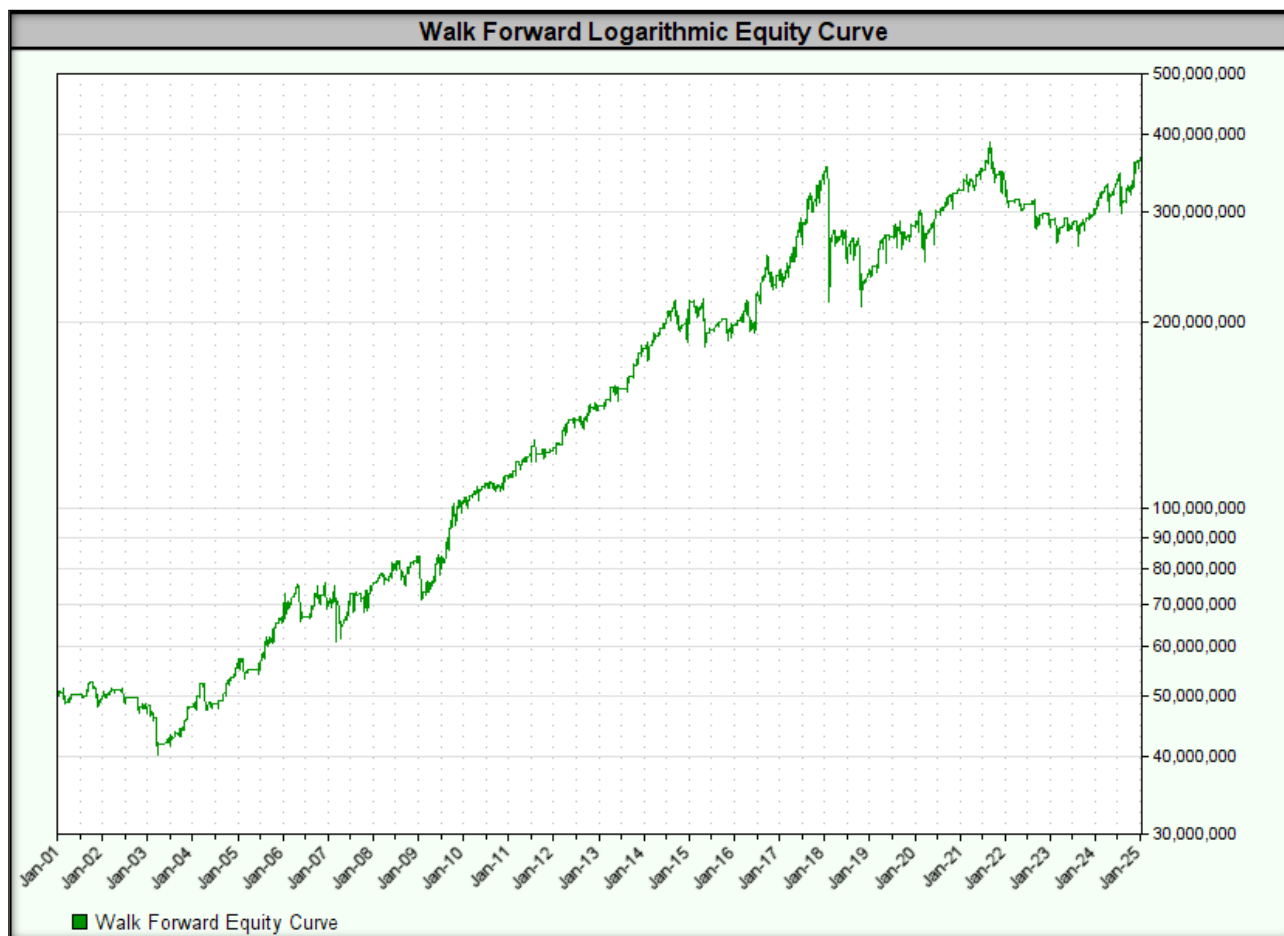
Optimization:	2192	CAGR%		Max DD		MAR	
WFA:	548	Projections	Real	Projections	Real	Projections	Real
20010101	20020702	12.4%	-1.4%	9.2%	8.7%	1.34	- 0.16
20020703	20040101	8.5%	-1.2%	9.9%	19.0%	0.86	- 0.06
20040102	20050701	7.3%	10.5%	16.6%	9.5%	0.44	1.10
20050704	20070101	7.2%	16.8%	18.3%	12.9%	0.39	1.30

20070102	20080702	13.1%	8.7%	17.7%	18.8%	0.74	0.47
20080703	20100101	16.6%	18.3%	21.0%	14.8%	0.79	1.24
20100104	20110701	12.7%	10.7%	10.8%	5.2%	1.18	2.06
20110704	20130101	13.2%	14.5%	9.7%	7.8%	1.36	1.87
20130102	20140703	15.7%	24.1%	9.5%	6.6%	1.65	3.68
20140704	20160101	17.7%	-1.7%	7.8%	16.6%	2.28	- 0.10
20160104	20170703	24.8%	23.1%	17.7%	12.0%	1.40	1.93
20170704	20190102	27.9%	-6.7%	18.0%	40.4%	1.55	- 0.17
20190103	20200703	13.4%	15.4%	20.6%	17.1%	0.65	0.90
20200706	20211231	11.5%	7.5%	20.6%	17.2%	0.56	0.44
20220103	20230704	13.4%	-9.5%	21.0%	19.7%	0.64	- 0.48
20230705	20250102	9.4%	16.5%	28.0%	13.6%	0.33	1.22
Mean		**14.1%**	**9.1%**	**16.0%**	**15.0%**	**0.50**	**0.23**
		WFE:	**64.8%**	**WFE:**	**93.7%**	**WFE:**	**44.9%**

7. Walk-Forward Analysis Summary

The above analysis shows that **regardless of the adopted combination of optimization and testing window lengths,** the **WFE results are very good:**

- **WFE for CAGR% remains around 60%-70%,** which indicates moderate performance of the strategy in real-world conditions. **One of the six tests had WFE below 50%.**
- **The WFE for drawdown remains around 90%-100%,** which means that the strategy does not lose significant stability outside of the optimization period.

Apart from the tests **for the combinations 1644/548 days and 1095/365,** the results are close to each other, which is good news.

Considering both **MAR** and **WFE,** the best results were achieved for **the combination of 1095/365 days** (1095 days of optimization, 365 days of testing). Therefore, in the next period we use the following parameters:

- **Moving Average Length (SMA-L):** 76 days;
- **Length of the moving average (SMA-S; take profit):** 6 days;
- **RSI Length:** 3 days;
- **RSI Entry Threshold:** 15.

Below is **a comparison of the WFA test results for the 1095/365 combination with the results of the strategy using the optimized parameters from Step 4:**

	WFA	Optimized
CAGR%	9.7%	10.3%
MAR Ratio	0.37	0.48
Max Drawdown	26.1%	21.4%

The results are similar at the CAGR% level, but the expected drawdown value has increased. Nevertheless, the strategy remains **stable** and **independent of overfitting to historical data.**

To sum up, after all the tests, **the strategy for 2025 has been optimized to the following parameters:**

- **Moving Average Length (SMA-L):** 76 days;
- **Length of the moving average (SMA-S; take profit):** 6 days;
- **RSI Length:** 3 days;
- **RSI Entry Threshold:** 15;
- **Stop loss:** none;
- **Method of opening a position:** at the opening price of the next day;
- **Position size:** corresponding to the risk of 2.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening position;
- **Maximum number of open positions in different categories:**
  - **Highly correlated instruments:** 6 items (units);
  - **Moderately correlated instruments:** 12 items (units);
  - **Maximum number of positions in one direction:** 24 positions (units);
- **Position direction:** long positions (buy) only.

Step 6: Using the strategy in real time

After **extensive testing, implementing a real-time** trading strategy becomes **relatively easy. Buy/sell signals and stop-loss orders are generated automatically** by the computer based on pre-established rules and formulas.

The most important element **of strategy execution** is **consistent execution of all signals, without exception. As Larry Williams noted:** *"Trading strategies work. Traders do not."*

Before making **a final decision to implement a strategy,** it is necessary to check **whether it really adds value** to the results of the entire portfolio. It does not make sense to implement a strategy that **generates similar signals** or **is characterized by a similar course of the equity curve.**

Key criteria for evaluating the strategy before implementation:

1. **Daily Return Correlation**
   - The **lower the correlation** with other strategies, the better.
   - **Optimal values:** Correlation **close to zero or negative.**
2. **Reducing maximum drawdown**
   - If adding a strategy to a portfolio results in **a lower maximum drawdown,** this is **a strong positive signal.**
3. **Objective Function Improvement (MAR)**
   - If adding a strategy causes **the MAR to increase,** this indicates that **it has added value** to the portfolio.
4. **Better results in Monte Carlo simulation**
   - Monte Carlo simulation determines the potential **maximum drawdown.**
   - If Monte Carlo results **improve** after adding a strategy, this is **a strong positive signal.**

The above elements are often interrelated – usually **all of them are met** or **none of them are met.**

Once you decide to add a strategy to your portfolio, **the question arises:** *Should you implement your strategy right away or is it better to wait?*

Some studies suggest **an incubation period** of **3-6 months,** during which:

- The strategy is **monitored** but **does not execute real transactions.**
- **Generated signals, positions and results** are observed to identify **potential anomalies.**

In our case, **the incubation period** lasts from the moment **the strategy is launched in a live environment** until **a drawdown occurs at a level of about half of the maximum drawdown** observed in historical data. **Only after reaching this threshold does the strategy begin to be used with real funds.**

Thanks to this:

- **We avoid investing real money in an untested environment.**

- **We wait for a drawdown to occur** before launching the strategy, which **reduces the risk of starting at an unfavorable moment.**

The final decision on its full implementation should be based on **thorough testing and analysis of the value added to the portfolio,** so that the strategy actually supports long-term investment goals and does not increase unnecessary risk.