Time Price Scale-In v.2

Investment Strategy Testing Summary

Time Price Strategy Scale-In (TPS) is a swing trading investment technique that uses the short-term **Relative Strength Index (RSI)** and **correction of the instrument in trend** (quotes above/below the 200-day moving average). The key assumption of the strategy is **to open long positions during a downward correction** and possibly **pyramid it when the price continues to fall,** and then close it after the price increases. **Similarly for short positions.**

Compared to the Time Price Strategy version Scale-In v.1 of this strategy, the parameters were optimized using **The Grid technique Search. It should be noted, however, that while the strategy's results on in-sample data are decent, the strategy failed the Monte Carlo test.** This means that the strategy loses its profitability and generates a significantly larger drawdown when tests are conducted under suboptimal conditions. Therefore, **it is not recommended to use it in real transactions.**

Our goal is to have a strategy that remains **profitable and effective over a wide range of parameters,** because the market is a changing organism and the optimal parameters can change over different periods. **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."

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

Time Price Strategy Scale-In (TPS) is a short-term investing approach developed by Larry Connors that **is based on market psychology** – primarily **the emotions of fear and greed** that are a natural part of investor behavior.

The strategy involves scaling positions in situations where the market is in a correction within the prevailing trend. Positions are opened gradually as prices continue to fall and the market becomes more oversold, allowing for **entry price averaging** and the potential price rebound to be exploited.

For the purposes of this test, **long and short positions** on **stock indices, bonds, gold** and **the US dollar index were used,** which allows us to assess the strategy's effectiveness across a broad spectrum of asset classes.

Key assumptions of the TPS strategy:

- **Time:** Taking advantage of specific moments in the market when emotions of fear or greed are at a high level.
- **Price:** Identifying price levels that indicate a market is oversold or overbought.
- **Scale-In:** Scaling a position by gradually adding units as the market becomes more oversold (for long positions) or more overbought (for short positions).

The strategy uses:

- **Short-term RSI** to generate entry and exit signals;
- **Long-term moving average** to determine the direction of the dominant trend;
- **Gradual building of positions in tranches:** 10%, 20%, 30%, 40% of the target position.

Characteristics of the strategy and its strengths and weaknesses:

- **Using market psychology:** The strategy is based on a deep understanding of investor emotions and their impact on price movements.
- **Scaling a position:** Scaling into a position gradually allows for better risk management and entry price averaging.
- **Simple Rules:** Clearly defined rules facilitate implementation and trading discipline.
- **Risk in strong trends:** In the event of strong, prolonged downward or upward trends, the strategy may generate losses because it assumes the market will return to the main trend.
- **Remote Stop Loss Orders:** The strategy closes all positions when the price breaches the moving average. This is an order that is activated only in the event of a dynamic trend change, and our positions may already be generating significant losses by that point.
- **Requires a lot of capital:** Scaling positions and potentially holding losing positions for long periods of time requires adequate capital.
- **Psychological Challenge:** Trading against dominant market emotions can be psychologically challenging and requires a lot of discipline.
- **Flexibility:** Can be used on various markets and financial instruments, especially stock indices.
- **Requires discipline:** The effectiveness of the strategy depends on strict adherence to the rules, which can be difficult in the face of strong market emotions.

- **Not suitable for trendless markets:** The strategy may not work effectively in consolidating markets or markets with no clear trend.

Time Price Strategy Scale-In is an investment approach that exploits **the emotions of fear and greed in the market.** By gradually scaling positions as fear (price drops/rises) increases, traders can take advantage of potential price rebounds when emotions calm down. **The strategy requires discipline and proper risk management,** but has historically proven to be highly effective, especially on stock indices.

Step 2: Define investment principles

Below is **the pseudocode** for the **Time Price Strategy Scale-In** on daily data:

1. **Calculation of indicators**
    a. **X-period RSI** (for short-term oversold market analysis);
    b. **YYY-day SMA** (to determine trend).
2. **Generating entry signals – long position:**
    a. **Entry conditions:**
        i. Price > SMA;
        ii. RSI < ZZ for 2 consecutive days.
    b. **Open 10% of the position at the open of the next day.**
    c. **Scaling a position:** On each subsequent day, if the closing price is lower than the opening price of the previous trade, do the following:
        i. First drop after entry: Buy an additional 20% of the position.
        ii. Second drop after entry: Buy an additional 30% of the position.
        iii. Third drop after entry: Buy an additional 40% of the position.

    After a total of four tranches you have 100% of your target position.
    d. **Additional conditions:** Do not make new transactions if the instrument price closes below the YYY-day SMA.
3. **Generating Exit Signals:** Close the entire position the next day on the open when the X-period RSI closes above WW.
4. **Loss Management:** Close all long positions when price breaches the moving average.
5. **Daily Monitoring:**
    a. **Calculation of indicators** – every day:
        i. Calculate X-period RSI.
        ii. Calculate the YYY-day SMA.
    b. **Checking entry conditions:** If the conditions are met, start the process of scaling the position according to the rules.
    c. **position monitoring** – if position is open:
        i. Watch the 2-period RSI.
        ii. When RSI closes above WW, close the position for the next day's open.
6. **Generating Entry Signals - Short Position:** all analogous rules also apply to short position.
7. **Additional Notes:**
    a. **Financial Instruments:** For the purposes of this test, **long and short 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.

Tests are conducted assuming that the risk of one position is **2.0% of the total capital,** with **a hypothetical stop loss order** distant from the position opening point by **2 x ATR (40 days). By one position should be**

understood a maximum of 4 units. Therefore, **the total risk of all 4 units** is **2.0% of the total capital,** with **a hypothetical stop loss order** distant from the position opening point by **2 x ATR (40 days).**

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.**

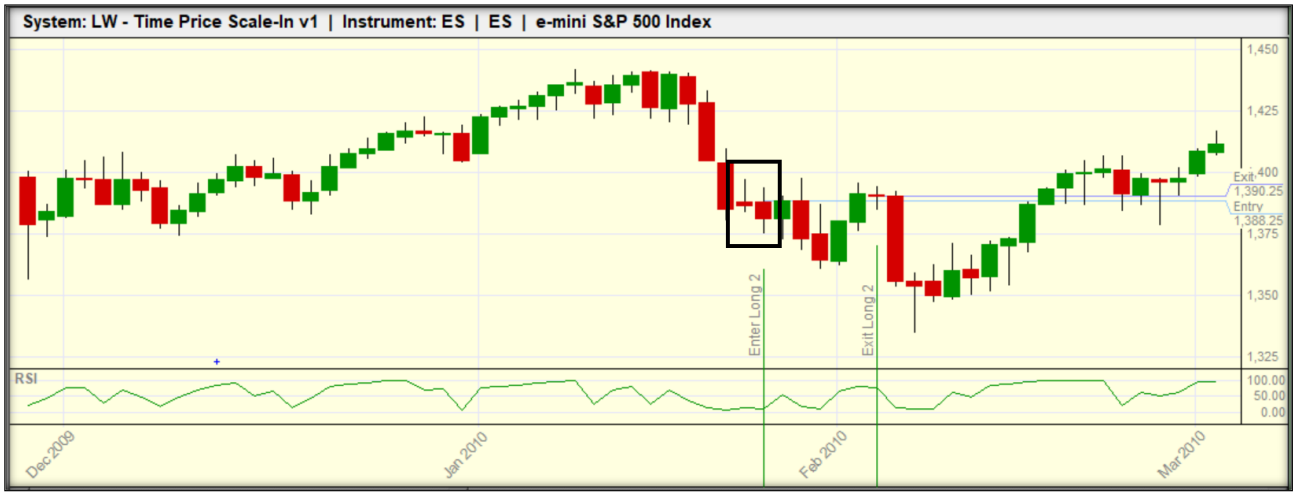
At this stage **it does not matter** whether the transactions are **profitable,** what **instrument was used** or whether they took place **recently** or **in the distant past.** The key is **to check whether the transactions are generated correctly** and in accordance with the assumptions described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

The first transaction is on a **futures contract for the S&P index.** In January 2010, the index **was in an upward trend** (price above the 200-day moving average). Therefore, we were only interested in **long positions.** To open a long position, **the RSI must be below 25 for two consecutive days.** This situation was created by the first two candles in the marked rectangle. So the next day we open a long position (the third candle in the rectangle). **The system worked correctly.**

In the context of further analysis, it should be noted that **the close of this candle falls below the opening of the position** - this will be important in the next step.

According to the strategy, the position is **increased by another unit when the closing price of the candle falls below the level at which the previous unit was opened.** And so it happened – as we indicated above, **the opening price of the first unit fell above the closing price of the day it was opened** (the first candle in the rectangle below). So **the next day, at the opening price, we buy the second unit** (the second candle in the rectangle). **The system worked correctly.**

Again, in the context of further analysis, note that **the close of this candle falls below the open of the second unit – this will be important in the next step.**



Again, we have the same situation as when opening the second unit - **the opening price of the second unit was above the closing price of the day it was open** (the first candle in the rectangle below). So **the next day, at the opening price, we buy the third unit** (the second candle in the rectangle). **The system worked correctly.**

Let's follow the further development of the situation, presented in the chart below. **The day of the opening of the third unit is the first candle in the rectangle.** We see that **the closing price falls above the opening price of the third unit, so we do nothing the next day.** In addition, **the RSI still has not reached the level of 70,** which signals the closing of the position. **The next day (the second candle in the rectangle) is strongly downward and closes significantly below the opening of the third unit.** So after such a candle **the next day we open the fourth and at the same time the last unit** (the third candle in the rectangle below). **The system worked correctly.**

It should also be noted that since the opening of the first unit, the RSI indicator has never once risen above 70, which would mean closing all positions the next day at the opening. This situation occurred only a few days after the opening of the fourth unit (the first candle in the rectangle below). Therefore, the next day (the second candle in the rectangle below) all four units were closed. **The system worked correctly.**

Once we are sure that the transactions are generated correctly, we can proceed to the first test of the strategy on the full **in-sample data set.** These tests are conducted on **the basic parameters** that were **proposed by the creator, Larry Connors.**

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.

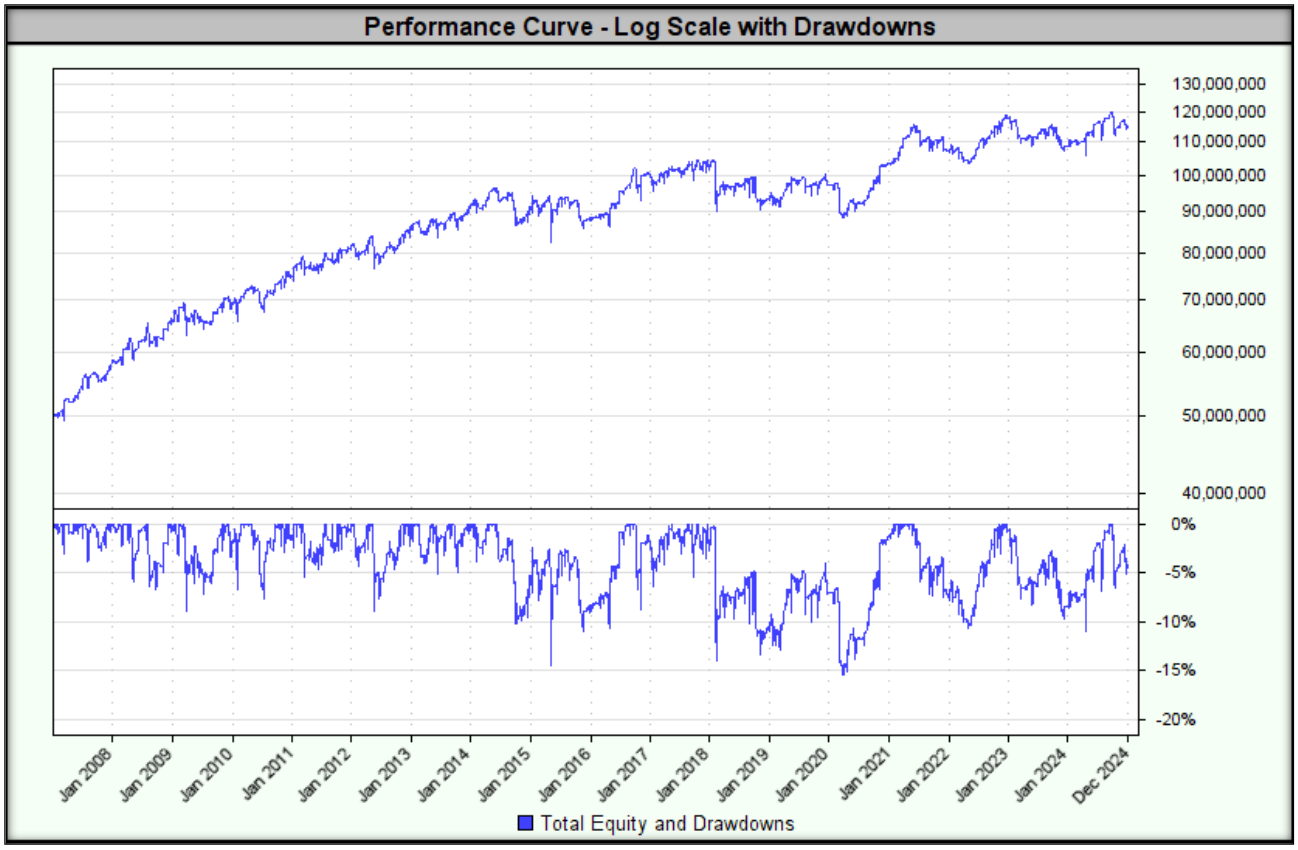
Our basic expectation is that the strategy generates **positive results,** even if they are at a low level.

Tested base parameters:

- **Length of the moving average (SMA):** 200 days;
- **RSI length: 2** days;
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;

- **RSI Entry Threshold:** 25;
- **RSI Exit Threshold:** 70;
- **Maximum number of item units:** 4;
- **Size of subsequent units:** 10%/20%/30%/40%;
- **Stop loss:** moving average;
- **Method of opening a position:** at the opening price of the next day;
- **Position sizes:** corresponding to a risk of 2.0% of total capital, with a hypothetical stop loss order placed 2 x ATR (40 days) away from the position opening position.

The test result is shown below.



Indicators/Measures	Concluding a transaction at the opening price
CAGR%	4.7%
MAR Ratio	0.31
RAR%	3.9%
R-Cubed	0.20
Robust Sharpe Ratio	0.47
Max Drawdown	15.3%
Wins	62.4%
Losses	37.6%
Average Win%	0.15%
Average Loss %	0.21%

Win/ Loss Ratio	0.75
Average Trade Duration (days)	5
Percent Profit Factor	1.24
SQN	-
Number of transactions	4734

In summary, the system works properly and generates signals as expected. Additionally, tests on basic parameters have yielded satisfactory results. We can now 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 considerations 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

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

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

- **Length of the moving average (SMA):** range **190-285 days (step: 5);**
- **RSI Lengths:** Range **2-3 days (step: 1);**
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;
- **RSI Entry Threshold:** range **20-25 (step: 1);**
- **RSI Exit Threshold:** range **55-80 (step: 2.5).**

The purpose of this test is to check whether **the strategy remains stable (robust)** over a wide range of parameters, which will allow to assess its usefulness in real market conditions. **The key evaluation criterion is that all test results show a positive MAR value, and the maximum drawdown does 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 completely rejected.

Entry Threshold range is narrower than the suggested 150 % due to the construction of the strategy based on **pyramiding positions on an increasingly large scale.** In combination with **different RSI entry threshold values (RSI Entry Threshold),** this significantly affects **the profile of the maximum drawdown. When** the **RSI Entry Threshold level is low** (e.g. **10–13**), **the probability of opening all four tranches** of the position is relatively small. On the other hand, at **higher values of this parameter** (e.g. **20–25**), **the chance of fully building the position increases significantly.** This means that the strategy – despite **a comparable MAR value**

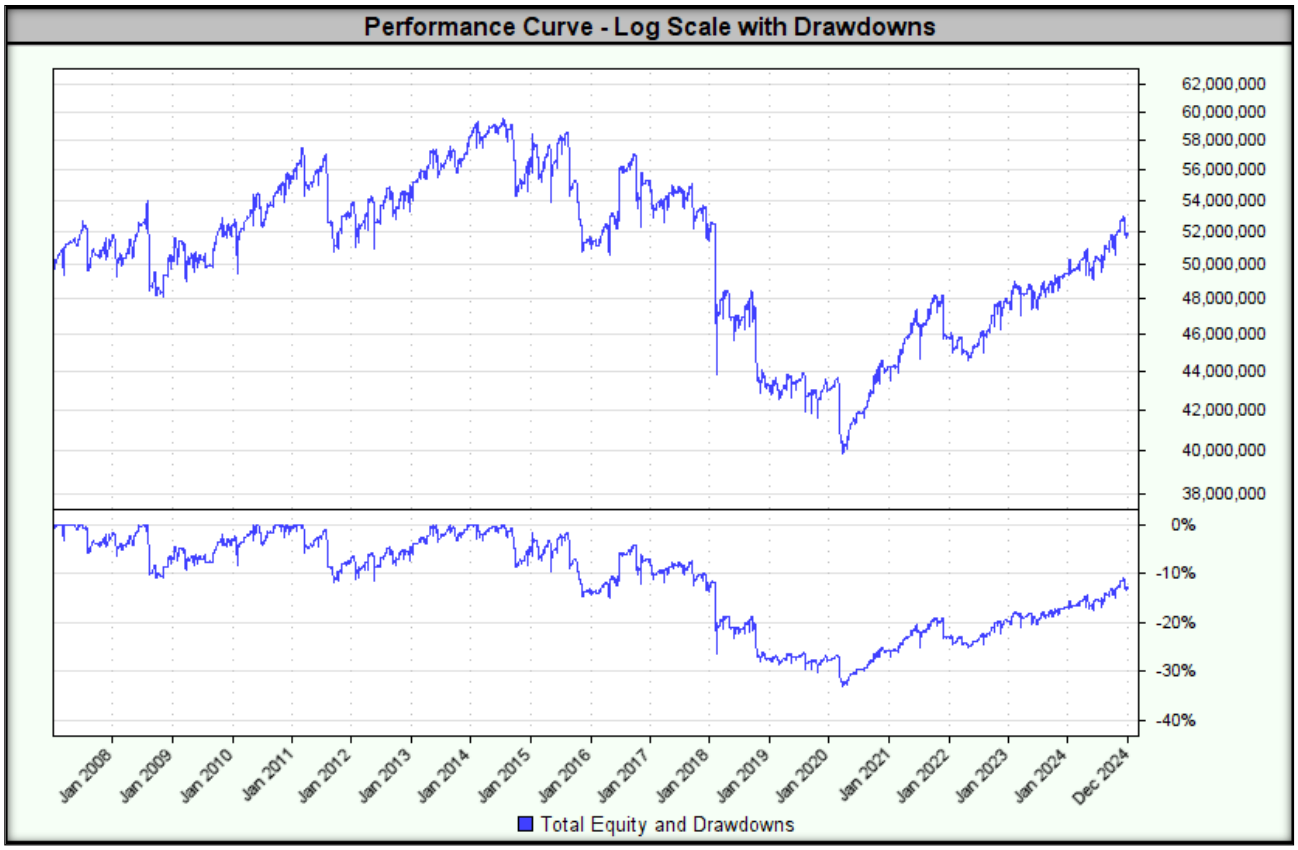
– can generate very different **drawdown levels,** which was observed in the tests conducted in version v.1. For this reason, it is worth **narrowing the RSI Entry Threshold range** to **stabilize the risk profile** and **limit the volatility of results.**

The lowest MAR value of -0.03 was achieved for the following parameters:

- **Length of the moving average (SMA):** 265;
- **RSI Lengths:** 2 days;
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;
- **RSI Entry Threshold:** 25;
- **RSI Exit Threshold:** 55.

Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
2036	265	2	25	55.0	$51,746,369.52	0.19%	0.01	0.06	0.03	33.0%	125.6	4715	-0.02	-0.87
2300	275	2	25	55.0	$52,251,746.56	0.25%	0.01	0.07	0.04	35.1%	125.5	4757	-0.02	-0.91
1772	255	2	25	55.0	$52,466,173.06	0.27%	0.01	0.07	0.04	33.5%	130.8	4722	-0.02	-0.96
2432	280	2	25	55.0	$52,638,854.35	0.29%	0.01	0.08	0.05	33.8%	125.6	4781	-0.02	-0.80
2168	270	2	25	55.0	$52,723,103.39	0.30%	0.01	0.08	0.05	32.8%	125.6	4727	-0.02	-0.76
1904	260	2	25	55.0	$54,090,856.28	0.44%	0.01	0.10	0.07	32.8%	130.8	4715	-0.02	-0.69
2564	285	2	25	55.0	$54,696,451.47	0.50%	0.01	0.10	0.08	34.2%	125.6	4791	-0.01	-0.56
56	190	2	25	55.0	$54,327,148.06	0.46%	0.02	0.10	0.10	25.1%	124.6	4561	-0.02	-0.55
188	195	2	25	55.0	$54,426,020.21	0.47%	0.02	0.10	0.10	25.0%	124.6	4587	-0.02	-0.51
848	220	2	25	55.0	$55,248,176.20	0.56%	0.02	0.11	0.11	28.4%	123.9	4636	-0.02	-0.52
716	215	2	25	55.0	$55,177,685.50	0.55%	0.02	0.11	0.11	27.2%	123.9	4624	-0.01	-0.46
1640	250	2	25	55.0	$56,214,686.81	0.65%	0.02	0.13	0.11	30.8%	125.5	4701	-0.02	-0.56
584	210	2	25	55.0	$55,830,277.66	0.61%	0.02	0.12	0.12	27.3%	123.9	4607	-0.01	-0.45

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



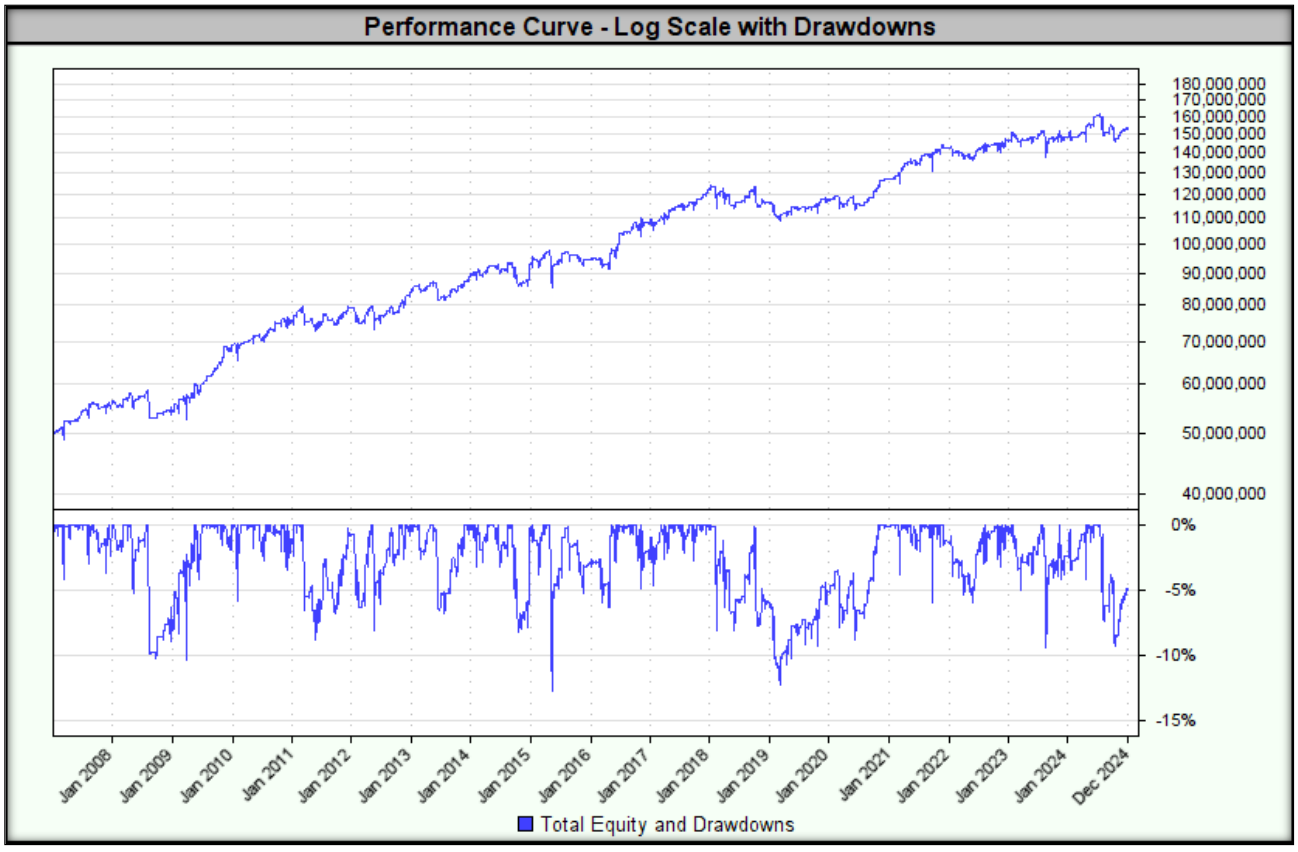
The highest MAR value of 0.51 was achieved for the following parameters:

- **Length of the moving average (SMA):** 240;
- **RSI Lengths:** 3 days;
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;
- **RSI Entry Threshold:** 25;
- RSI **Exit Threshold:** 62.5.

The highest MAR value was accompanied by **a drawdown of 12.7%.**

Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
1445	240	3	25	62.5	$153,018,854.39	6.41%	0.51	0.85	0.88	12.7%	33.6	3140	0.53	6.35
1402	240	3	21	65.0	$150,203,769.39	6.30%	0.50	0.98	1.19	12.6%	20.9	2412	0.83	6.54
1313	235	3	25	62.5	$150,027,183.35	6.30%	0.50	0.84	0.85	12.7%	33.2	3117	0.48	6.26
1577	245	3	25	62.5	$149,468,504.28	6.27%	0.49	0.83	0.84	12.7%	33.8	3151	0.46	6.16
742	215	3	21	65.0	$140,274,139.31	5.90%	0.49	0.94	1.31	12.0%	21.8	2353	0.70	6.32
389	200	3	25	62.5	$137,055,350.61	5.76%	0.49	0.83	0.99	11.8%	25.0	3041	0.47	5.73
1138	230	3	21	65.0	$145,896,044.76	6.13%	0.49	0.97	1.27	12.6%	21.6	2385	0.78	6.36
1534	245	3	21	65.0	$145,616,651.53	6.12%	0.49	0.94	1.10	12.6%	21.8	2426	0.72	6.30
2498	280	3	25	55.0	$129,362,201.96	5.42%	0.49	0.79	0.87	11.2%	28.8	3225	0.36	4.64
1270	235	3	21	65.0	$144,881,114.43	6.09%	0.48	0.94	1.14	12.6%	25.7	2390	0.74	6.29
786	215	3	25	65.0	$134,668,863.15	5.66%	0.48	0.74	0.97	11.8%	28.1	3082	0.44	6.03
874	220	3	21	65.0	$137,616,505.12	5.79%	0.48	0.91	1.30	12.1%	22.0	2365	0.67	6.22
654	210	3	25	65.0	$126,928,248.62	5.31%	0.48	0.69	0.92	11.2%	26.1	3062	0.38	5.47

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 35.1%.**

Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
2300	275	2	25	55.0	$52,251,746.56	0.25%	0.01	0.07	0.04	35.1%	125.5	4757	-0.02	-0.91
2564	285	2	25	55.0	$54,696,451.47	0.50%	0.01	0.10	0.08	34.2%	125.6	4791	-0.01	-0.56
2582	285	3	20	72.5	$79,845,553.33	2.63%	0.08	0.32	0.30	33.9%	97.3	2346	0.08	3.48
2432	280	2	25	55.0	$52,638,854.35	0.29%	0.01	0.08	0.05	33.8%	125.6	4781	-0.02	-0.80
1772	255	2	25	55.0	$52,466,173.06	0.27%	0.01	0.07	0.04	33.5%	130.8	4722	-0.02	-0.96
2318	275	3	20	72.5	$73,979,752.90	2.20%	0.07	0.28	0.26	33.2%	97.3	2327	0.07	3.06
2450	280	3	20	72.5	$75,572,060.91	2.32%	0.07	0.29	0.27	33.2%	97.3	2344	0.07	3.13
74	190	3	20	72.5	$69,821,060.53	1.87%	0.06	0.27	0.27	33.0%	91.3	2132	0.07	2.53
2036	265	2	25	55.0	$51,746,369.52	0.19%	0.01	0.06	0.03	33.0%	125.6	4715	-0.02	-0.87
1904	260	2	25	55.0	$54,090,856.28	0.44%	0.01	0.10	0.07	32.8%	130.8	4715	-0.02	-0.69
2168	270	2	25	55.0	$52,723,103.39	0.30%	0.01	0.08	0.05	32.8%	125.6	4727	-0.02	-0.76
2301	275	2	25	57.5	$62,165,730.71	1.22%	0.04	0.19	0.19	32.4%	125.8	4788	-0.00	-0.06
2186	270	3	20	72.5	$72,623,626.44	2.10%	0.06	0.27	0.26	32.4%	97.3	2310	0.07	2.96

In summary, the strategy **passed the stability test** in a wide range of optimized parameters because:

- **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 (**31.8% vs. 12.7%)** – which means an acceptable risk of deep capital drawdowns.

Questions may arise as to why **I did not directly compare the maximum drawdown** of all tests with **the maximum drawdown of the strategy with the highest MAR** – as I did in other analyses. This is due to the fact I mentioned earlier: **the strategy is very sensitive to the structure of the trade,** or more precisely – to whether it is dominated by **positions consisting of 2, 3 or 4 units.**

Results where **full 4 unit trades predominate** are characterized by **higher rates of return,** but also **higher drawdown.** Similarly, when the strategy rarely achieves full exposure (i.e. 4 units), results are **lower,** but also **drawdown is smaller.**

Therefore, to **compare apples to apples,** we consider not only the MAR, but also **the structure of the number of transactions.** We know that **the strategy with the highest MAR generated 3140 transactions,** so we compare its drawdown with **the test with the highest drawdown but with a similar number of transactions.** Below is such a test (**number 2364)** that has **a similar number of transactions** to the strategy with the highest MAR.

Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
2300	275	2	25	55.0	$52,251,746.56	0.25%	0.01	0.07	0.04	35.1%	125.5	4757	-0.02	-0.91
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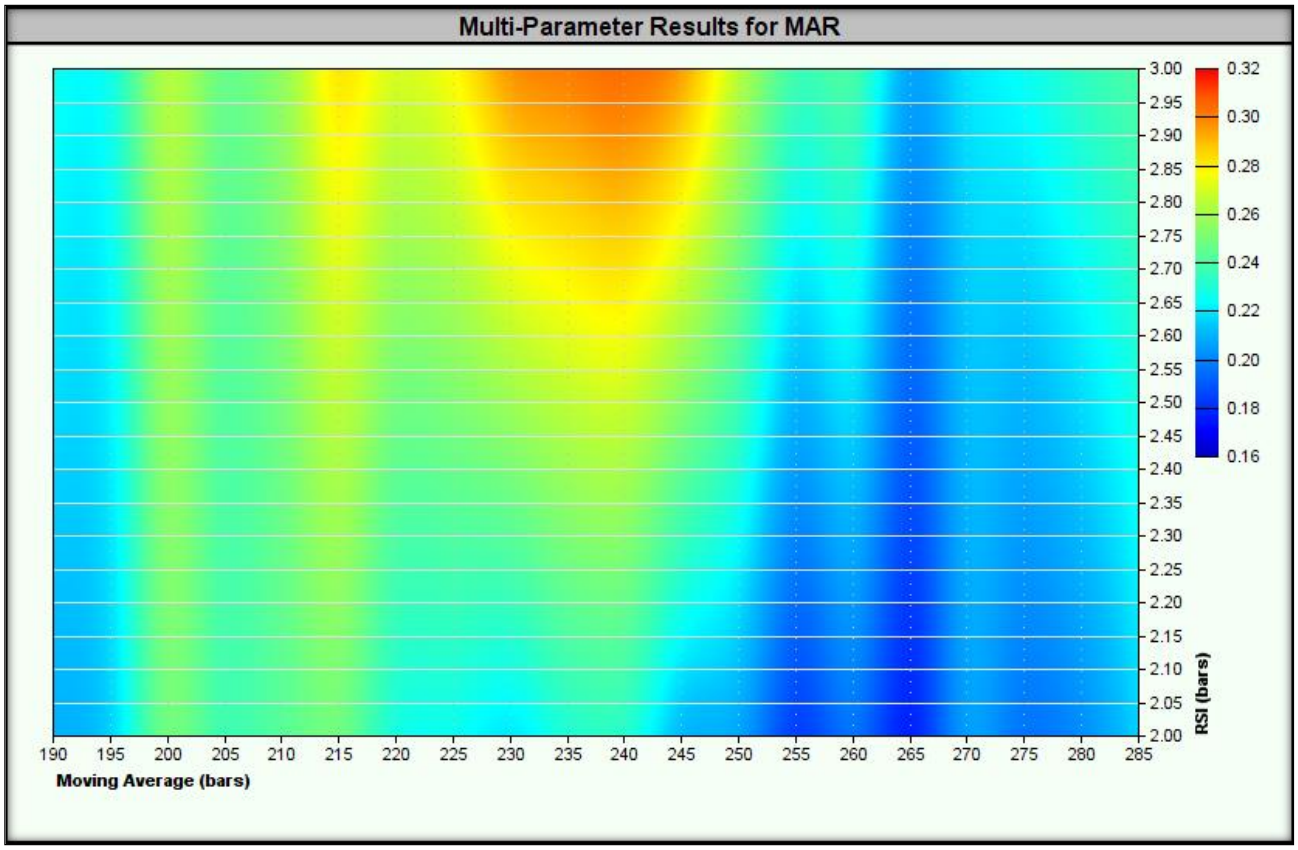
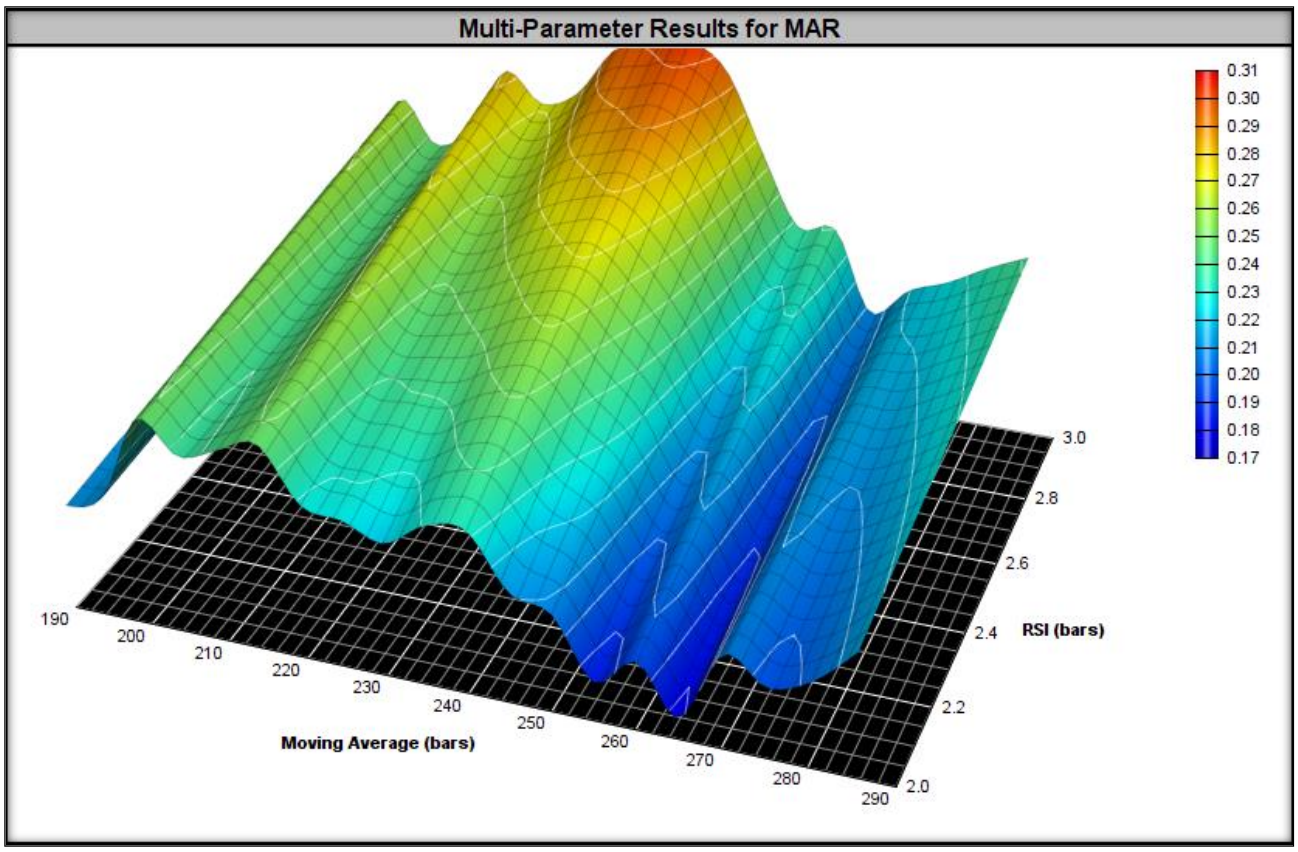
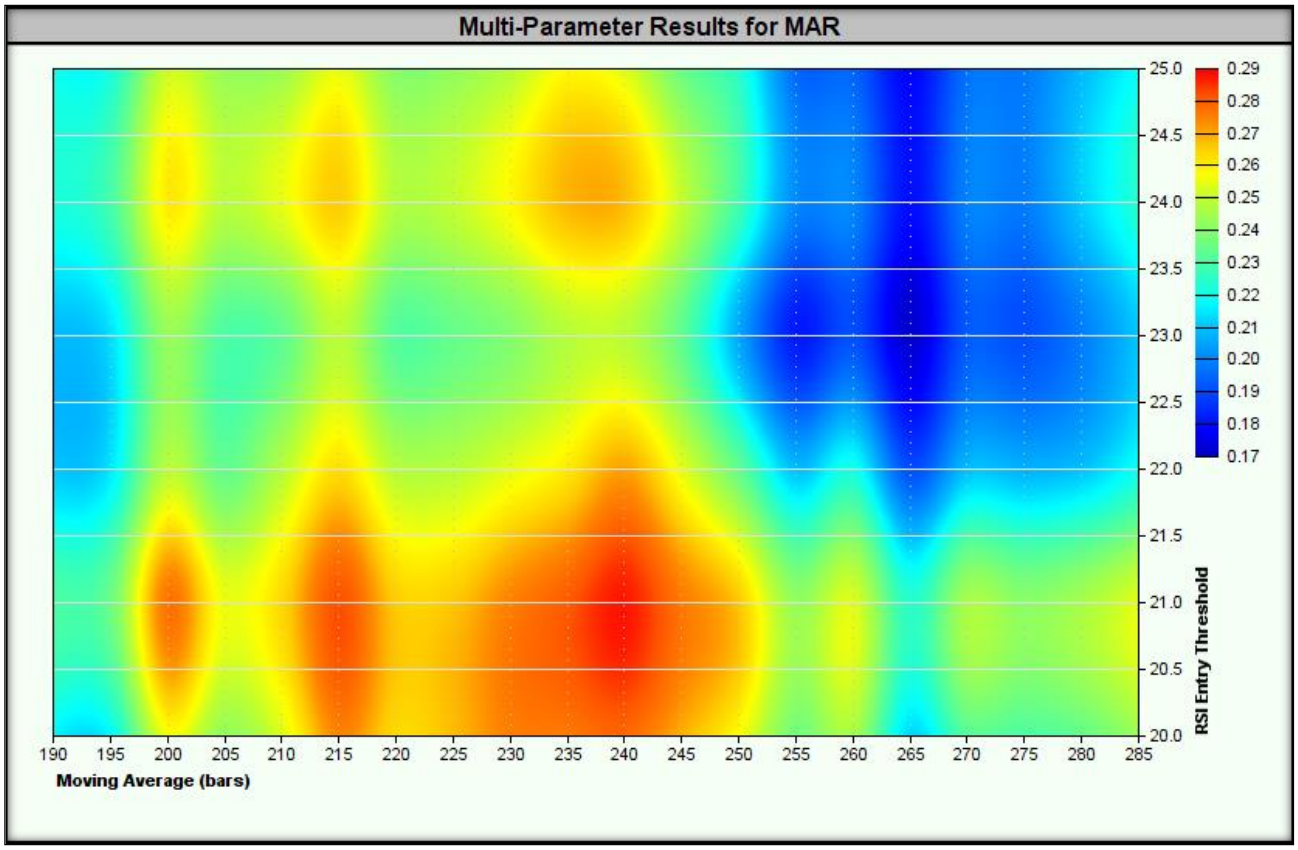
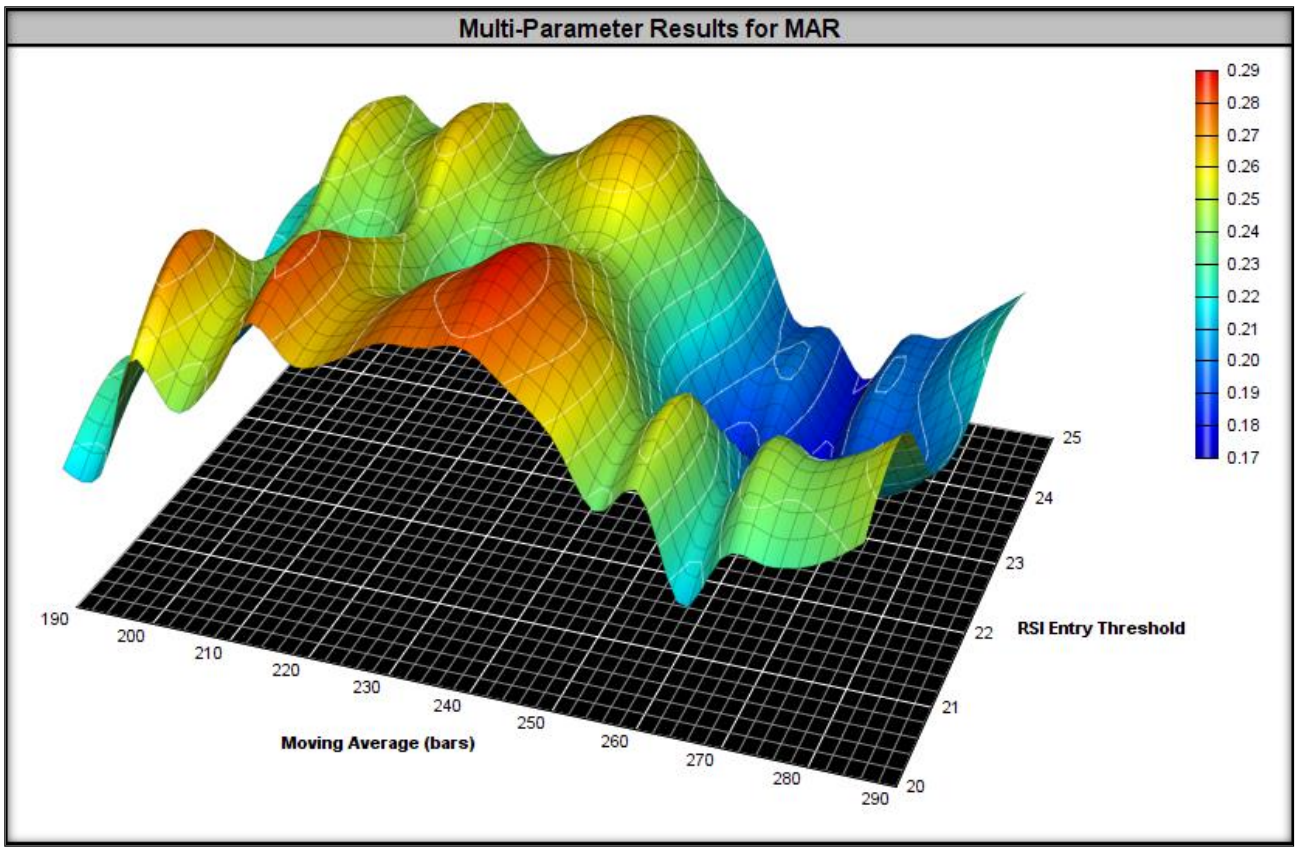
2450	280	3	20	72.5	$75,572,060.91	2.32%	0.07	0.29	0.27	33.2%	97.3	2344	0.07	3.13
74	190	3	20	72.5	$69,821,060.53	1.87%	0.06	0.27	0.27	33.0%	91.3	2132	0.07	2.53
2036	265	2	25	55.0	$51,746,369.52	0.19%	0.01	0.06	0.03	33.0%	125.6	4715	-0.02	-0.87
1904	260	2	25	55.0	$54,090,856.28	0.44%	0.01	0.10	0.07	32.8%	130.8	4715	-0.02	-0.69
2168	270	2	25	55.0	$52,723,103.39	0.30%	0.01	0.08	0.05	32.8%	125.6	4727	-0.02	-0.76
2301	275	2	25	57.5	$62,165,730.71	1.22%	0.04	0.19	0.19	32.4%	125.8	4788	-0.00	-0.06
2186	270	3	20	72.5	$72,623,626.44	2.10%	0.06	0.27	0.26	32.4%	97.3	2310	0.07	2.96
1958	260	3	23	80.0	$101,555,315.25	4.02%	0.13	0.37	0.40	32.1%	74.9	2739	0.13	5.50
2604	285	3	22	72.5	$83,679,226.23	2.90%	0.09	0.32	0.34	32.0%	80.8	2699	0.09	4.04
2565	285	2	25	57.5	$64,743,217.61	1.45%	0.05	0.22	0.21	31.9%	124.3	4822	0.01	0.28
2364	275	3	24	77.5	$115,030,256.31	4.74%	0.15	0.43	0.47	31.8%	74.9	2982	0.12	5.51
2232	270	3	24	77.5	$109,818,125.15	4.47%	0.14	0.41	0.46	31.7%	74.9	2961	0.11	5.27
1826	255	3	23	80.0	$103,140,823.13	4.10%	0.13	0.38	0.39	31.6%	74.9	2737	0.13	5.39
2375	275	3	25	77.5	$120,383,192.11	5.00%	0.16	0.43	0.54	31.6%	74.9	3155	0.12	5.84
2243	270	3	25	77.5	$110,379,112.29	4.50%	0.14	0.40	0.49	31.5%	74.9	3136	0.11	5.29

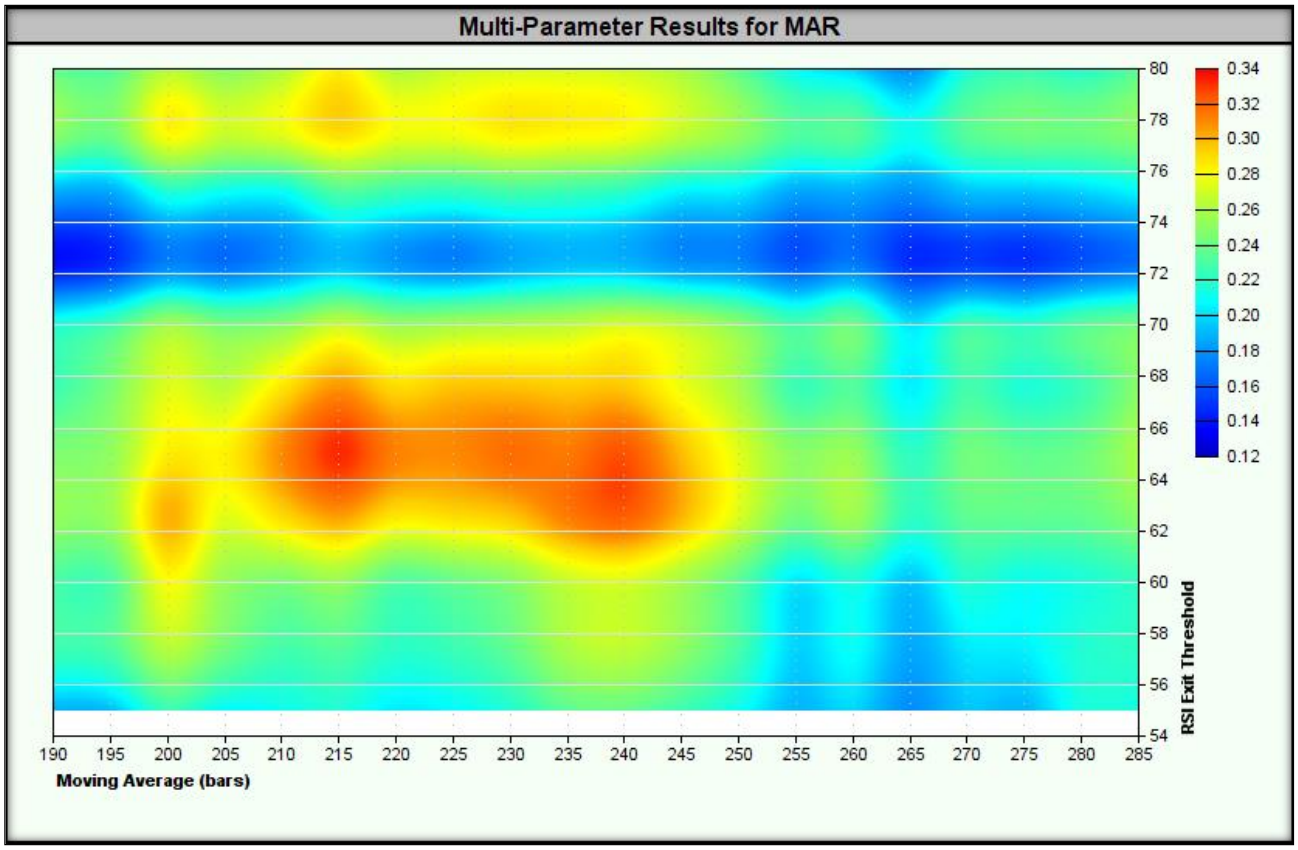
Heatmaps for the tested ranges are presented below.

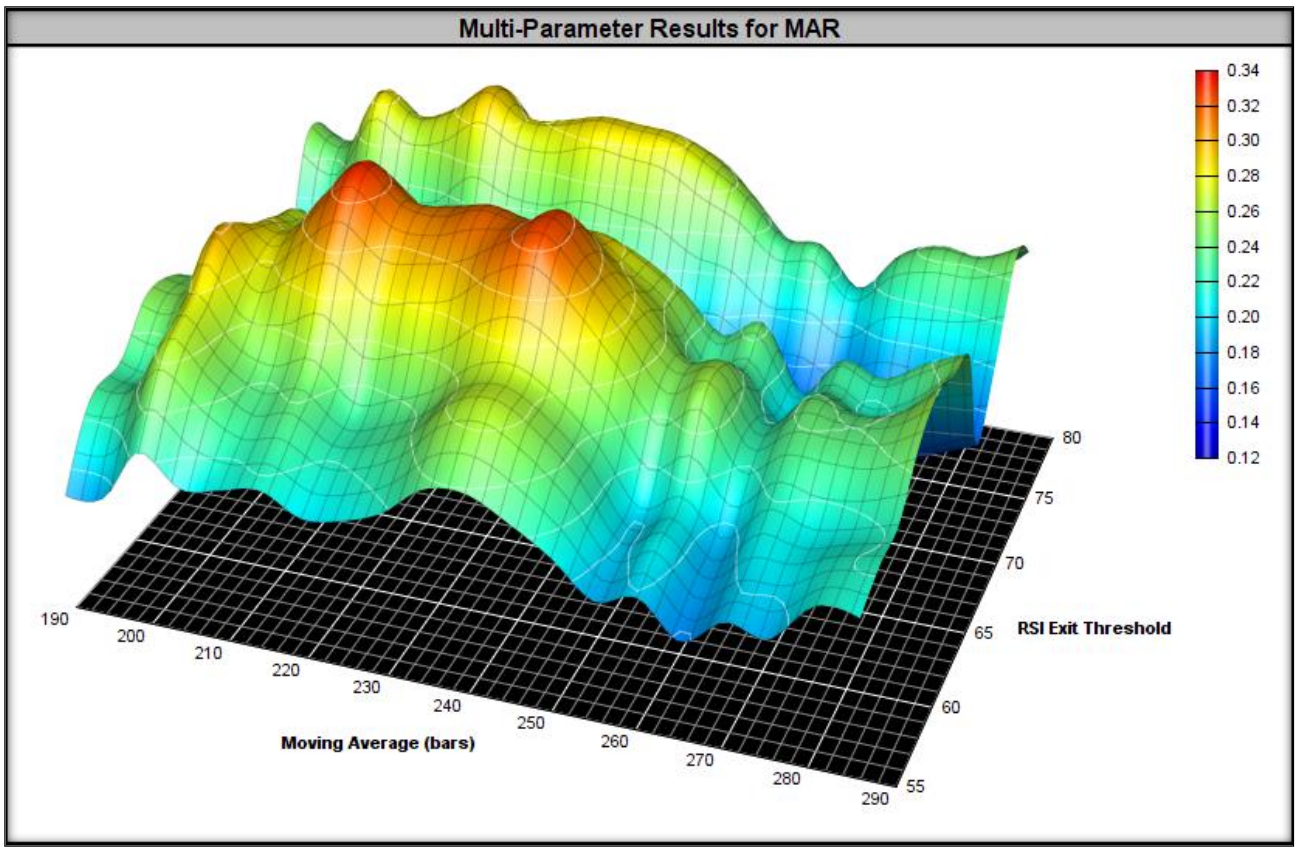

Multi-Parameter Results for MAR
Moving Average (bars)
RSI (bars)

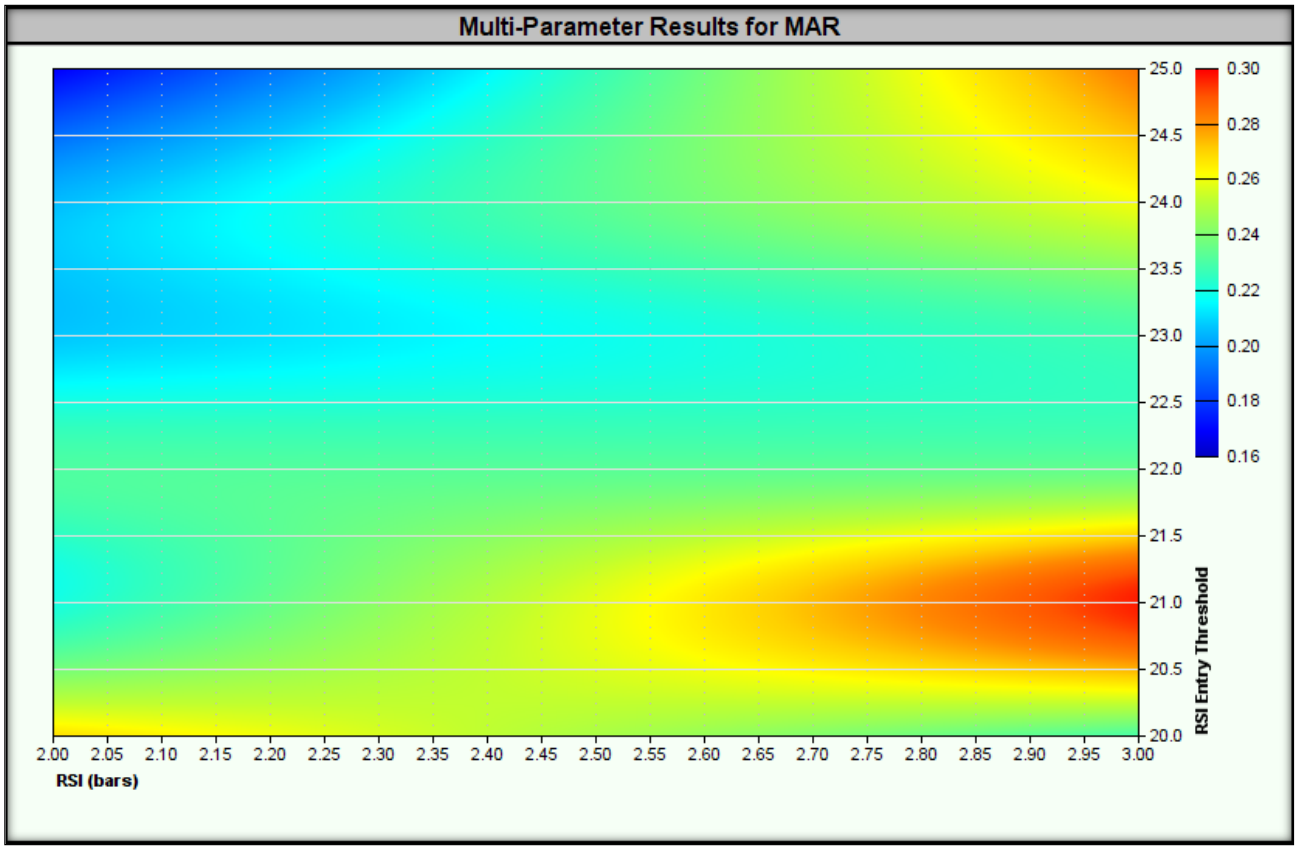

Multi-Parameter Results for MAR
Moving Average (bars)
RSI (bars)

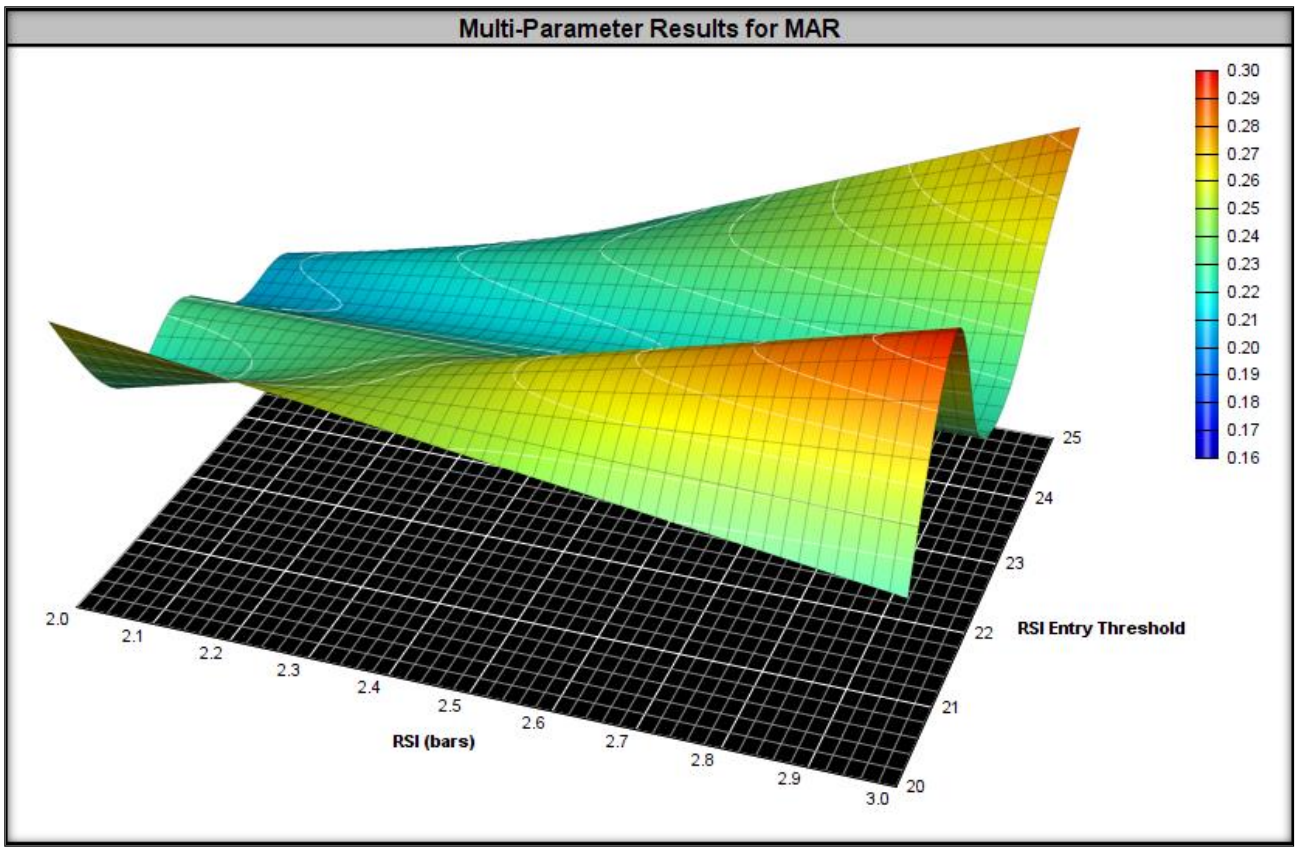

Multi-Parameter Results for MAR
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
RSI Entry Threshold
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285
Moving Average (bars)

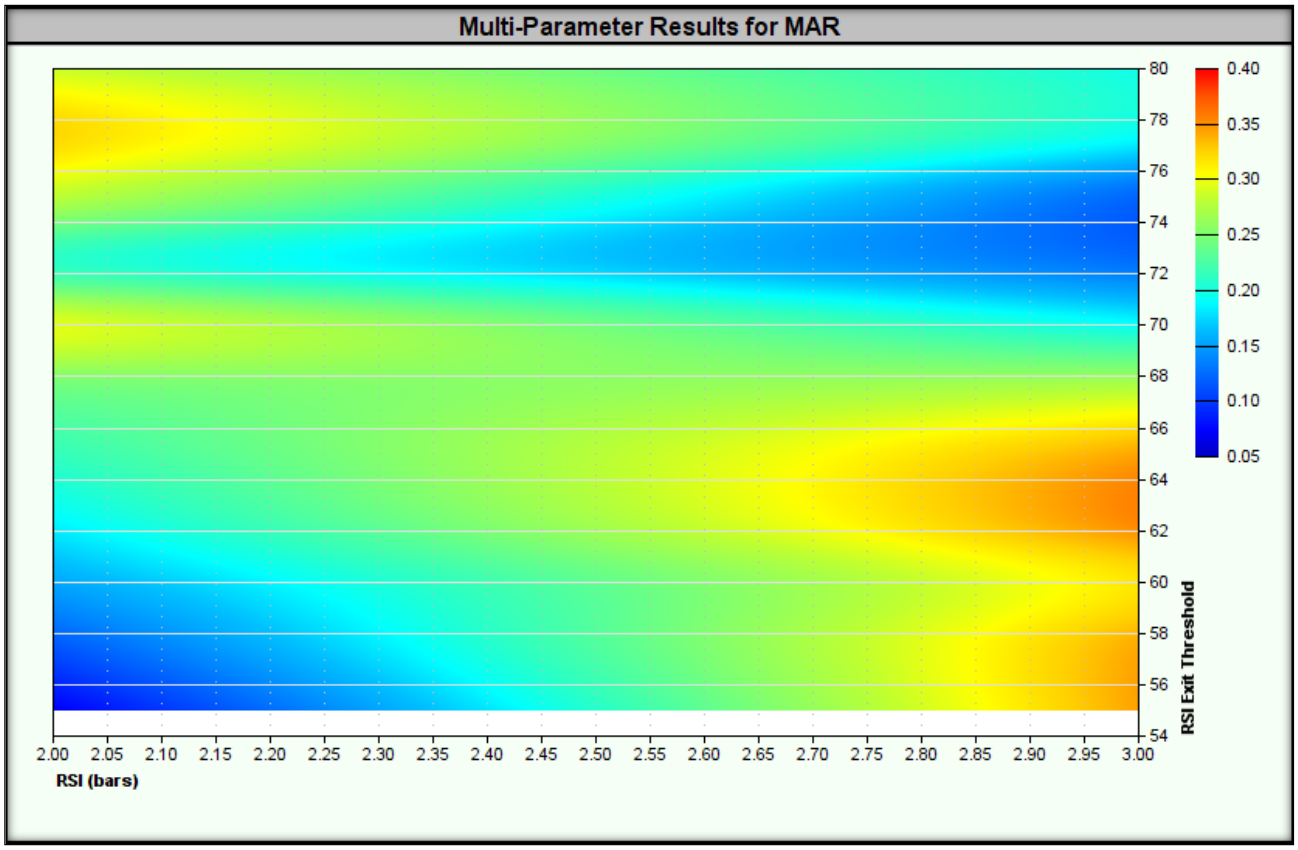

Multi-Parameter Results for MAR
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
190
200
210
220
230
240
250
260
270
280
290
Moving Average (bars)
25
24
23
22
21
20
RSI Entry Threshold

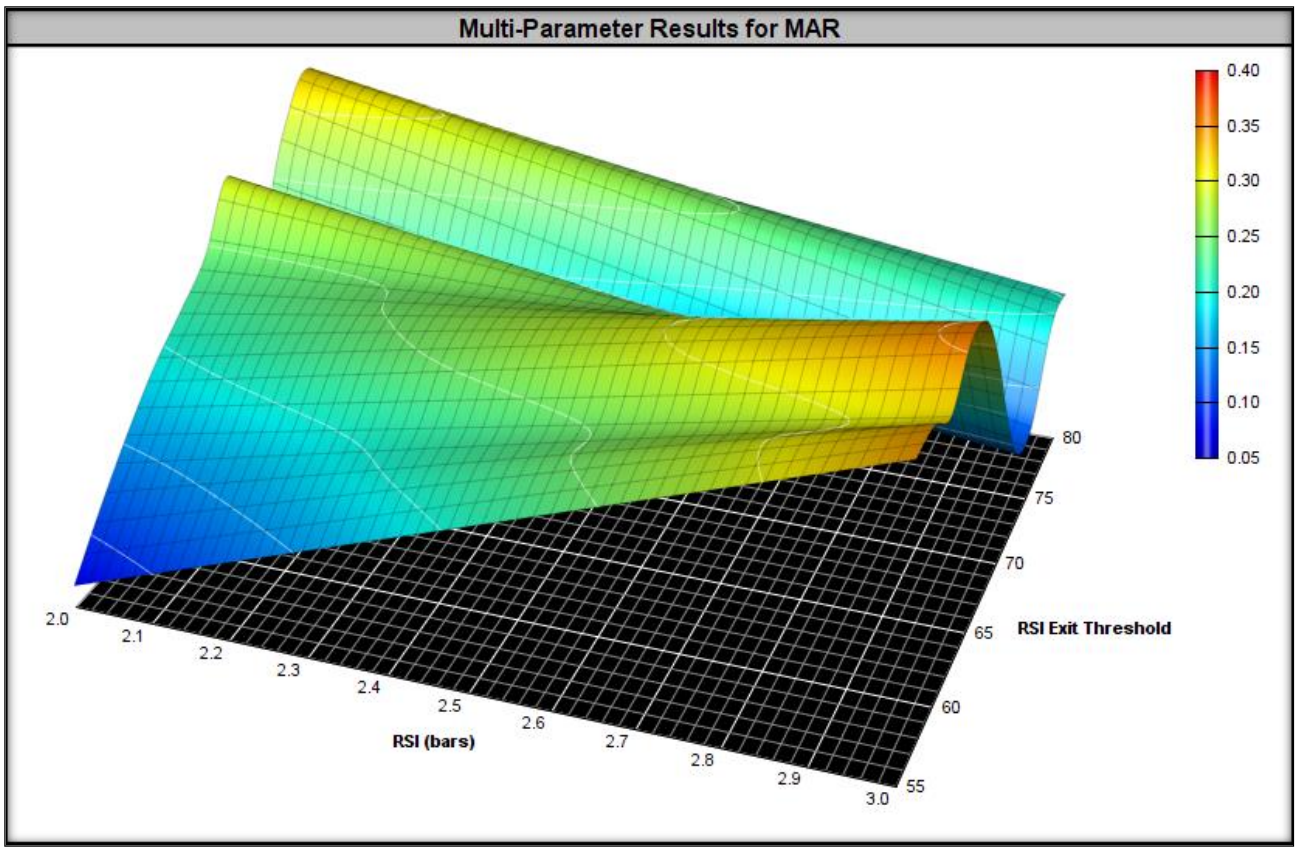

Multi-Parameter Results for MAR
Moving Average (bars)
RSI Exit Threshold

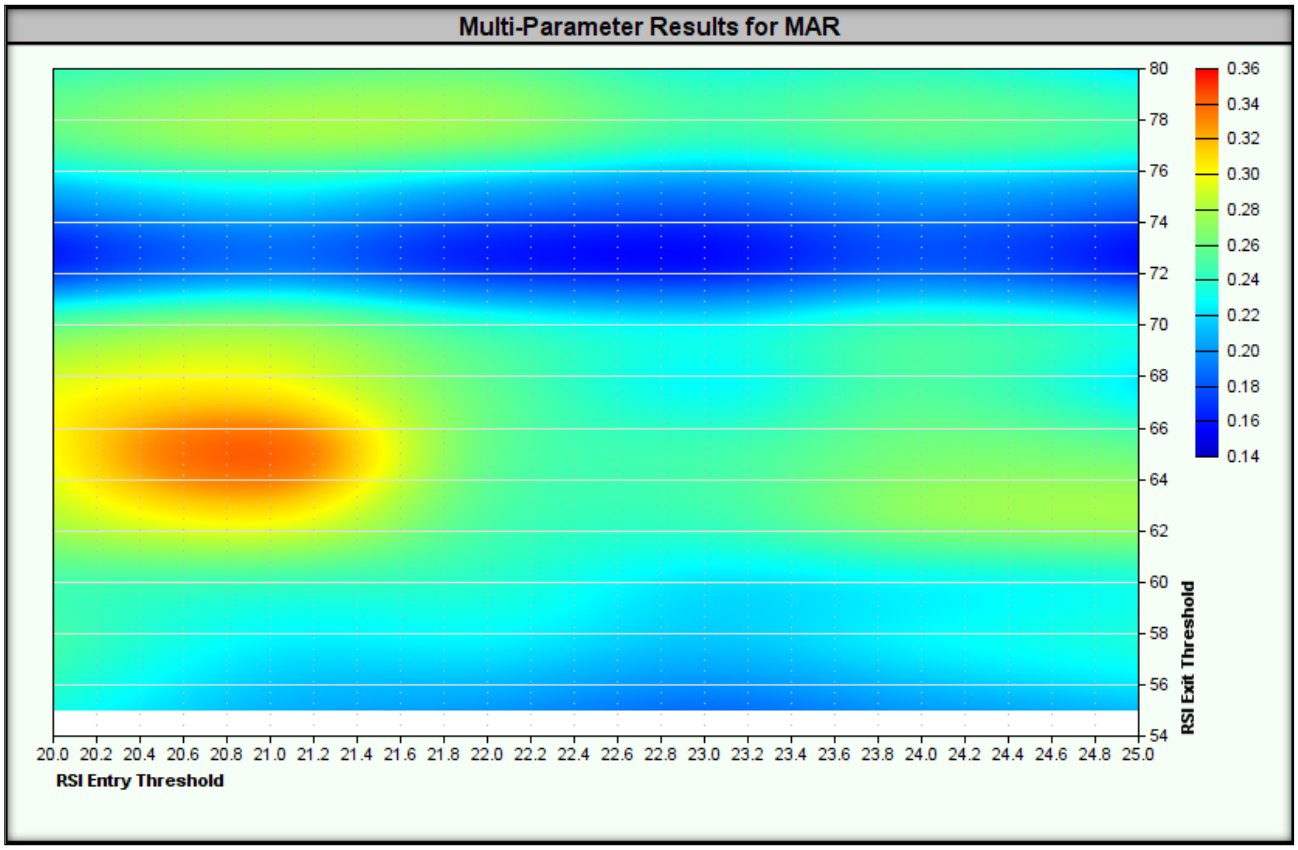

Multi-Parameter Results for MAR
Moving Average (bars)
RSI Exit Threshold

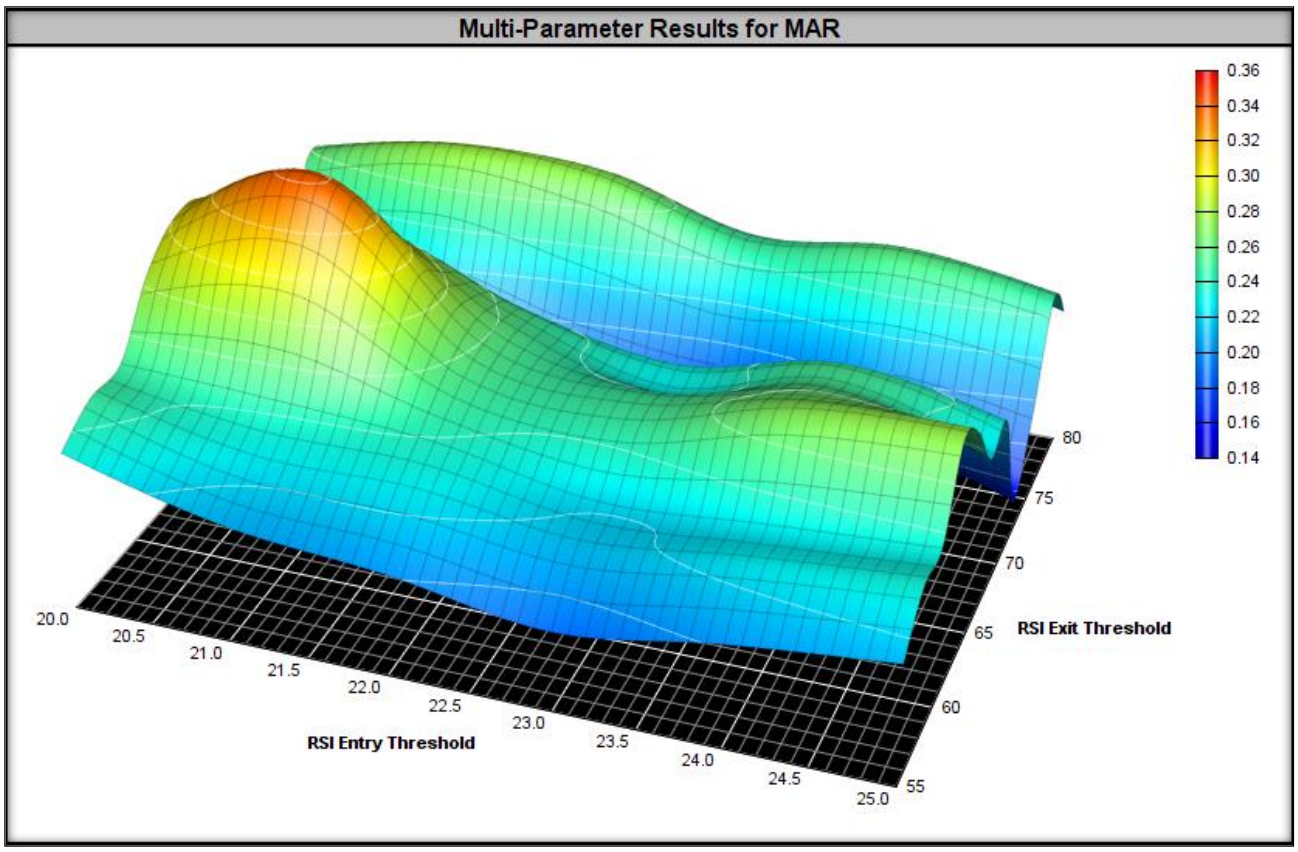

Multi-Parameter Results for MAR
RSI (bars)
RSI Entry Threshold

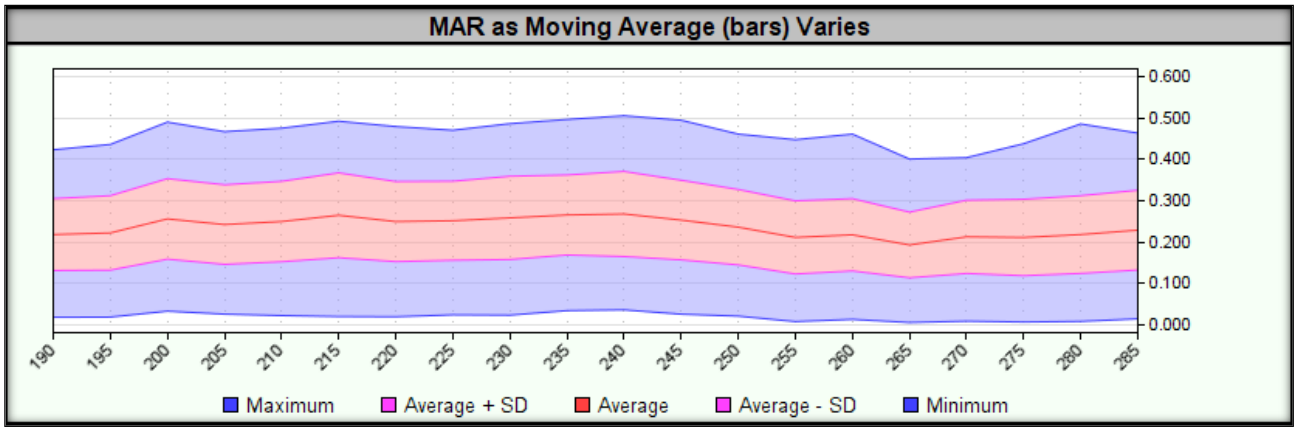

Multi-Parameter Results for MAR
RSI (bars)
RSI Entry Threshold

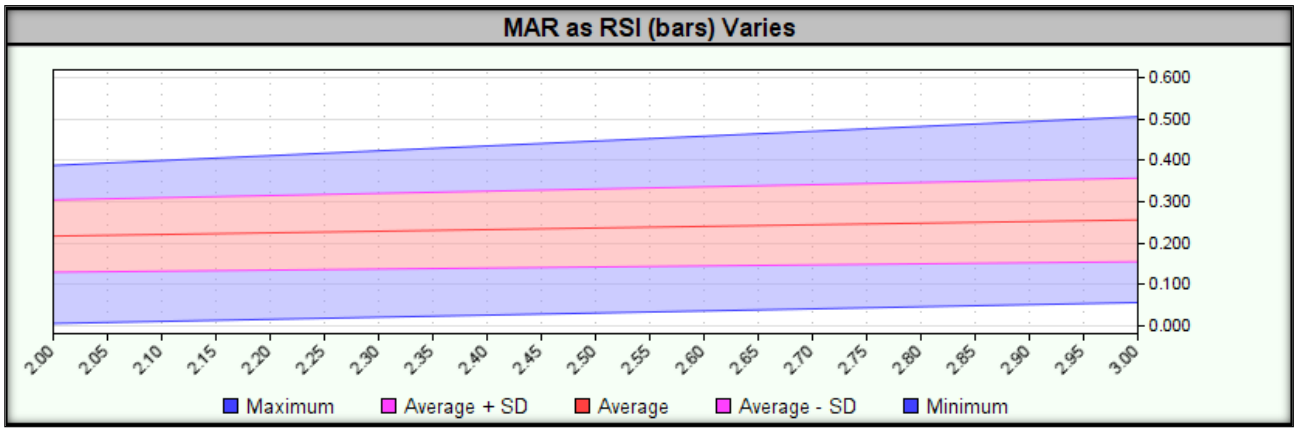

Multi-Parameter Results for MAR
RSI (bars)
RSI Exit Threshold

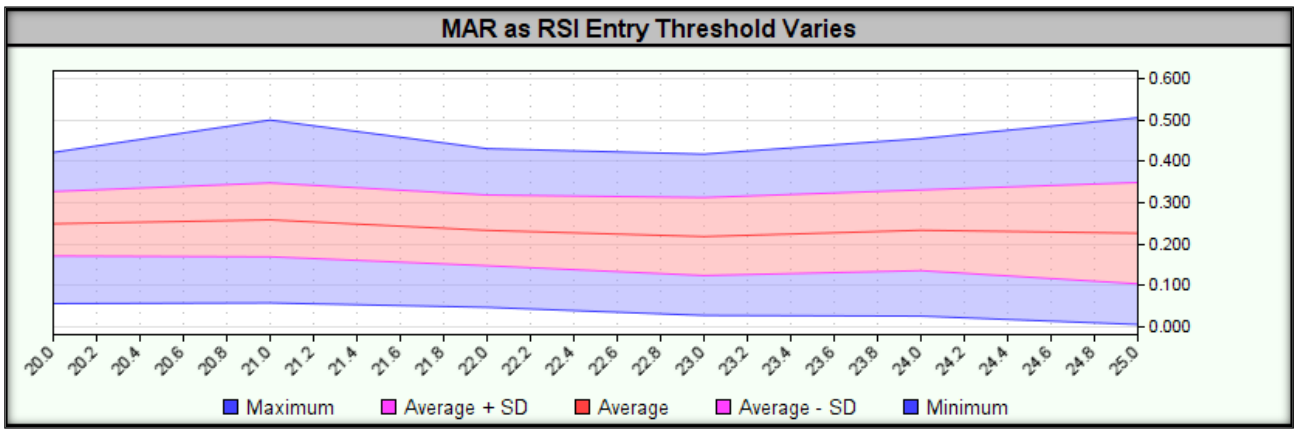

Multi-Parameter Results for MAR
RSI (bars)
RSI Exit Threshold

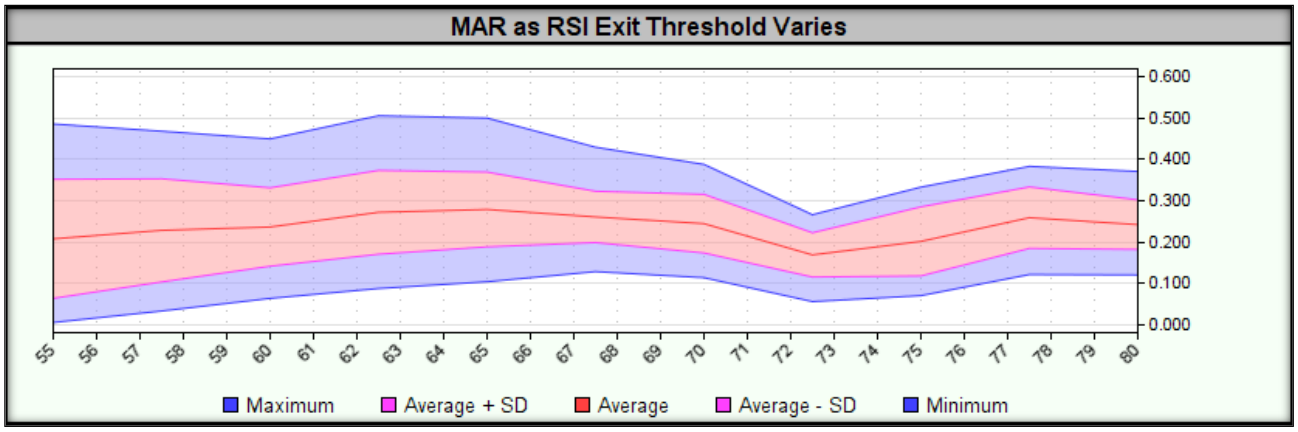

Multi-Parameter Results for MAR
RSI Entry Threshold
RSI Exit Threshold
20.0 20.2 20.4 20.6 20.8 21.0 21.2 21.4 21.6 21.8 22.0 22.2 22.4 22.6 22.8 23.0 23.2 23.4 23.6 23.8 24.0 24.2 24.4 24.6 24.8 25.0
80 78 76 74 72 70 68 66 64 62 60 58 56 54
0.36 0.34 0.32 0.30 0.28 0.26 0.24 0.22 0.20 0.18 0.16 0.14


Multi-Parameter Results for MAR
RSI Entry Threshold
RSI Exit Threshold
20.0 20.5 21.0 21.5 22.0 22.5 23.0 23.5 24.0 24.5 25.0
80 75 70 65 60 55
0.36 0.34 0.32 0.30 0.28 0.26 0.24 0.22 0.20 0.18 0.16 0.14


MAR as Moving Average (bars) Varies
0.600
0.500
0.400
0.300
0.200
0.100
0.000
190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285
Maximum
Average + SD
Average
Average - SD
Minimum


MAR as RSI (bars) Varies
0.600
0.500
0.400
0.300
0.200
0.100
0.000
2.00 2.05 2.10 2.15 2.20 2.25 2.30 2.35 2.40 2.45 2.50 2.55 2.60 2.65 2.70 2.75 2.80 2.85 2.90 2.95 3.00
Maximum
Average + SD
Average
Average - SD
Minimum


MAR as RSI Entry Threshold Varies
0.600
0.500
0.400
0.300
0.200
0.100
0.000
20.0 20.2 20.4 20.6 20.8 21.0 21.2 21.4 21.6 21.8 22.0 22.2 22.4 22.6 22.8 23.0 23.2 23.4 23.6 23.8 24.0 24.2 24.4 24.6 24.8 25.0
Maximum
Average + SD
Average
Average - SD
Minimum



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

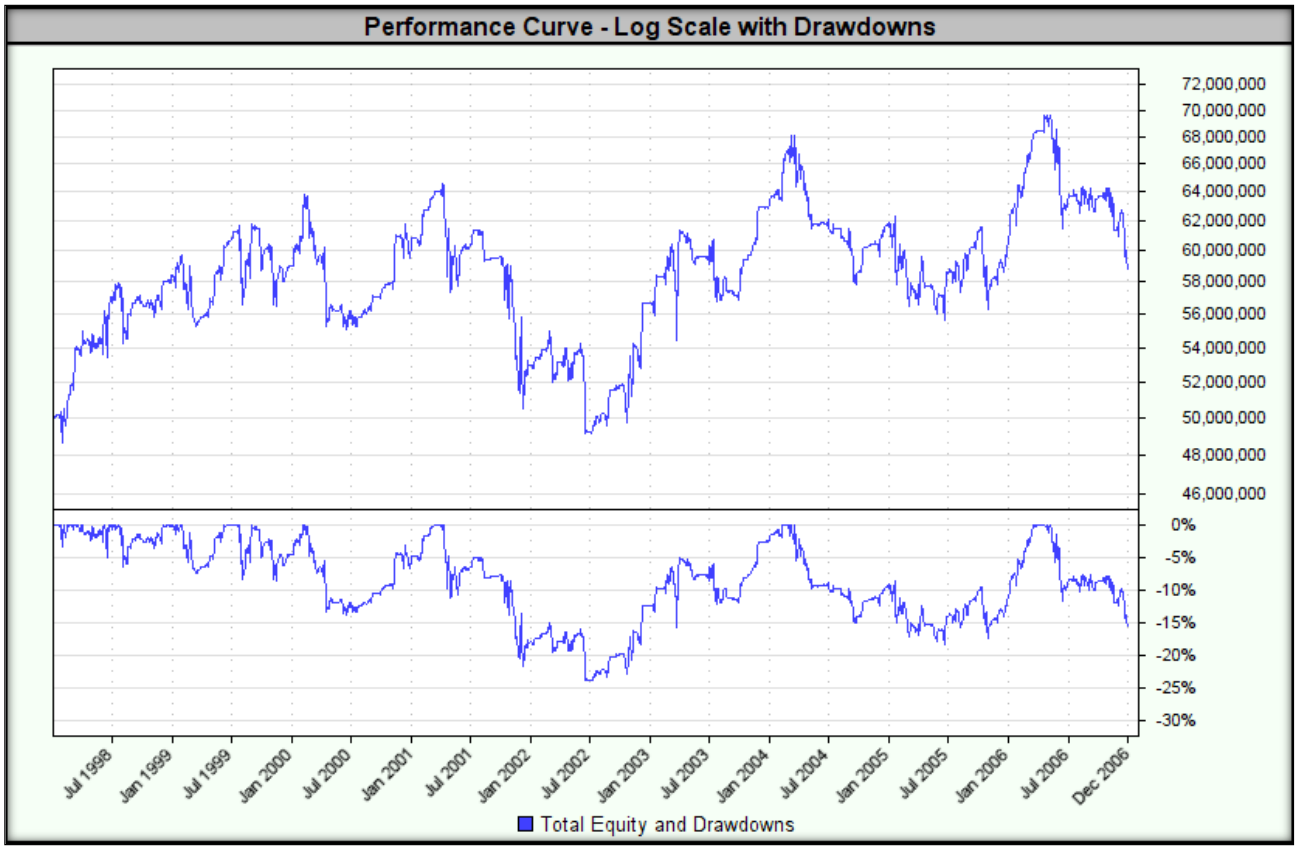
- **Length of the moving average (SMA):** range **190-285 days (step: 5);**
- **RSI Lengths:** Range **2-3 days (step: 1);**
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;
- **RSI Entry Threshold:** range **20-25 (step: 1);**
- **RSI Exit Threshold:** range **55-80 (step: 2.5).**

The lowest MAR value of 0.08 was achieved for the following parameters:

- **Length of the moving average (SMA):** 190;
- **RSI Lengths:** 3 days;
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;
- **RSI Entry Threshold:** 25;
- **RSI Exit Threshold:** 80.

Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
132	190	3	25	80.0	$58,810,305.92	1.82%	0.08	0.22	0.22	23.9%	34.0	1305	0.06	1.30
77	190	3	20	80.0	$57,279,859.11	1.52%	0.08	0.20	0.23	18.5%	33.4	986	0.08	1.32
110	190	3	23	80.0	$58,159,570.12	1.70%	0.08	0.21	0.21	20.5%	33.4	1154	0.09	1.80
99	190	3	22	80.0	$57,887,851.26	1.64%	0.09	0.21	0.22	18.6%	36.8	1088	0.10	1.85
2057	265	3	20	80.0	$63,387,545.66	2.67%	0.09	0.28	0.23	28.8%	44.2	1048	0.12	2.43
88	190	3	21	80.0	$59,582,738.58	1.97%	0.10	0.25	0.29	19.2%	33.4	1047	0.13	2.06
2585	285	3	20	80.0	$65,749,352.77	3.09%	0.11	0.32	0.28	29.0%	42.5	1062	0.13	2.88
2079	265	3	22	80.0	$66,715,141.45	3.26%	0.11	0.32	0.25	29.8%	42.5	1151	0.17	3.60
121	190	3	24	80.0	$60,721,042.70	2.18%	0.11	0.26	0.27	19.7%	25.0	1244	0.12	2.03
2189	270	3	20	80.0	$66,494,448.62	3.22%	0.11	0.33	0.27	28.7%	42.5	1049	0.15	3.00
2321	275	3	20	80.0	$66,495,159.52	3.22%	0.12	0.33	0.28	27.7%	42.5	1051	0.16	2.77
1925	260	3	20	80.0	$67,260,542.86	3.35%	0.12	0.34	0.30	27.8%	42.5	1043	0.16	3.25
2607	285	3	22	80.0	$69,668,314.82	3.76%	0.12	0.36	0.30	30.2%	42.5	1163	0.20	4.17

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



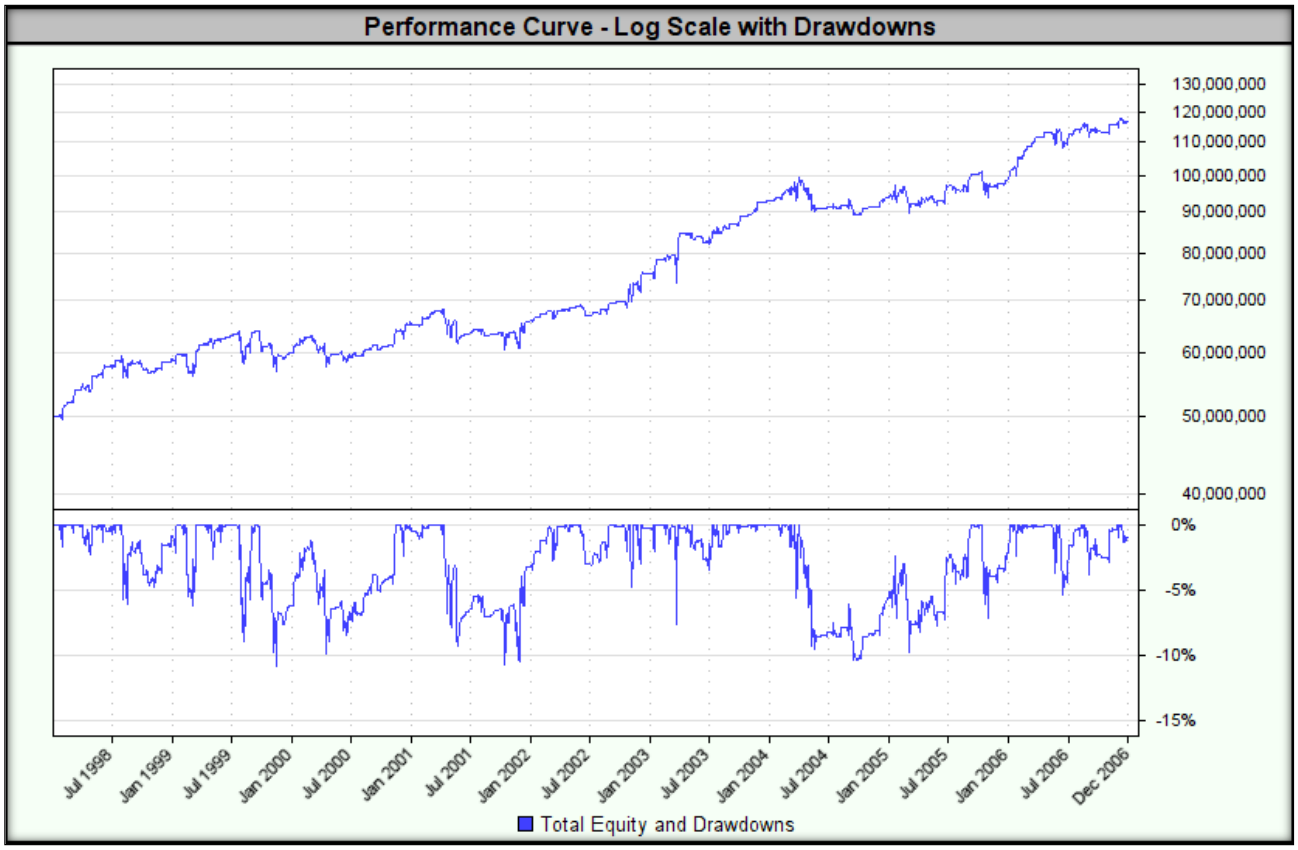
The highest MAR value of 0.91 was achieved for the following parameters:

- **Length of the moving average (SMA):** 245;
- **RSI Lengths:** 3 days;
- **Number of consecutive days with RSI below Entry Threshold:** 2 days;
- **RSI Entry Threshold:** 24;
- **RSI Exit Threshold:** 70.

The highest MAR value was accompanied by **a drawdown of 10.8%.**

Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
1569	245	3	24	70.0	$116,626,400.01	9.88%	0.91	1.11	1.24	10.8%	17.2	1337	1.37	9.07
1437	240	3	24	70.0	$113,900,672.46	9.59%	0.86	1.07	1.14	11.2%	18.2	1333	1.16	8.84
1305	235	3	24	70.0	$114,456,732.34	9.65%	0.83	1.08	1.14	11.6%	18.1	1335	1.08	8.89
1173	230	3	24	70.0	$114,969,360.84	9.70%	0.83	1.10	1.09	11.7%	21.9	1330	1.12	8.97
1536	245	3	21	70.0	$102,452,971.10	8.31%	0.81	1.01	1.27	10.3%	17.9	1135	1.20	8.30
2625	285	3	24	70.0	$120,251,973.25	10.25%	0.78	1.13	1.09	13.1%	17.2	1400	1.18	8.58
1568	245	3	24	67.5	$109,905,001.08	9.15%	0.78	1.13	1.35	11.7%	15.8	1344	1.49	8.90
1172	230	3	24	67.5	$108,962,731.79	9.05%	0.78	1.12	1.23	11.6%	15.7	1337	1.61	8.80
1304	235	3	24	67.5	$106,995,403.69	8.83%	0.78	1.08	1.27	11.4%	15.8	1343	1.49	8.60
1558	245	3	23	70.0	$106,584,852.17	8.78%	0.77	1.00	1.17	11.3%	21.1	1257	1.11	8.43
1436	240	3	24	67.5	$108,762,799.35	9.03%	0.77	1.10	1.29	11.7%	16.7	1342	1.47	8.84
645	210	3	24	70.0	$112,109,697.94	9.40%	0.76	1.16	1.18	12.3%	17.2	1301	1.20	8.50
2493	280	3	24	70.0	$117,484,706.43	9.97%	0.76	1.08	1.09	13.1%	18.5	1391	0.99	8.35

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



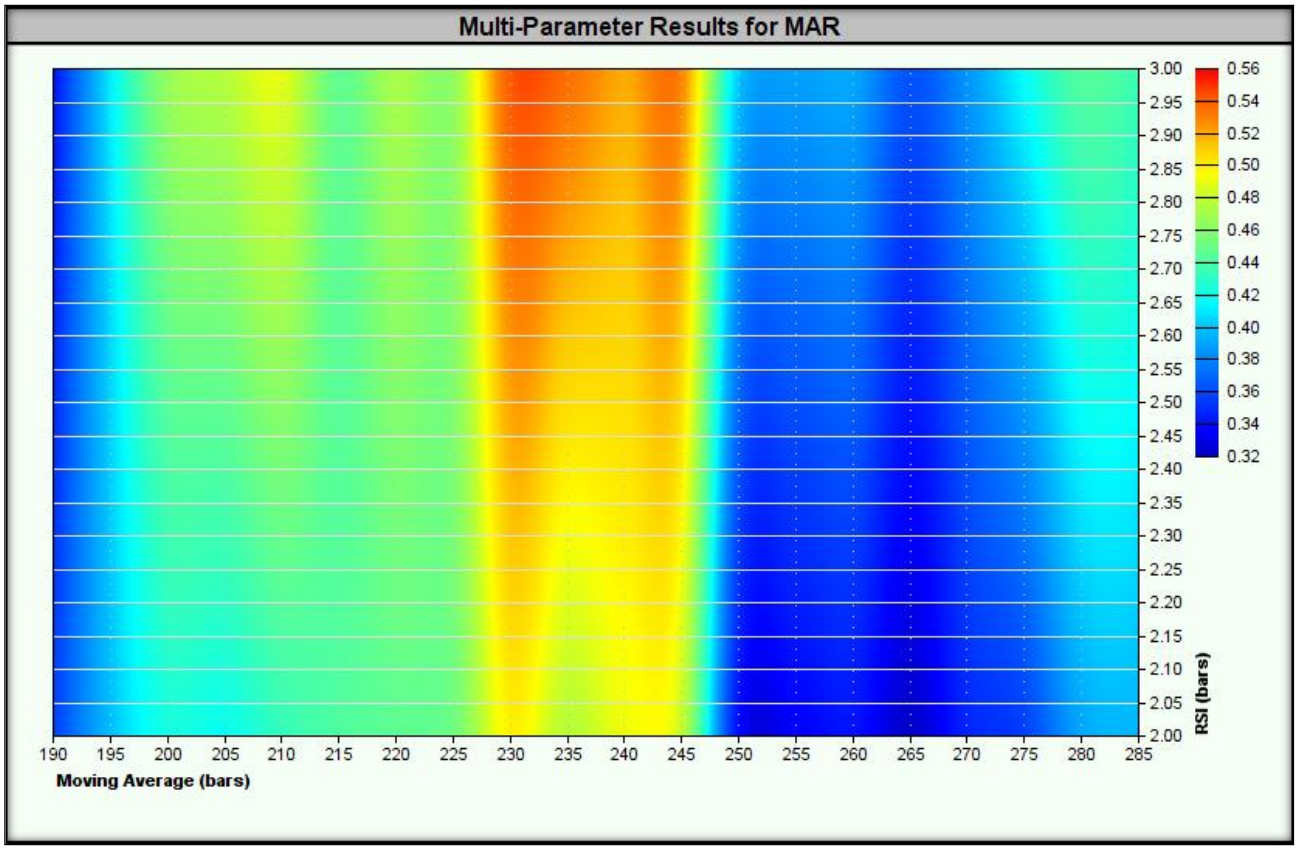
For all combinations of tested parameter ranges, **the highest drawdown was 33.5%.**

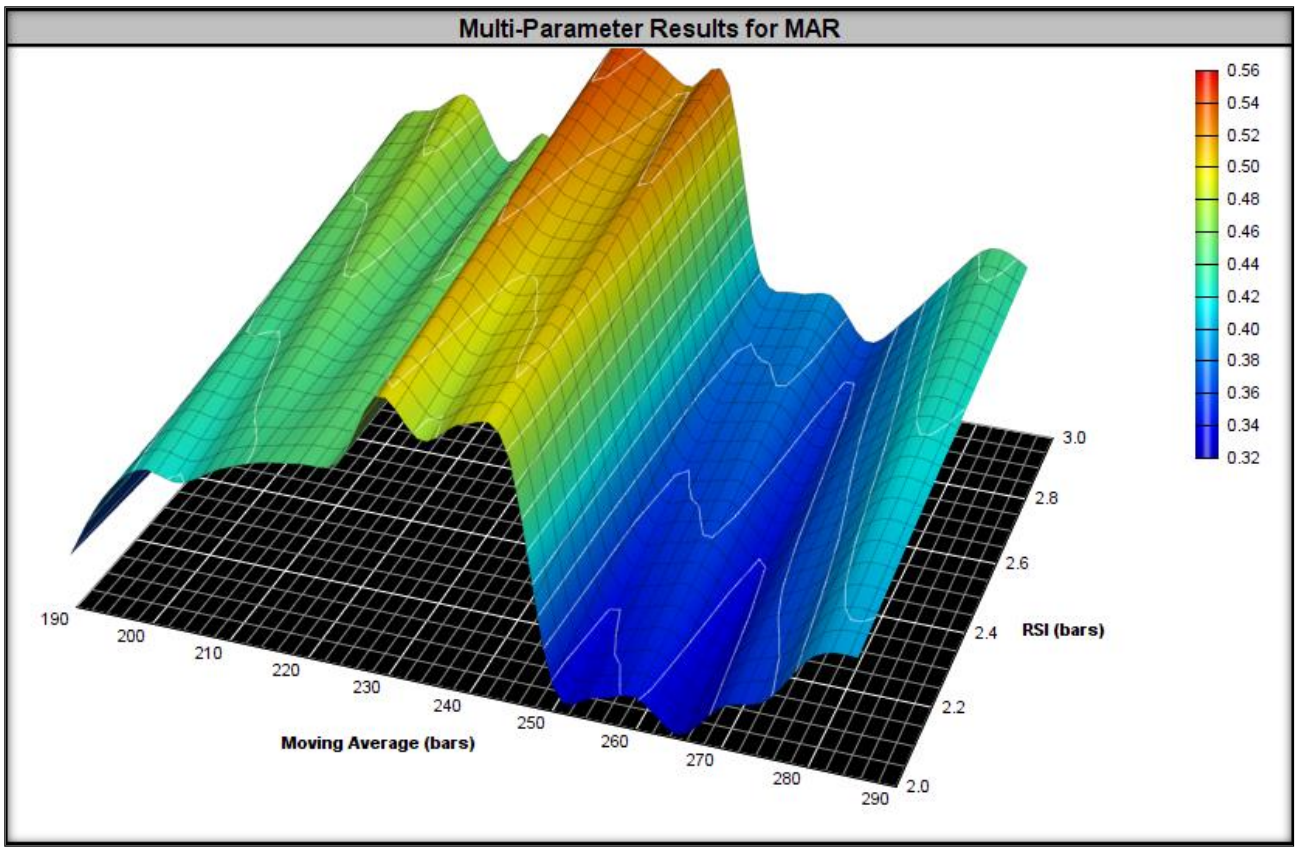
Test	Moving Average (bars)	RSI (bars)	RSI Entry Threshold	RSI Exit Threshold	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]
2640	285	3	25	80.0	$74,904,159.74	4.60%	0.14	0.41	0.34	33.5%	42.5	1364	0.18	3.91
2508	280	3	25	80.0	$78,082,615.00	5.08%	0.16	0.45	0.37	32.3%	42.5	1357	0.20	4.10
2112	265	3	25	80.0	$72,627,369.84	4.24%	0.13	0.38	0.30	32.2%	50.4	1348	0.17	3.69
2376	275	3	25	80.0	$75,610,128.07	4.71%	0.15	0.42	0.34	32.0%	42.5	1354	0.17	3.75
2244	270	3	25	80.0	$76,558,304.86	4.85%	0.15	0.43	0.34	31.8%	42.5	1347	0.20	4.33
1980	260	3	25	80.0	$77,829,017.23	5.04%	0.16	0.44	0.38	31.1%	42.5	1344	0.23	4.55
2618	285	3	23	80.0	$73,260,349.46	4.34%	0.14	0.41	0.34	30.8%	42.5	1221	0.22	4.54
1848	255	3	25	80.0	$78,303,152.27	5.12%	0.17	0.45	0.39	30.3%	42.5	1337	0.24	4.73
2607	285	3	22	80.0	$69,668,314.82	3.76%	0.12	0.36	0.30	30.2%	42.5	1163	0.20	4.17
1716	250	3	25	80.0	$78,100,839.79	5.09%	0.17	0.45	0.38	30.1%	42.5	1328	0.21	4.39
2090	265	3	23	80.0	$70,739,711.78	3.93%	0.13	0.37	0.30	30.1%	42.5	1206	0.19	4.08
2222	270	3	23	80.0	$74,781,199.92	4.58%	0.15	0.43	0.35	30.0%	42.5	1209	0.24	4.77
2079	265	3	22	80.0	$66,715,141.45	3.26%	0.11	0.32	0.25	29.8%	42.5	1151	0.17	3.60

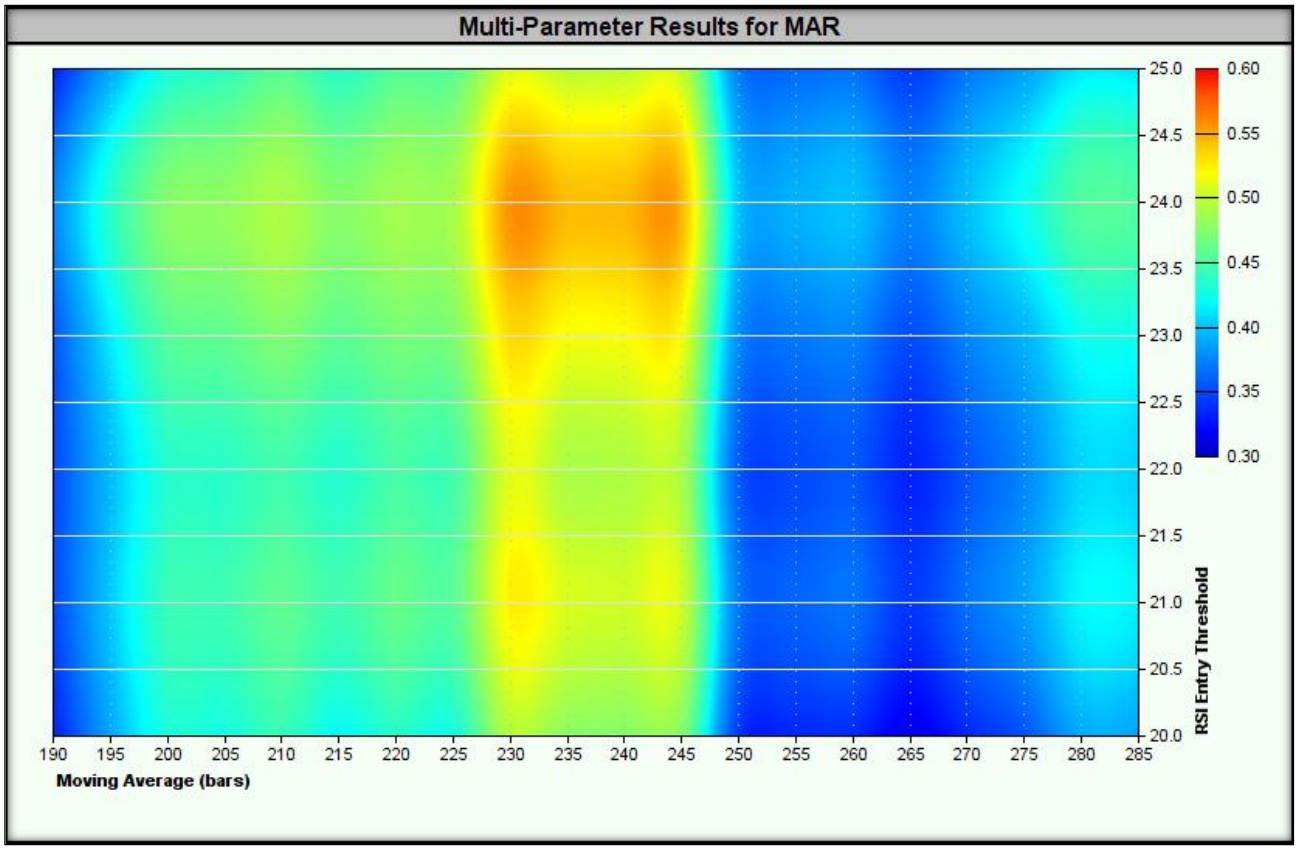
In summary, the strategy **passed the stability test** over a wide range of optimized parameters on out-of-sample data because:

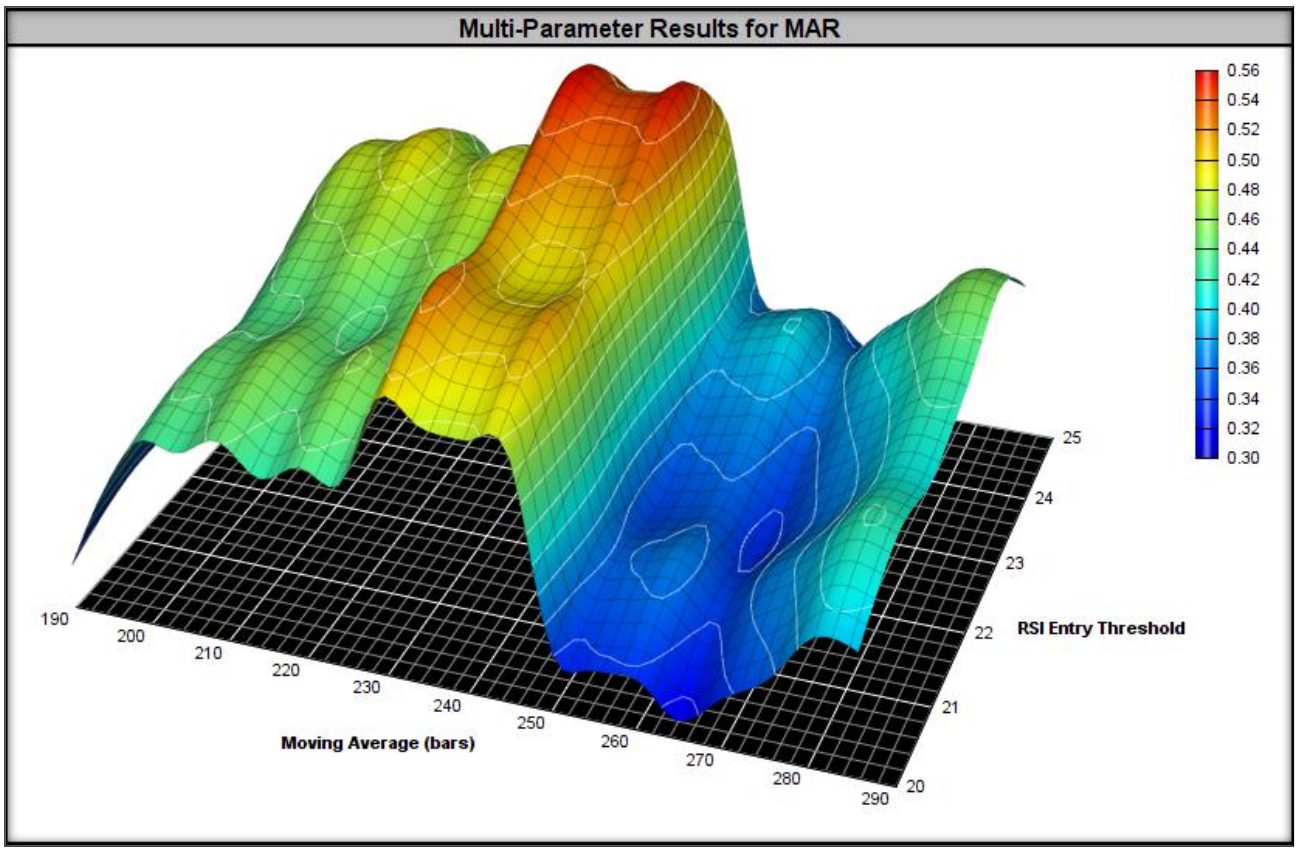
- **MAR value** – which indicates the stability of the strategy in various market conditions.
- **Maximum drawdown on out-of-sample data did not exceed 150% of the maximum drawdown value on in-sample data (33.5% vs. 35.1%)** – which means an acceptable risk of capital drawdown.
- **The decrease in the maximum MAR value on the out-of-sample data was less than 50% relative to the in-sample test results (0.91 vs. 0.51)** – indicating that the strategy can perform well in a variety of market conditions.

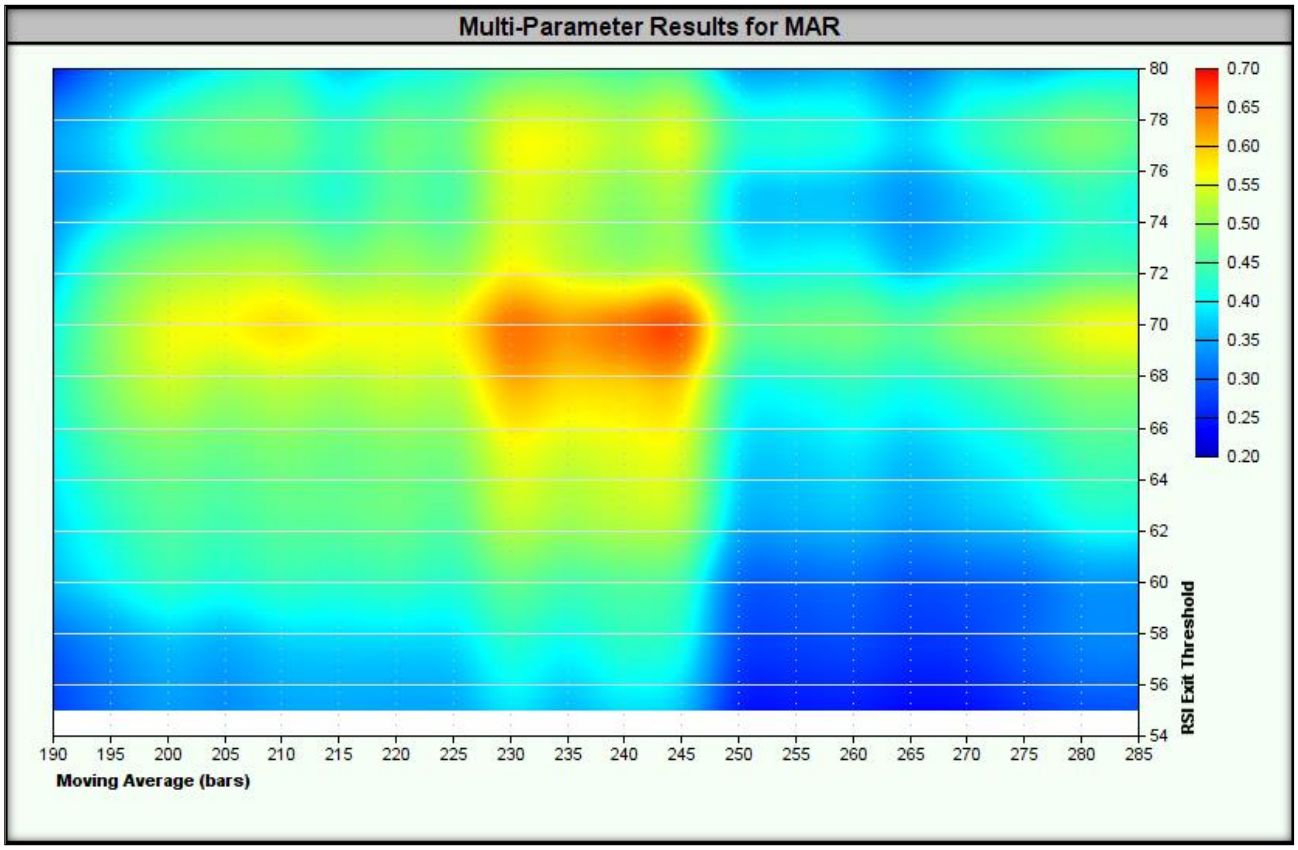
Heatmaps for the tested ranges are presented below.

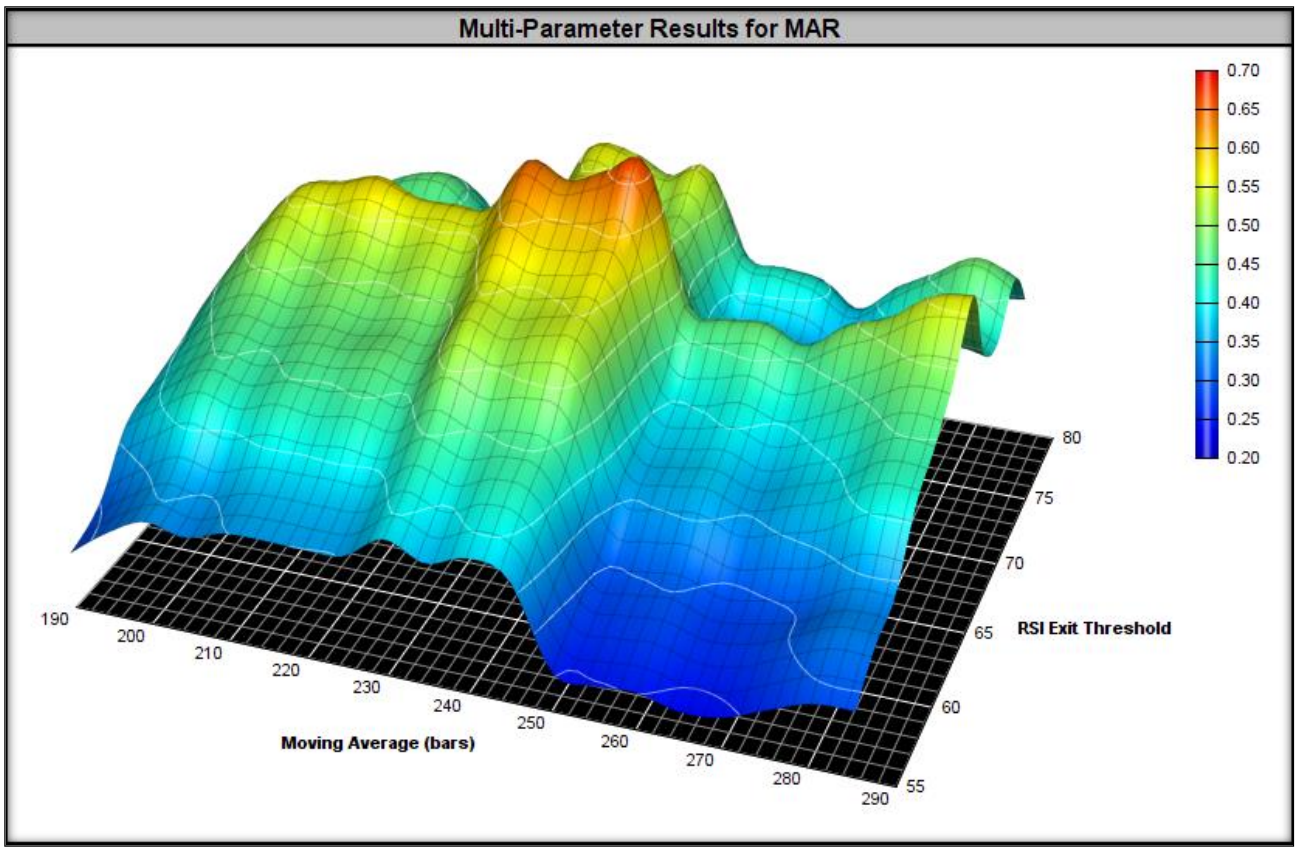

Multi-Parameter Results for MAR
Moving Average (bars)
RSI (bars)

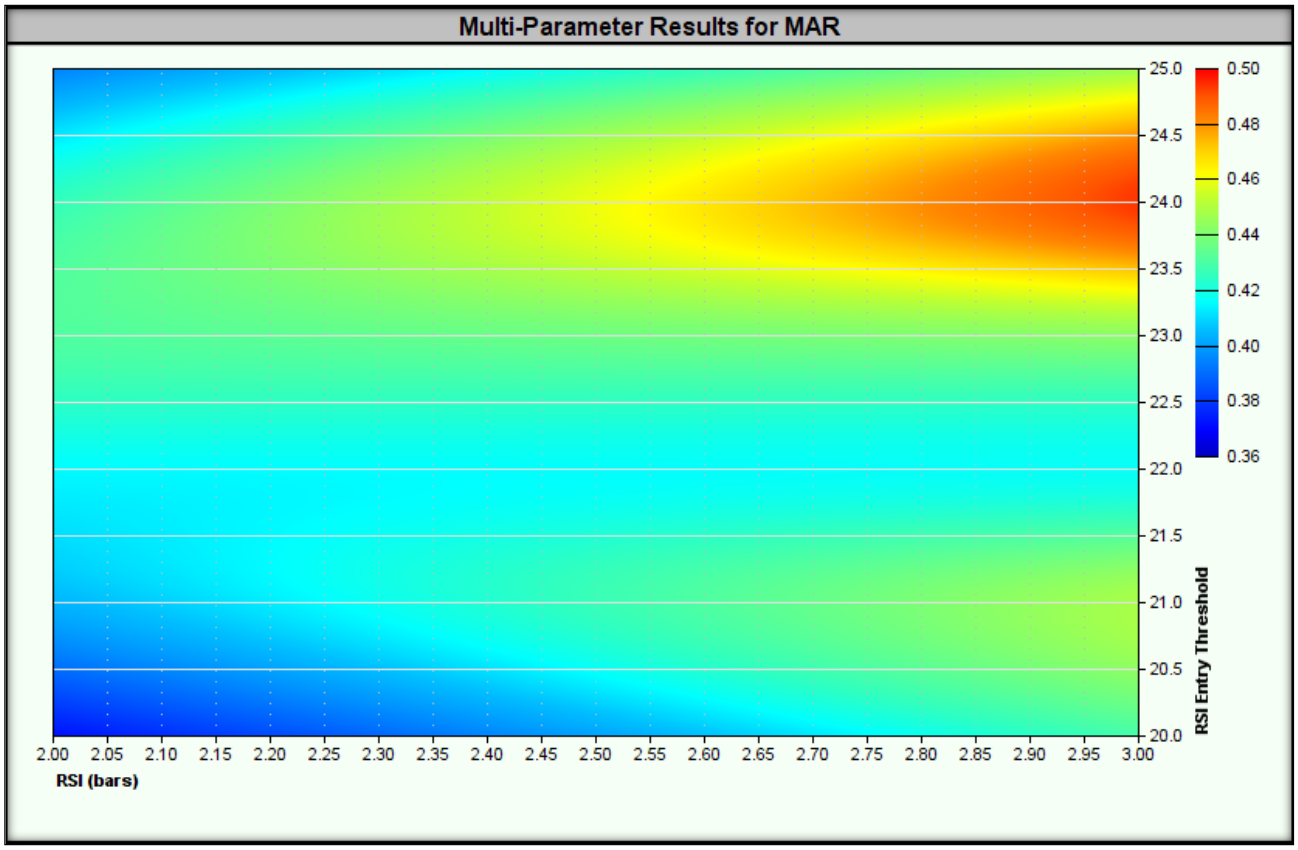

Multi-Parameter Results for MAR
Moving Average (bars)
RSI (bars)

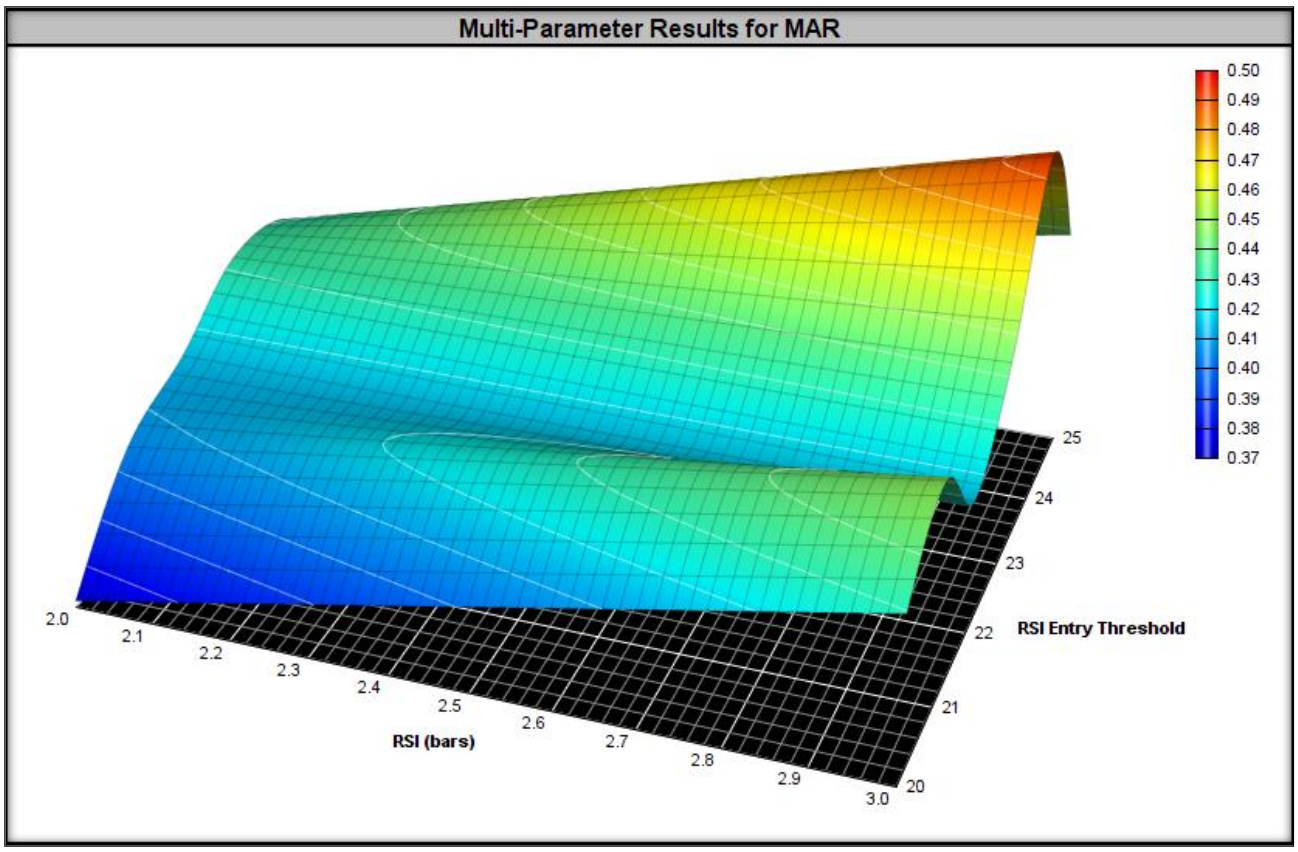

Multi-Parameter Results for MAR
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
RSI Entry Threshold
0.60
0.55
0.50
0.45
0.40
0.35
0.30
190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285
Moving Average (bars)

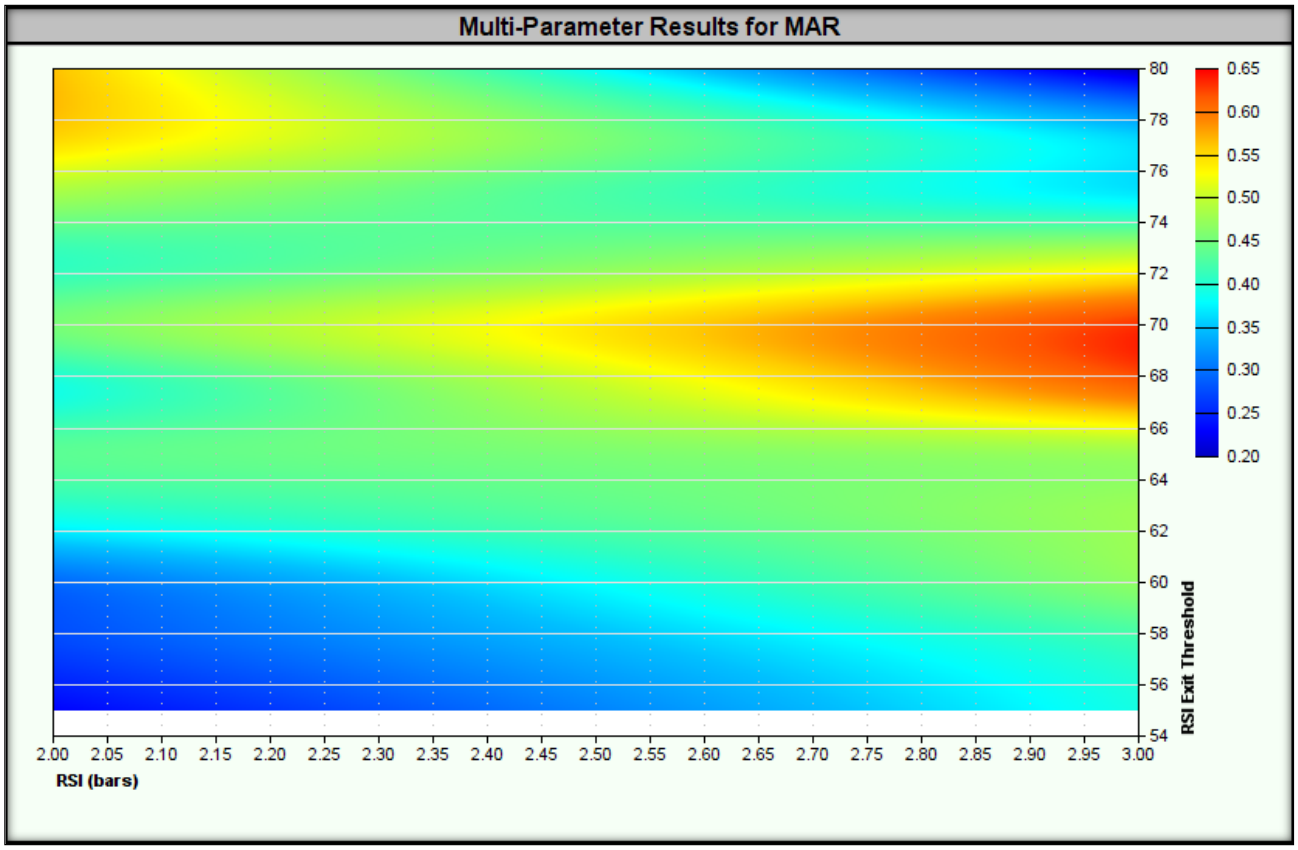

Multi-Parameter Results for MAR
0.56
0.54
0.52
0.50
0.48
0.46
0.44
0.42
0.40
0.38
0.36
0.34
0.32
0.30
190
200
210
220
230
240
250
260
270
280
290
Moving Average (bars)
25
24
23
22
21
20
RSI Entry Threshold

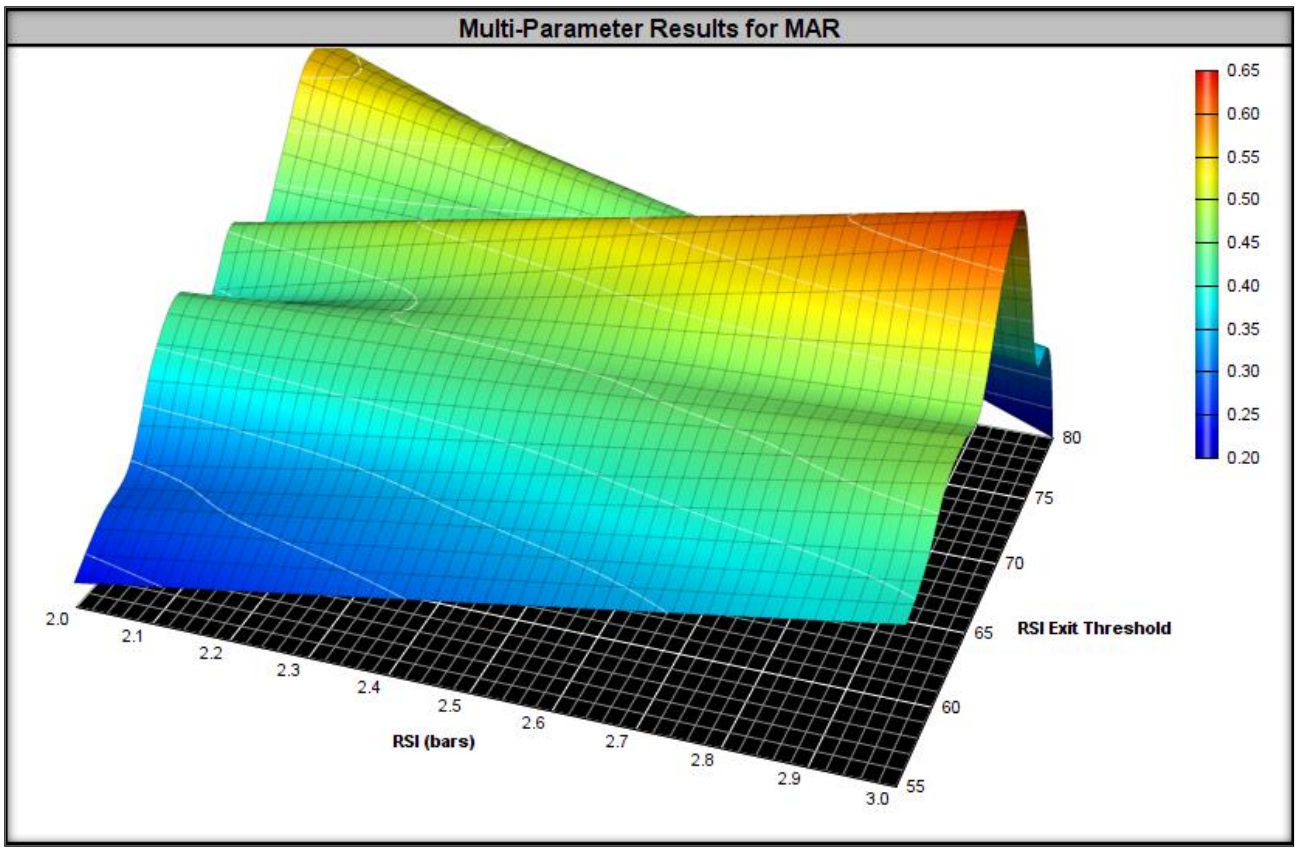

Multi-Parameter Results for MAR
Moving Average (bars)
RSI Exit Threshold

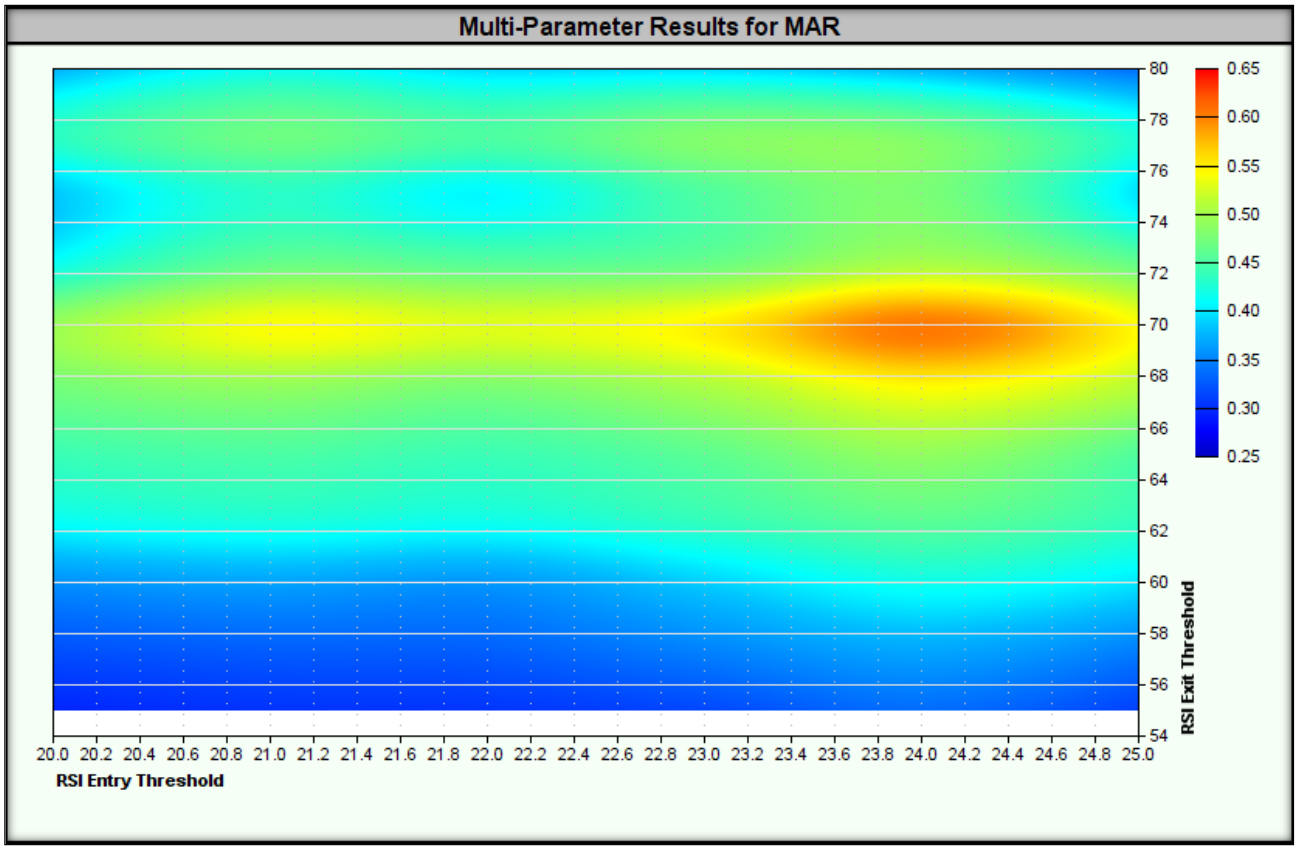

Multi-Parameter Results for MAR
Moving Average (bars)
RSI Exit Threshold

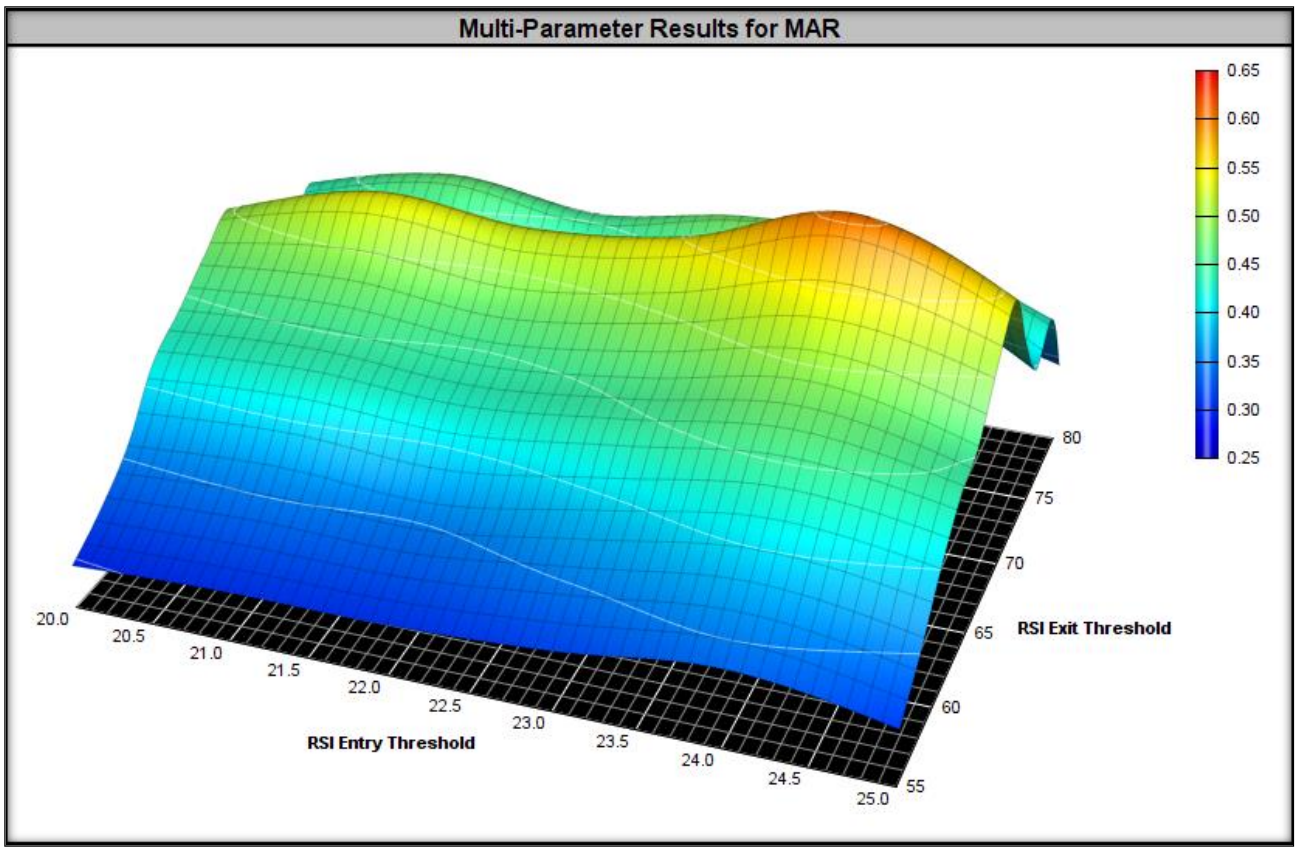

Multi-Parameter Results for MAR
RSI (bars)
RSI Entry Threshold

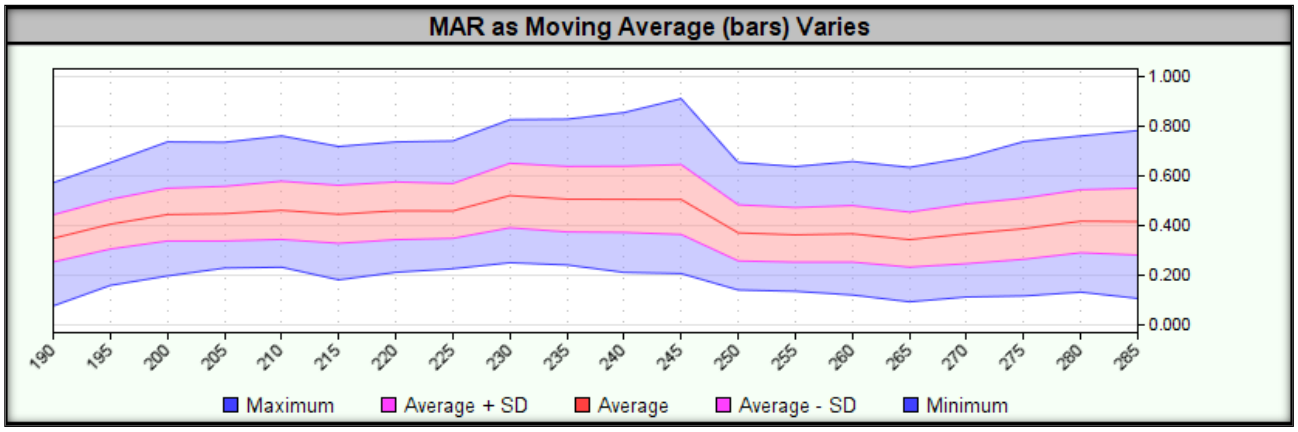

Multi-Parameter Results for MAR
RSI (bars)
RSI Entry Threshold

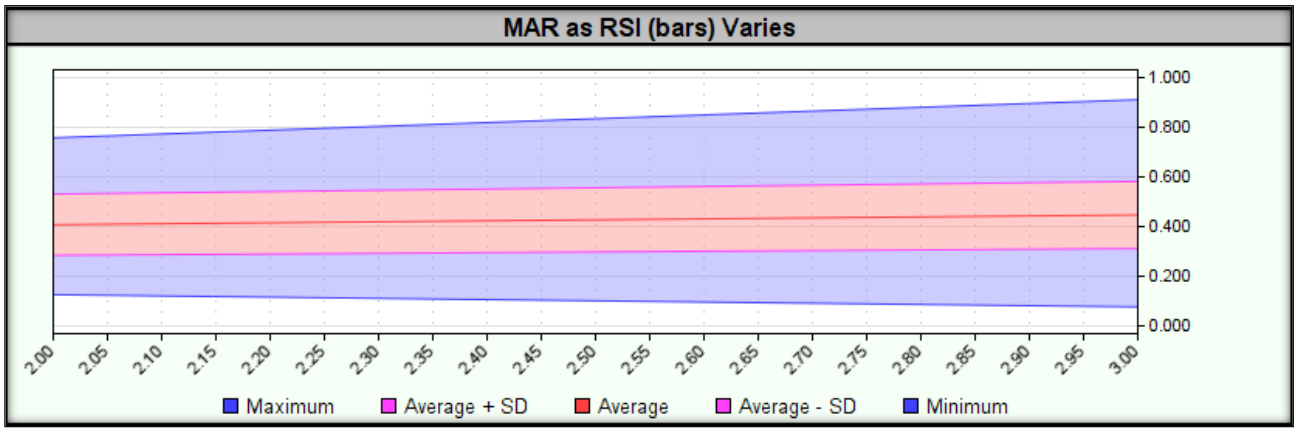

Multi-Parameter Results for MAR
RSI (bars)
RSI Exit Threshold

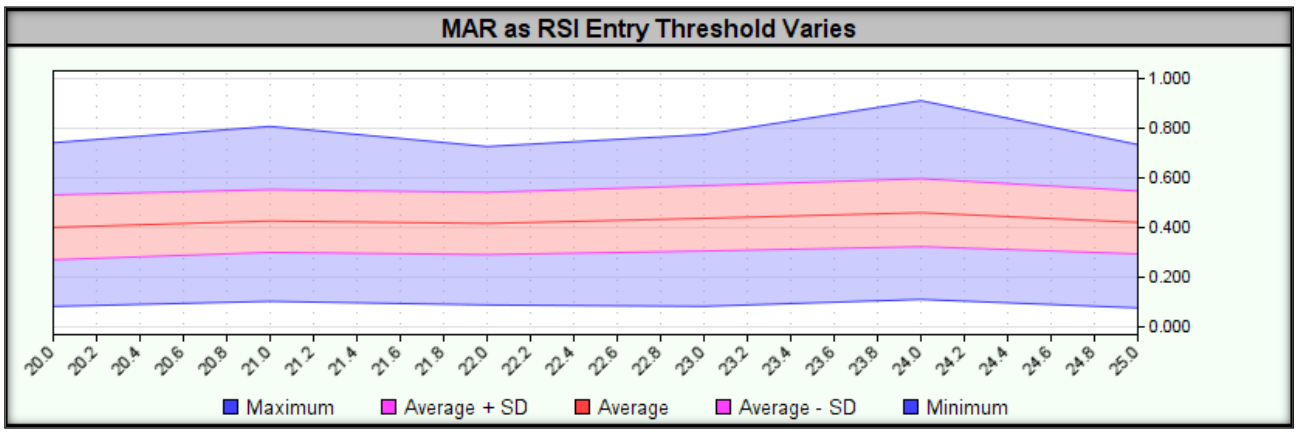

Multi-Parameter Results for MAR
RSI (bars)
RSI Exit Threshold

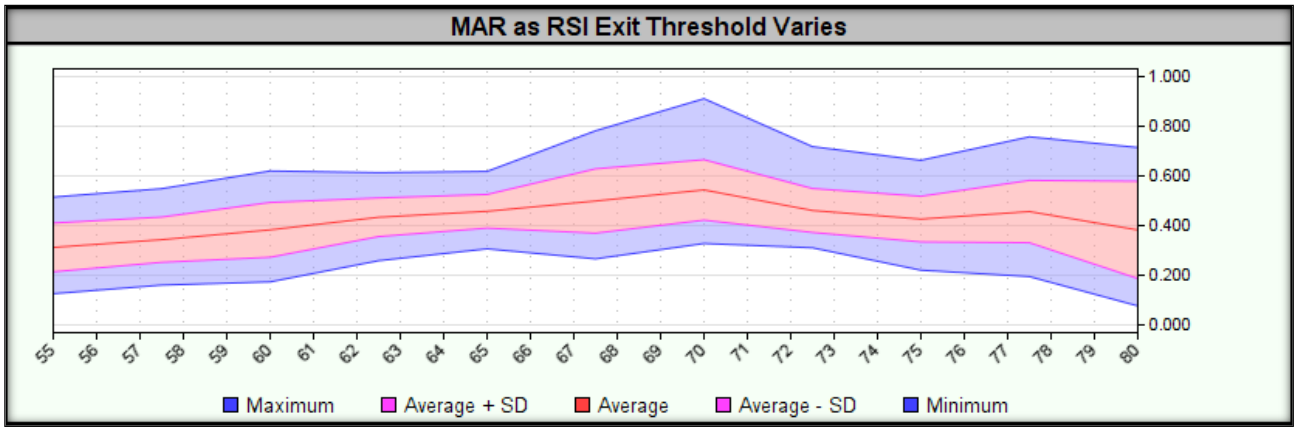

Multi-Parameter Results for MAR
RSI Entry Threshold
RSI Exit Threshold


Multi-Parameter Results for MAR
RSI Entry Threshold
RSI Exit Threshold


MAR as Moving Average (bars) Varies
1.000
0.800
0.600
0.400
0.200
0.000
190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285
Maximum
Average + SD
Average
Average - SD
Minimum


MAR as RSI (bars) Varies
1.000
0.800
0.600
0.400
0.200
0.000
2.00 2.05 2.10 2.15 2.20 2.25 2.30 2.35 2.40 2.45 2.50 2.55 2.60 2.65 2.70 2.75 2.80 2.85 2.90 2.95 3.00
Maximum
Average + SD
Average
Average - SD
Minimum


MAR as RSI Entry Threshold Varies
1.000
0.800
0.600
0.400
0.200
0.000
20.0 20.2 20.4 20.6 20.8 21.0 21.2 21.4 21.6 21.8 22.0 22.2 22.4 22.6 22.8 23.0 23.2 23.4 23.6 23.8 24.0 24.2 24.4 24.6 24.8 25.0
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.

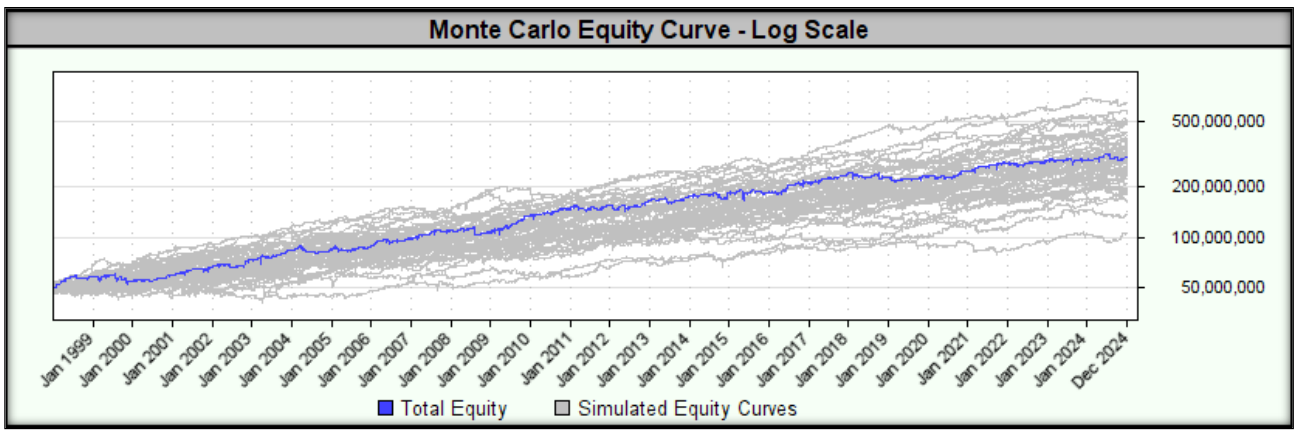
2. Monte Carlo simulation

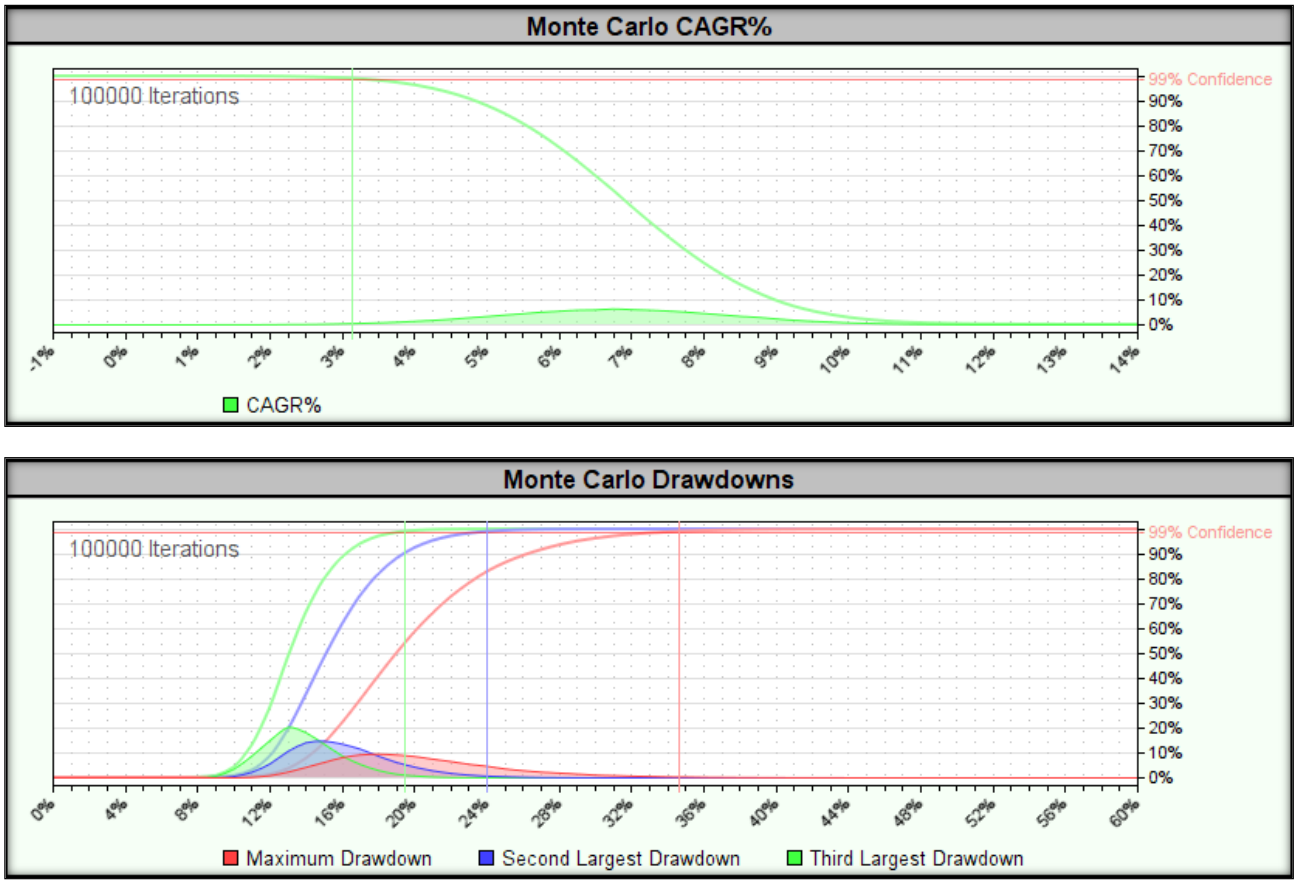
Monte Carlo simulation involves running multiple simulations to examine how a strategy might perform in different market scenarios. The key objective of this method is to assess the potential **drawdown** of an optimized strategy. **Monte Carlo simulation** better reflects the possible swings of the 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** was carried out **Monte Carlo simulation** 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%.**

The simulation with sample replacement are presented below.





- **CAGR%** – In 99% of simulations achieved **a rate of return equal to or higher than 3%.**
- **Drawdown** – in 99% of simulations, **drawdown equal to or lower than 34.8% was achieved.** For parameters optimized on in-sample data, drawdown was 13.2%.

The strategy stability criteria **were not met** because **the drawdown In Monte Carlo simulation He exceeded 250% values drawdown from tests on optimized parameters.** Therefore, **further testing of the strategy is not justified,** because its use in real transactions **is highly doubtful.**

3. **Stability over a moving time window**

This step was skipped due to **failure of previous stability tests.**

4. **Stability long/short**

This step was skipped due to **failure of previous stability tests.**

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

This step was skipped due to **failure of previous stability tests.**

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

This step was skipped due to **failure of previous stability tests.**

7. Strategy Risk Management

This step was skipped due to **failure of previous stability tests.**

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 profit and risk** after the optimization process and allows for answering 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 measure 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.

This step was skipped due to **failure of previous stability tests.**

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 previously established rules and formulas.

The most important element of **strategy implementation** is **consistent enforcement of all signals, without exceptions. How 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 to fully implement it 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.