Small Turtle v.1

Investment Strategy Testing Summary

Small Turtle Strategy **v.1** is a mechanical **trend-following** system, inspired by Richard Dennis's original "turtle" principles. It uses the **55/20-day Donchian channel** to define entry and exit points, as well as **the ATR(20) volatility** to determine position sizes, stop loss distances, and pyramiding steps. Positions are built gradually, with subsequent units added every **0.5 × ATR(20),** up to a maximum of **4 units per instrument,** with a fixed **stop loss of 2 × ATR(20)** from the last entry. The risk of one unit is set at **1% of the portfolio value** (fixed fractional). The strategy is designed to trade futures markets and instruments that historically exhibit strong trends.

It's worth noting that while the strategy's results on in-sample data are decent, the strategy failed stability testing across a wide range of optimized parameters. This means the strategy loses its profitability and generates significantly larger drawdowns when tested with suboptimal parameters. Therefore, **it is not recommended for use in real-world trading.**

Our goal is to have a strategy that remains **profitable and effective across a wide range of parameters,** because the market is a volatile organism, and optimal parameters can change over time. **I can't** emphasize enough that for **a strategy to work** in real-world conditions, it must also perform under **suboptimal parameters** and **conditions.** In short, **it must be stable** to changing market conditions.

I don't know who said these words, but they perfectly capture 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

Small Turtle Strategy **v.1** originates from the classic "turtle" strategy. It's based on the observation that **the biggest trends** emerge after breakouts from long-term consolidations. The system defines such a consolidation as a range **of the last 55 sessions** and treats **a breakout above the highest high from that period** as a signal of the start or continuation of an uptrend (long position), while **a breakout below the lowest low** as a signal of a downtrend (short position).

The first unit of the position is opened, sized so that **a price movement of 2×ATR(20)** in an unfavorable direction would result in **an approximately 1% decline in the portfolio's value.** If the trend develops as expected, each price movement towards the open position by **0.5×ATR(20)** results in the addition of another unit (pyramidization), up to a maximum of **4 units on a single instrument. A stop loss** is maintained for the entire position **at a distance of 2×ATR(20)** from the last entry level, allowing for upfront risk control.

The market exit occurs via **a counter-movement breakout of the 20-day Donchian channel** – the long position is closed when the price breaks down below **the 20-day low,** and the short position is closed when the price breaks up above **the 20-day high.** As a result, the system gives back some profit at the end of the trend, but in return, **it holds the position for most of the strong move.** At the portfolio level, additional limits are applied to the number of units in **strongly and weakly correlated markets** and **to the maximum directional exposure** – to 6, 10, and 12 units, respectively – which limits risk concentration.

The Small Turtle v.1 strategy uses:

- **Donchian Channel for opening positions** – used to identify breakouts from long consolidations;
- **Donchian Channel for closing positions** – signals when a trend ends;
- **Average True Range (ATR)** – used to determine position size, stop-loss levels, and pyramid entry levels;
- **Pyramiding** – adding units in the direction of profit, up to a maximum of 4 units;
- **Portfolio limits** – maximum number of units allocated to correlated markets and in a single direction.

Characteristics of the strategy and its strengths and weaknesses:

- **Strengths:**
  - **Natural trend-following system** – profits from rare, large trends;
  - **Fully mechanical** – no discretion, easy to test and automate;
  - **Pyramiding Winners** – Increasing your exposure when the market behaves as expected;
  - **Risk scaled by ATR** – adjusting the position to current volatility.
- **Weaknesses:**
  - **Poor performance in consolidations** – numerous false breakouts and short, losing trades;
  - **Delayed entries** – joining the trend only after breaking out of the range;
  - **The need for broad diversification** – a single market may not generate profitable trends for a long time.

Small Turtle v.1 strategy, despite its relatively simple structure, requires the acceptance of longer periods of drawdowns and consistent adherence to money management principles, but in return it gives the opportunity to participate in large, directional price movements.

Step 2: Determine investment principles

Below is **the pseudocode** for the **Small Turtle v.1 strategy** on daily data:

1. **Calculation of indicators:**
    a. **Entry Breakout (55 days):**
        i. **Upper Boundary:** Highest price in the last 55 sessions;
        ii. **Lower Boundary:** Lowest price over the last 55 sessions.
    b. **Exit Breakout (20 days):**
        i. **Upper Boundary:** Highest price in the last 20 sessions;
        ii. **Lower Boundary:** Lowest price in the last 20 sessions.
    c. **ATR(20):** 20-day average true volatility range.
2. **Entry – long position (buy):**
    a. **Entry condition:** the candle's high falls above the upper border of the 55-day Donchian channel.
    b. **Calculate the unit size** so that a price movement of 2 × ATR(20) down would mean a 1% decline in the portfolio value.
    c. **Open the first long unit**; set a stop loss 2 × ATR(20) below the entry price.
3. **Entry – short position (sell):**
    a. **Entry requirement:** The low of the candle falls below the lower border of the 55-day Donchian channel.
    b. **Calculate the unit size** as in point 2b.
    c. **Open the first short unit**; set stop loss 2 × ATR(20) above the entry price.
4. **Pyramiding positions:**
    a. If the price has moved towards profit by 0.5 × ATR(20) since the last entry price, add another unit in the same direction (long/short).
    b. After each unit addition, move the stop for the entire position so that it is approximately 2 × ATR(20) from the last entry level (according to the accepted method).
    c. Do not add more than 4 units per instrument (including the first one).
5. **Exiting a position:**
    a. **Long position:** Close all units when the price falls below the lower border of the 20-day Donchian channel or when a stop loss is activated.
    b. **Short position:** Close all units when the price rises above the upper border of the 20-day Donchian channel or when a stop loss is activated.
6. **Portfolio risk management:**
    a. Respect the maximum unit limits for closely correlated markets (6 units), weakly correlated markets (10 units) and the total number of units in one direction (12 units).
    b. Do not open new positions if adding another unit violates any of these restrictions.
7. **Daily monitoring:**
    a. Donchian channel values (55 and 20 days) and ATR(20).
    b. Check entry, pyramiding, exit conditions and compliance with portfolio limits.

The above rules are 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 **1.0% of the total capital,** with **the stop loss order placed 2 x ATR (20 days)** away from the position opening point.

Step 3: Pre-test your investment strategy

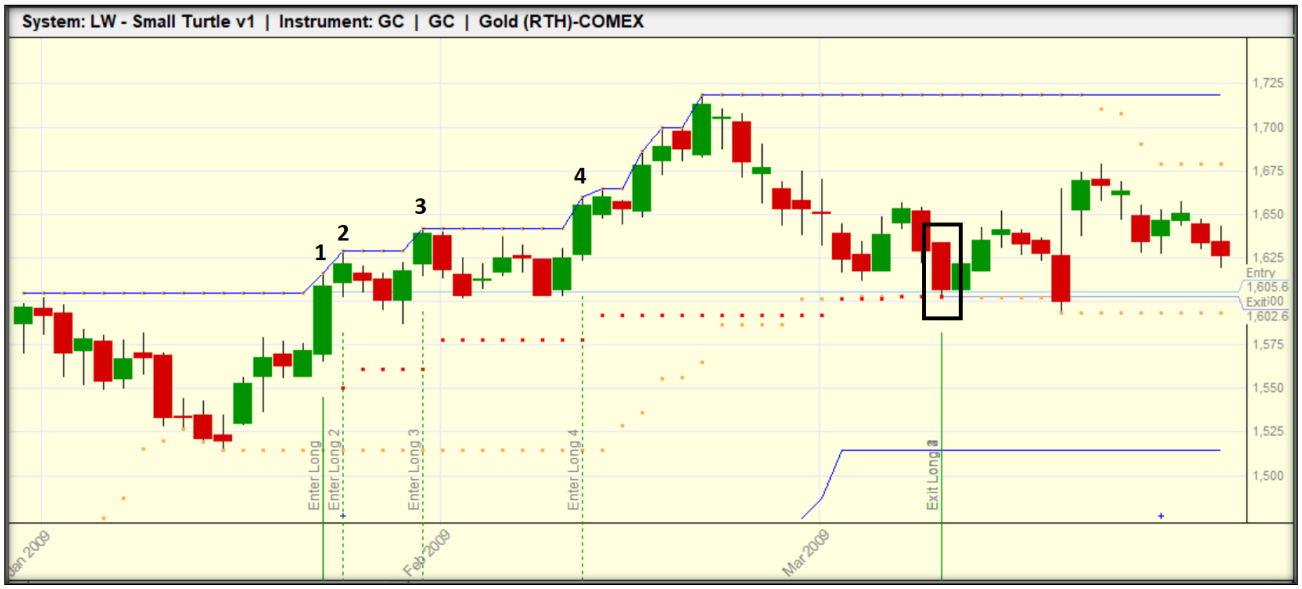
Below are some purchase and sale transactions that allow you to verify the following aspects:

- **Correctness of generated signals;**
- **Direction of opening a position;**
- **Moment of opening the position;**
- **The opening price of the position;**
- **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 doesn't matter** whether the trades are **profitable,** what **instrument was used,** or whether they occurred **recently** or **in the distant past.** The key is **to verify that the trades are generated correctly** and in line with the assumptions described in the previous step.

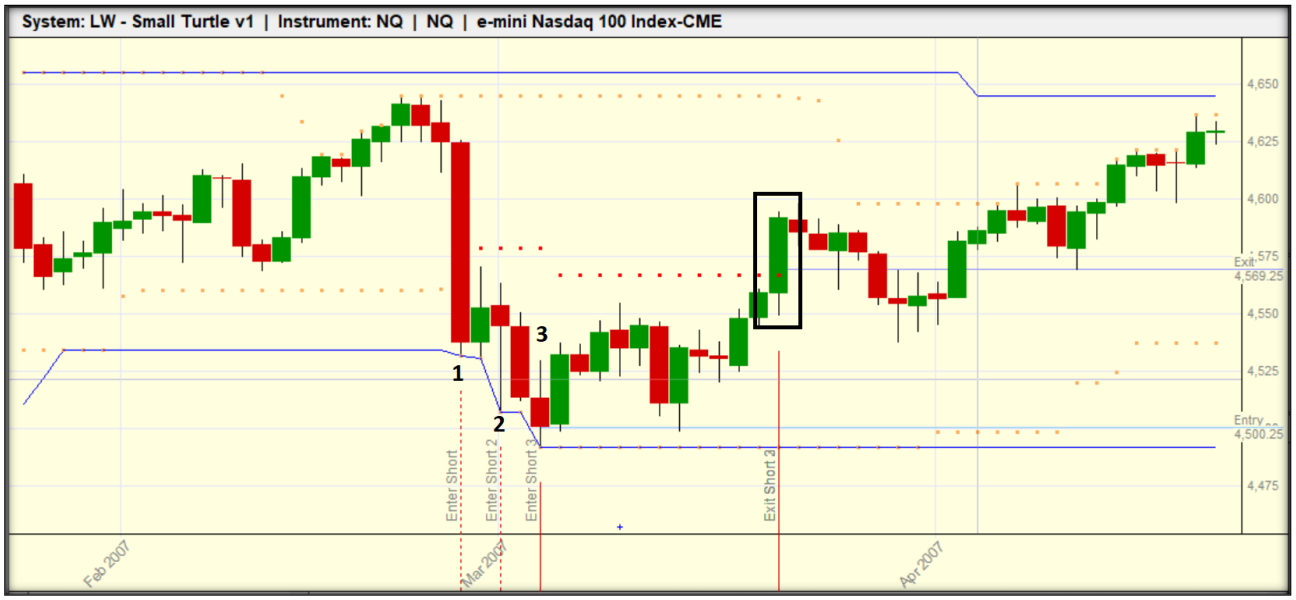
The first transaction was made on a gold futures contract. At the end of January 2009, the price **broke above the 55-day Donchian channel,** which, in accordance with the rules of the Small Turtle v.1 strategy, generated **the signal to open a long position** (the first candle marked with number 1). The system thus opened the first long unit, setting **the initial stop loss at a distance of 2 × ATR(20) below the entry price** (red dots on the chart). In the following days, **the market continued to rise,** and each **price move of 0.5 × ATR(20) up** opened **further units:** the second unit was added by candle marked with number 2, the third by candle 3, and the fourth by candle 4. **In total, a maximum, four-unit long position was built,** and the stop for the entire position was adjusted each time to remain at a distance of approximately 2 × ATR(20) from the last entry level. **The system worked as intended** – the position was increased only when the market was clearly moving towards profit.

According to the strategy's rules, a long position is held as long as the price **remains above the lower boundary of the 20-day Donchian channel or the stop loss level is not reached.** In early March 2009, a stronger downward correction occurred, and the low of one session (the candle marked with a rectangle) **fell below the 20-day low,** which **generated an exit signal.** According to the system, all four long units were closed. Throughout the entire transaction, the protective stop of 2 × ATR(20) was not hit, and the position was closed precisely when the price crossed the 20-day exit channel. **The system worked correctly.**



The second transaction was made on the futures contract for the Nasdaq 100 index. At the beginning of March 2007, after a strong, falling daily candle, **the price broke down the 55-day Donchian channel,** which, in accordance with the rules of the Small Turtle v.1 strategy, generated **signal to open a short position** (the first candle marked with number 1). Thus, the system opened the first long unit, setting **the initial stop loss at a distance of 2 × ATR(20) above the entry price** (red dots on the chart). As **the price continued to move down by subsequent multiples of 0.5 × ATR(20), further position units were added:** the second at candle marked with number 2, and the third at candle 3. As a result, a three-unit short position was built, and **the protective stop for the entire position** was adjusted each time so that it remained approximately **2 × ATR(20)** above the last entry level. **The system therefore implemented pyramiding only when the market was consistently moving towards profit.**

According to the strategy's rules, a long position is held as long as the price **remains below the upper boundary of the 20-day Donchian channel or the stop loss level is not reached.** A few weeks later, **the market entered an upward correction phase.** In mid-March, a strong bullish candle appeared on the chart (marked with a rectangle), **which triggered a defensive stop loss for all units.** Consequently, all three units were closed, generating a loss. **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 baseline parameters** proposed **by the strategy's creator, Richard Dennis.**

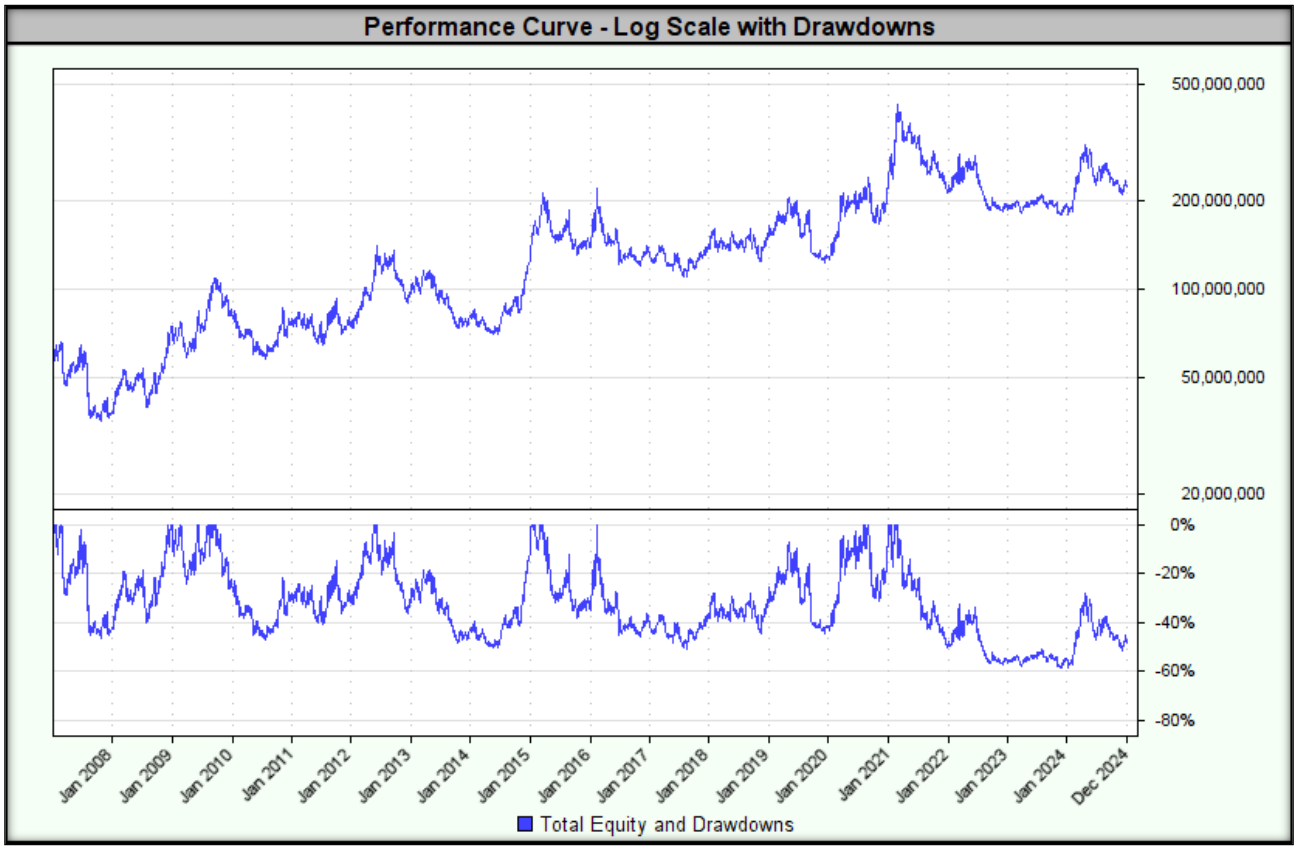
First, **we reject strategies that linearly lose capital.** If a strategy exhibits this pattern, it's a clear signal that any parameter optimization is pointless.

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

Tested base parameters:

- **Entry Breakout (days):** 55;
- **Exit Breakout (days):** 20;
- **ATR (days):** 20;
- **Stop loss:** 2 × ATR(20);
- **Pyramiding (Unit Add):** every 0.5 × ATR(20);
- **Max units in one instrument:** 4;
- **Max units in highly correlated instruments:** 6;
- **Max units in weakly correlated instruments:** 10;
- **Max units in one direction (long/short):** 12;
- **Position Sizing Method:** Fixed Fractional, 1% of capital per unit;
- **Position direction:** long and short.

The test result is shown below.



Indicators/Measures	Concluding a transaction at the opening price
CAGR%	8.7%
MAR Ratio	0.15
RAR%	9.9%
R-Cubed	0.06
Robust Sharpe Ratio	0.25
Max Drawdown	58.3%
Wins	31.4%
Losses	68.6%
Average Win%	1.10%
Average Loss%	0.41%
Win/Loss Ratio	2.68
Average Trade Duration (days)	35
Percent Profit Factor	1.22
SQN	0.54
Number of transactions	4154

In summary, the system is working properly and generating signals as expected. Furthermore, tests on the baseline parameters yielded satisfactory results. We can now move on to the most interesting stage of creating an investment strategy – **optimization and stability.**

Step 4: Optimizing and assessing the stability of the investment strategy

This stage of strategy development and testing is **crucial** because it determines how **effective** the strategy will be in **real-world conditions. I cannot** emphasize enough that for **a strategy to work** in real-world conditions, it must also perform under **suboptimal parameters** and **conditions.** In short, **it must be stable** to changing market conditions.

I don't know who said these words, but they perfectly capture 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 topic of consideration in **Step 5, "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

Turtle Strategy v.1 in this version, it assumes **the optimization of parameters proposed by the creator of the strategy, Richard Dennis.** The optimization will be performed using **The Grid method. Search,** which involves **full optimization of all specified parameters by creating a wide range of possible combinations.** Our goal is to find **parameter ranges** that will ensure **the strategy remains stable (robust),** allowing us to assess its suitability in real market conditions.

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

In the first step, we test the stability of the parameters on **the in-sample data.** To do this, we determine the ranges of parameter **values** so that **the ratio of the highest and lowest values of the range was at least 150%.**

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

- **Entry Breakout (days):** range **40–70 (step: 1);**
- **Exit Breakout (days):** range **15–25 (step: 1);**
- **Stop (ATR):** range **1.5–2.5 (step: 0.25).**

Other parameters remain unchanged.

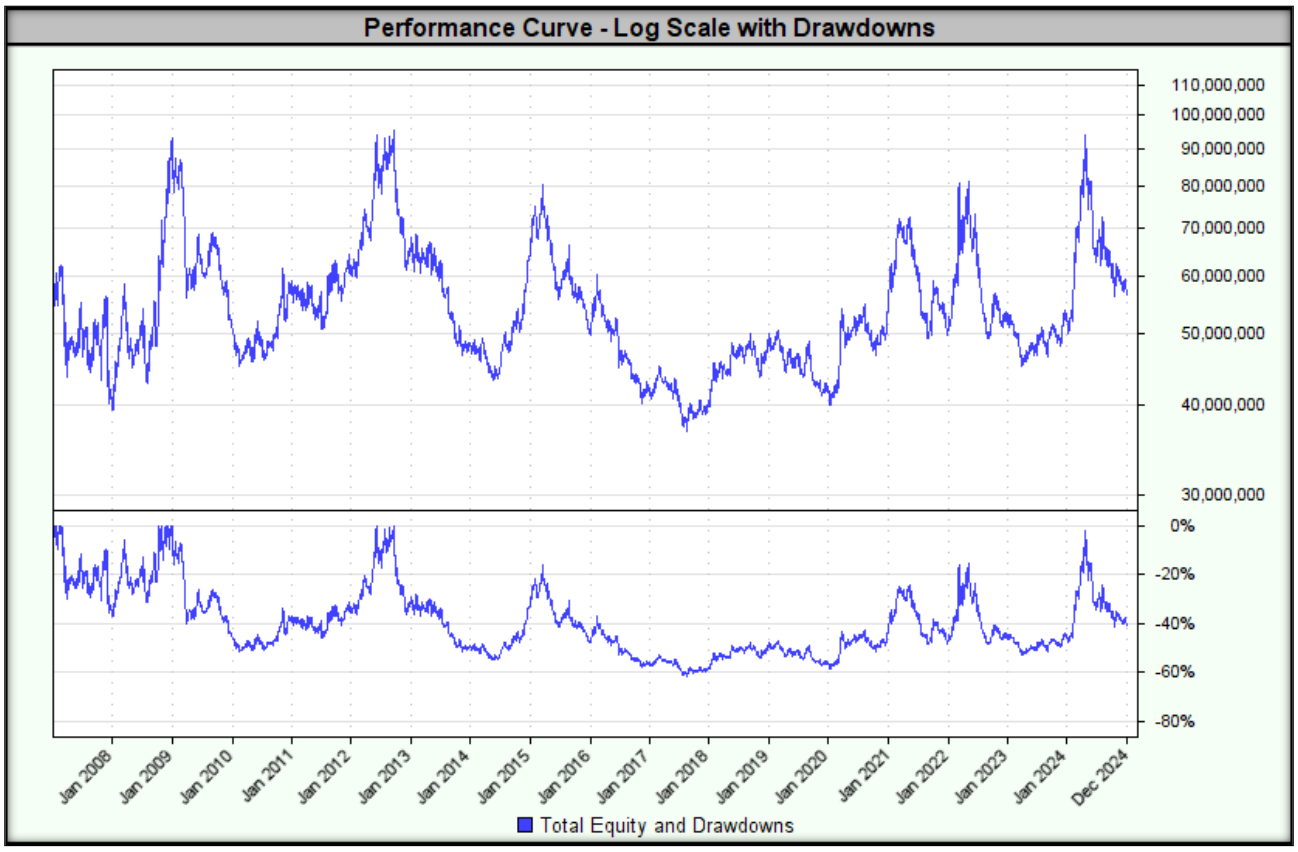
The lowest MAR value of 0.01 was achieved for the following parameters:

- **Entry Breakout (days):** 40;

- **Exit Breakout (days):** 15;
- **Alloy (ATR):** 2.5.

Test	Entry Breakout (days)	Stop (ATR)	Exit Breakout (days)	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF
45	40	2.50	15	$56,699,807.64	0.70%	0.01	0.17	0.02	61.5%	147.5	4721	-0.00	-0.29	1.08
408	47	2.00	15	$61,970,949.68	1.20%	0.02	0.21	0.03	63.2%	147.5	5020	0.00	0.32	1.10
354	46	2.00	16	$67,550,224.23	1.69%	0.03	0.22	0.04	63.0%	147.5	4918	0.01	0.88	1.12
299	45	2.00	16	$71,298,934.87	1.99%	0.03	0.23	0.05	63.7%	147.5	4892	0.01	1.36	1.12
516	49	1.75	24	$72,691,013.66	2.10%	0.03	0.24	0.06	63.8%	71.0	4324	0.01	1.65	1.13
144	42	2.25	15	$72,455,708.24	2.08%	0.03	0.23	0.05	59.7%	147.5	4882	0.00	0.60	1.11
24	40	2.00	16	$75,058,445.08	2.28%	0.04	0.24	0.05	65.0%	101.1	4973	0.01	1.76	1.12
244	44	2.00	16	$74,958,313.21	2.28%	0.04	0.24	0.05	64.1%	101.2	4886	0.01	2.02	1.13
409	47	2.00	16	$75,027,992.32	2.28%	0.04	0.24	0.06	61.3%	147.5	4876	0.02	2.04	1.12
562	50	1.75	15	$78,699,675.34	2.55%	0.04	0.24	0.06	64.0%	147.5	5337	0.02	2.77	1.12
12	40	1.75	15	$80,611,885.17	2.69%	0.04	0.24	0.05	67.3%	147.5	5652	0.01	1.93	1.12

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



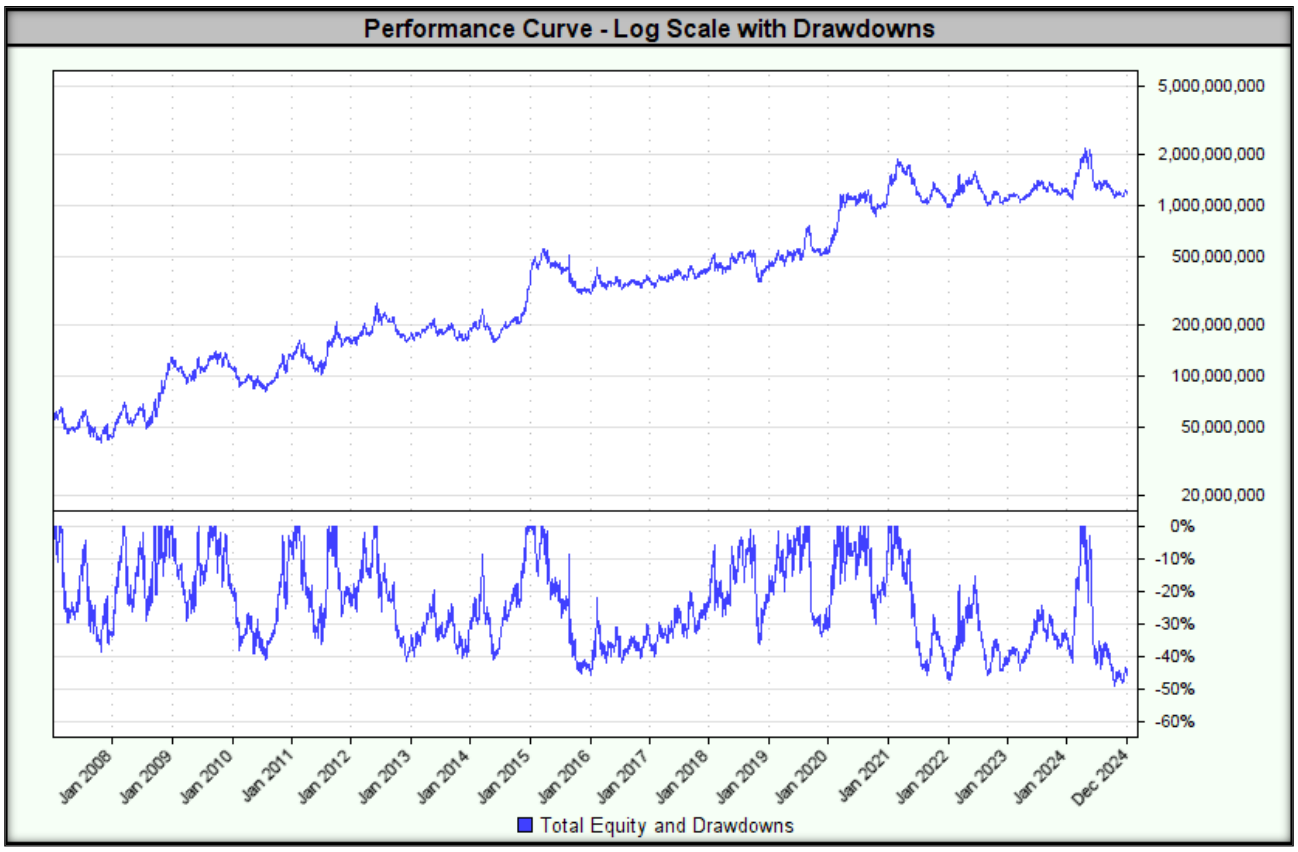
The highest MAR value of 0.39 was achieved for the following parameters:

- **Entry Breakout (days):** 40;
- **Exit Breakout (days):** 25;
- **Alloy (ATR):** 2.25.

The highest MAR value was accompanied by **a drawdown of 49.0%.**

Test	Entry Breakout (days)	Stop (ATR)	Exit Breakout (days)	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF
44	40	2.25	25	$1,173,982,779.98	19.17%	0.39	0.61	0.36	49.0%	51.6	3539	0.20	21.57	1.40
961	57	2.00	18	$1,662,668,849.54	21.49%	0.37	0.66	0.35	57.7%	43.7	4202	0.19	22.74	1.42
1072	59	2.00	19	$1,410,826,648.40	20.39%	0.36	0.65	0.35	56.4%	60.0	4069	0.15	19.29	1.41
66	41	1.50	25	$1,182,780,155.50	19.22%	0.36	0.59	0.30	53.2%	39.5	4629	0.16	19.35	1.31
906	56	2.00	18	$1,527,651,276.84	20.92%	0.36	0.64	0.39	58.0%	43.7	4240	0.19	23.47	1.41
1291	63	2.00	18	$1,648,006,138.76	21.43%	0.36	0.67	0.38	60.0%	59.6	4090	0.16	20.50	1.45
1336	64	1.75	19	$1,452,153,253.79	20.58%	0.35	0.62	0.39	58.1%	59.6	4346	0.14	19.78	1.42
1061	59	1.75	19	$1,504,308,190.24	20.82%	0.35	0.62	0.35	59.0%	59.6	4465	0.15	20.83	1.42
1346	64	2.00	18	$1,519,669,377.04	20.89%	0.35	0.66	0.38	60.3%	59.6	4074	0.15	20.16	1.43
795	54	2.00	17	$1,492,440,440.29	20.77%	0.35	0.62	0.41	60.0%	43.7	4381	0.21	22.77	1.40
209	43	2.25	25	$875,661,068.25	17.24%	0.34	0.58	0.34	50.1%	46.2	3447	0.18	18.10	1.37

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 72.5%.**

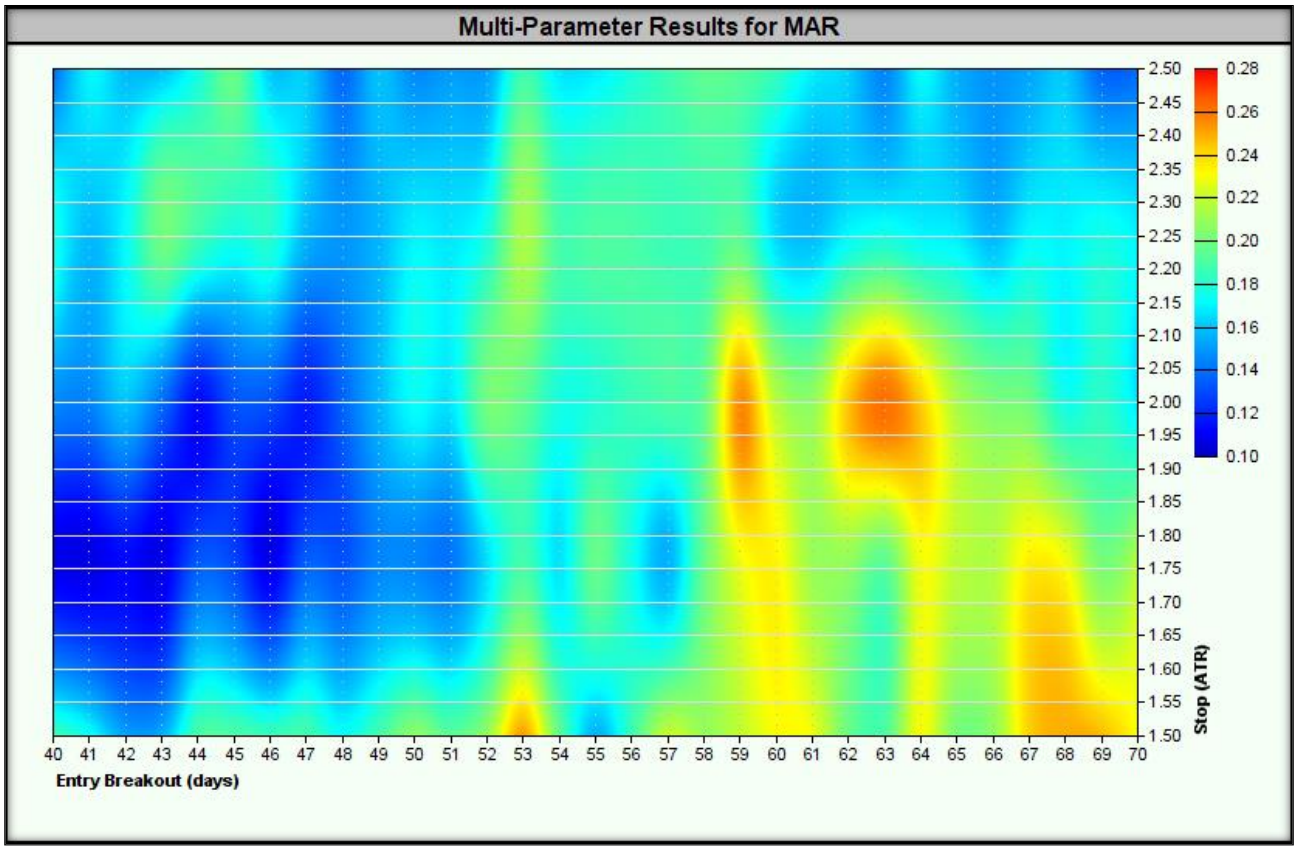
Test	Entry Breakout (days)	Stop (ATR)	Exit Breakout (days)	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF
59	41	1.50	18	$800,431,991.03	16.66%	0.23	0.52	0.25	72.5%	47.3	5531	0.12	18.81	1.33
1221	62	1.50	25	$327,458,406.31	11.01%	0.15	0.44	0.23	71.8%	70.0	4535	0.07	11.80	1.27
1276	63	1.50	25	$411,606,067.83	12.43%	0.17	0.47	0.25	71.8%	69.8	4454	0.08	13.08	1.30
836	55	1.50	25	$234,442,583.03	8.96%	0.12	0.40	0.21	71.8%	62.4	4655	0.06	10.71	1.23
835	55	1.50	24	$157,786,982.66	6.59%	0.09	0.36	0.15	71.5%	59.8	4720	0.05	7.57	1.21
58	41	1.50	17	$268,273,195.79	9.78%	0.14	0.41	0.15	70.7%	43.8	5756	0.06	10.08	1.23
834	55	1.50	23	$449,512,490.40	12.98%	0.18	0.48	0.22	70.7%	53.5	4774	0.11	16.41	1.30
114	42	1.50	18	$468,710,282.27	13.24%	0.19	0.49	0.23	70.7%	47.2	5554	0.10	15.57	1.28
1651	70	1.50	15	$137,855,939.71	5.80%	0.08	0.33	0.14	70.5%	117.5	5376	0.03	5.54	1.17
1219	62	1.50	23	$384,126,383.29	11.99%	0.17	0.46	0.21	70.4%	71.3	4637	0.09	12.88	1.29
1487	67	1.50	16	$292,101,481.93	10.30%	0.15	0.43	0.22	70.4%	70.7	5245	0.07	10.74	1.24

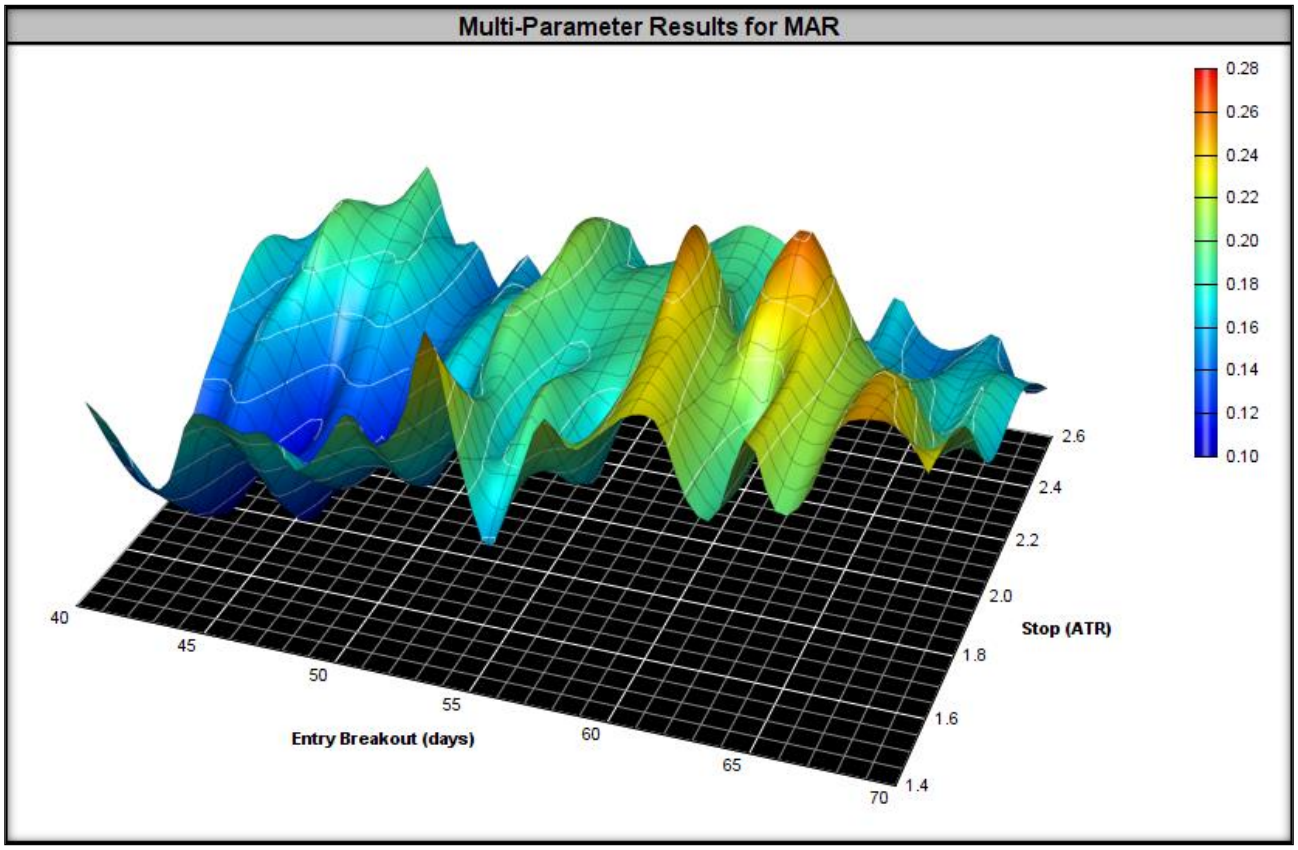
In summary, the strategy **passed the stability test** over a wide range of optimized parameters on in-sample data because:

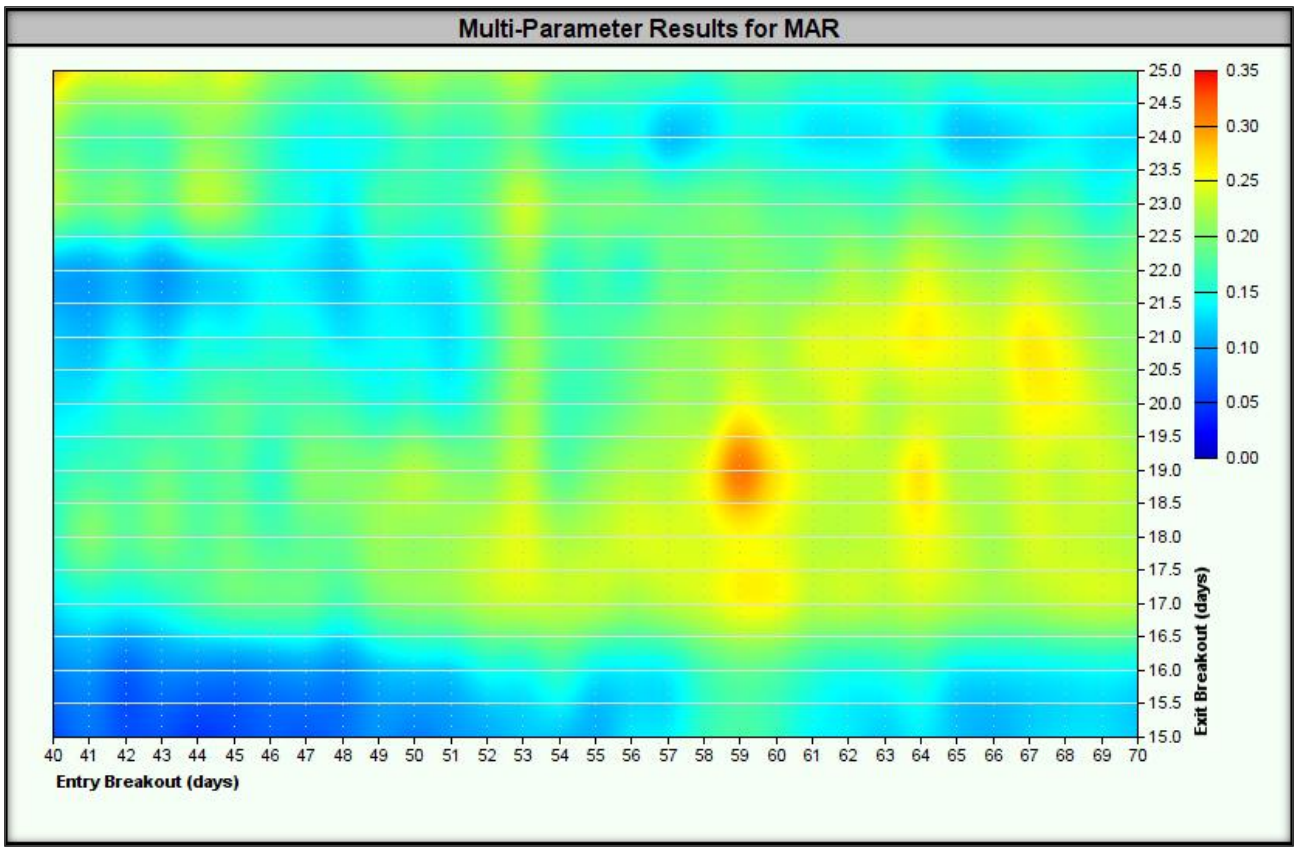
- **MAR value** – which indicates the stability of the strategy in various market conditions.

- **The maximum drawdown did not exceed 150% of the drawdown value** for the result with the highest MAR (**72.5% vs. 49.0%)** – which means an acceptable risk of deep capital drawdowns.

Heatmaps for the tested ranges are shown below.







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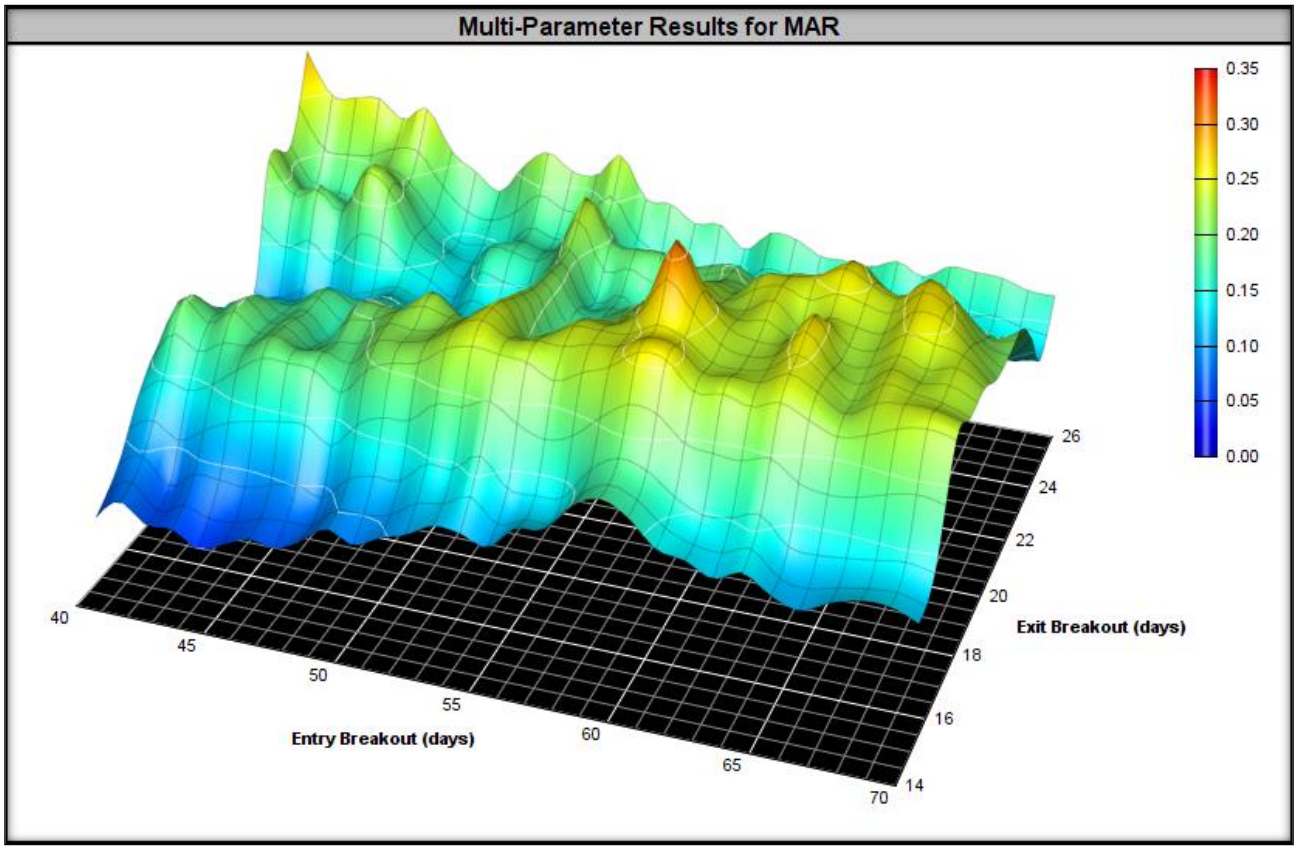

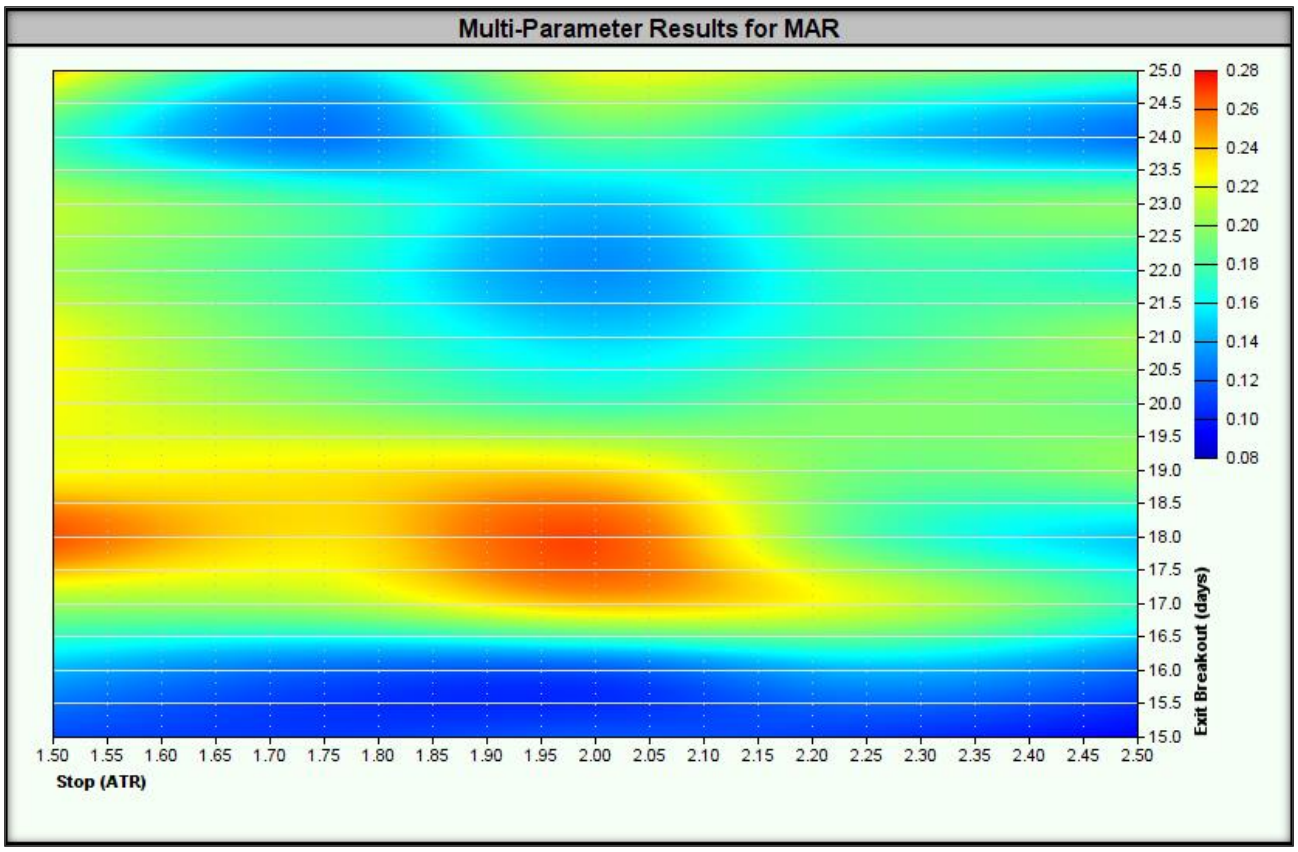

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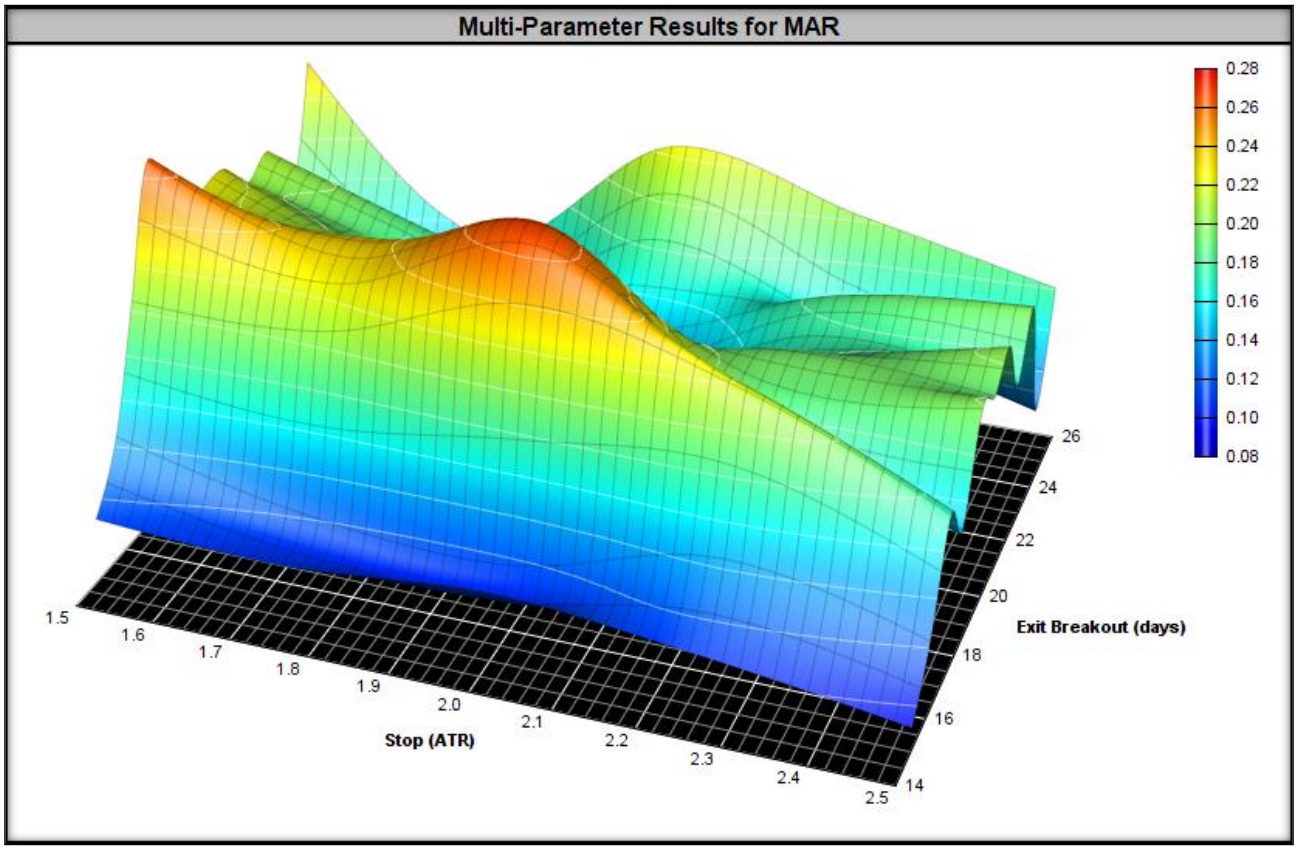
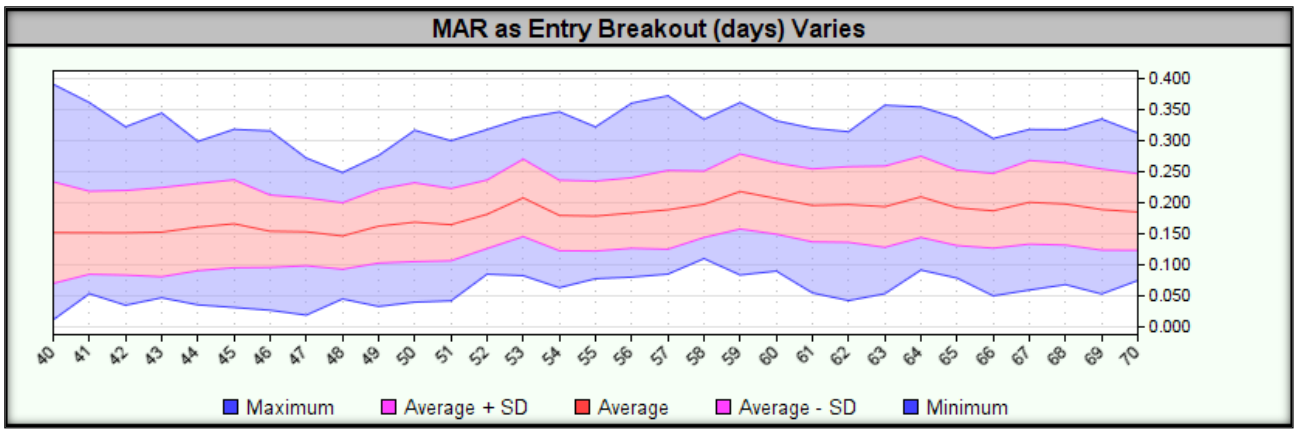
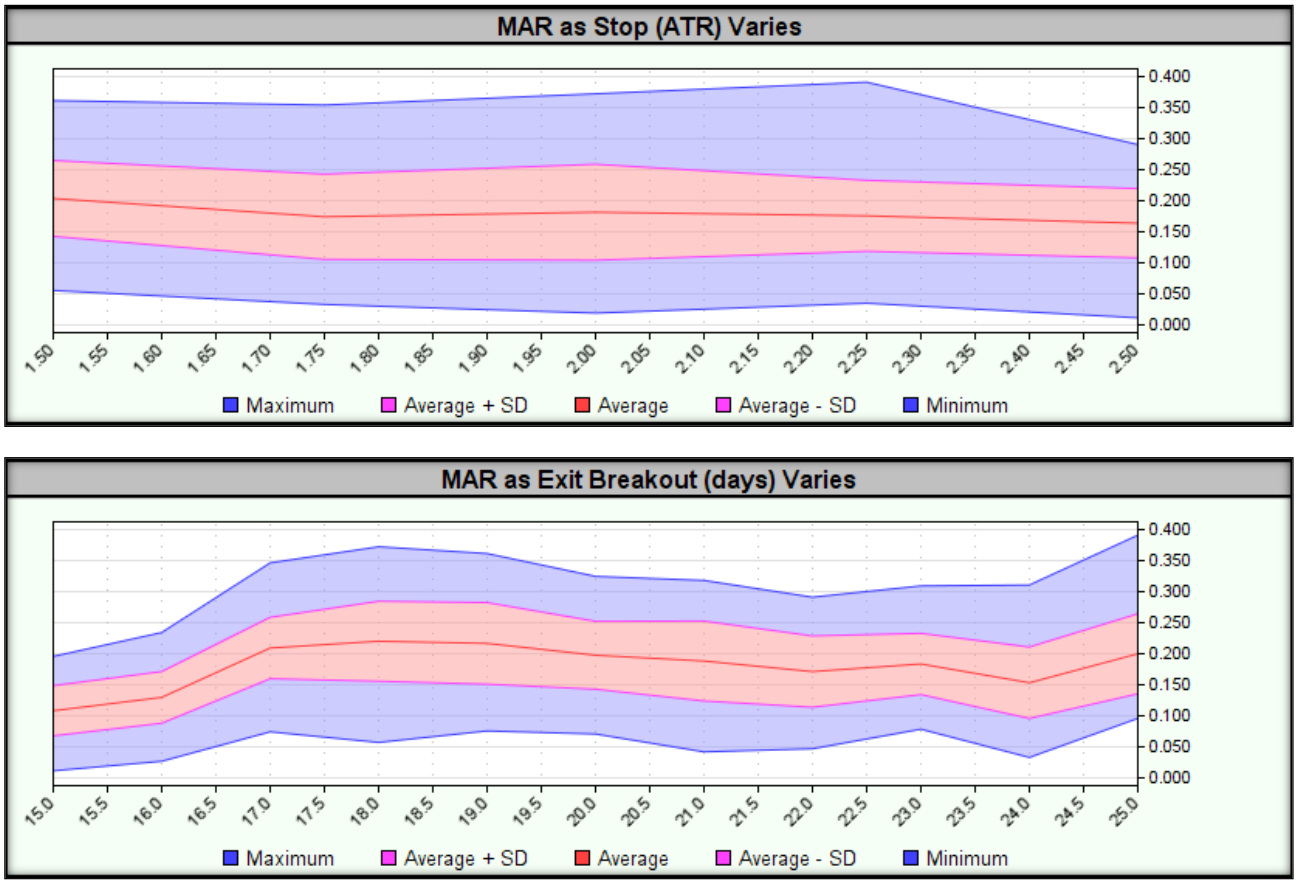

Multi-Parameter Results for MAR
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
Stop (ATR)
26
24
22
20
18
16
14
Exit Breakout (days)


MAR as Entry Breakout (days) Varies
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
Maximum
Average + SD
Average
Average - SD
Minimum



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

- **Entry Breakout (days):** range **40–70 (step: 1);**
- **Exit Breakout (days):** range **15–25 (step: 1);**
- **Stop (ATR):** range **1.5–2.5 (step: 0.25).**

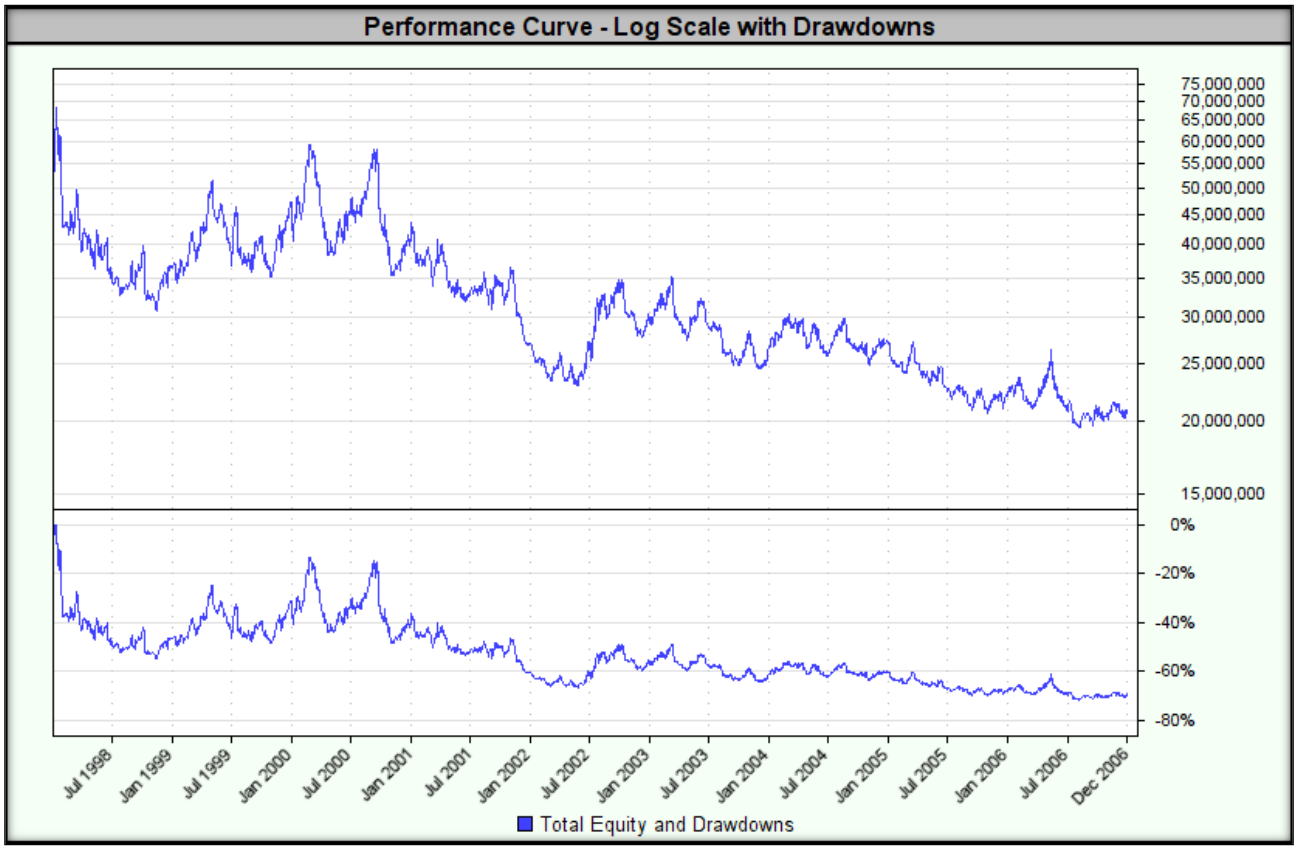
Other parameters remain unchanged.

The lowest MAR value of -0.13 was achieved for the following parameters:

- **Entry Breakout (days):** 57;
- **Exit Breakout (days):** 16;
- **Alloy (ATR):** 1.5.

Test	Entry Breakout (days)	Stop (ATR)	Exit Breakout (days)	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF
937	57	1.50	16	$20,649,442.87	-9.37%	-0.13	-0.16	-0.53	71.5%	107.5	2865	-0.31	-8.27	0.93
772	54	1.50	16	$20,861,894.41	-9.26%	-0.13	-0.17	-0.55	71.2%	107.5	2889	-0.30	-8.05	0.93
827	55	1.50	16	$20,970,381.48	-9.21%	-0.13	-0.17	-0.53	71.0%	107.5	2887	-0.29	-7.81	0.93
717	53	1.50	16	$20,683,084.65	-9.35%	-0.13	-0.18	-0.52	72.2%	107.5	2912	-0.31	-8.48	0.93
552	50	1.50	16	$21,075,271.46	-9.16%	-0.13	-0.16	-0.49	71.9%	107.5	2923	-0.31	-8.53	0.94
830	55	1.50	19	$19,978,007.90	-9.70%	-0.13	-0.17	-0.47	76.6%	75.3	2686	-0.16	-10.41	0.94
829	55	1.50	18	$21,215,642.48	-9.09%	-0.13	-0.15	-0.45	72.6%	107.5	2759	-0.32	-8.80	0.93
774	54	1.50	18	$21,350,265.28	-9.03%	-0.12	-0.15	-0.46	72.6%	107.5	2755	-0.33	-8.94	0.94
1047	59	1.50	16	$22,052,898.50	-8.70%	-0.12	-0.12	-0.49	70.3%	107.5	2821	-0.30	-8.02	0.95
992	58	1.50	16	$22,152,161.43	-8.66%	-0.12	-0.14	-0.47	70.1%	107.5	2840	-0.29	-7.62	0.94
662	52	1.50	16	$21,995,082.37	-8.73%	-0.12	-0.16	-0.46	70.9%	107.5	2894	-0.29	-7.71	0.94

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



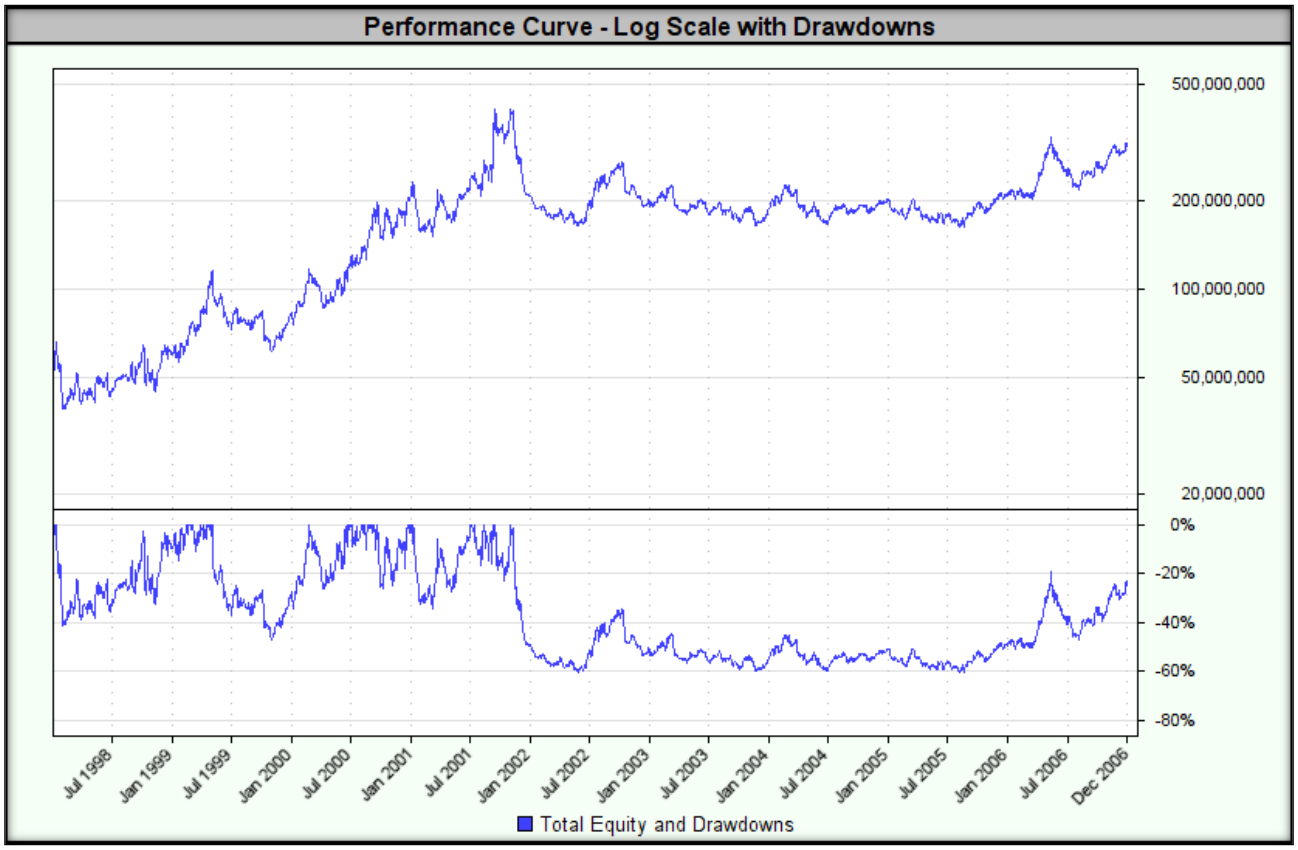
The highest MAR value of 0.37 was achieved for the following parameters:

- **Entry Breakout (days):** 45;
- **Exit Breakout (days):** 25;
- **Alloy (ATR):** 1.75.

The highest MAR value was accompanied by **a drawdown of 60.3%.**

Test	Entry Breakout (days)	Stop (ATR)	Exit Breakout (days)	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF
297	45	1.75	25	$308,095,333.17	22.41%	0.37	0.69	0.46	60.3%	61.9	2005	0.27	17.93	1.42
242	44	1.75	25	$259,227,108.68	20.09%	0.33	0.65	0.55	60.7%	63.5	2020	0.21	14.99	1.38
231	44	1.50	25	$217,088,039.76	17.74%	0.30	0.59	0.62	58.7%	61.9	2264	0.19	12.91	1.31
187	43	1.75	25	$218,603,549.02	17.83%	0.29	0.61	0.51	60.7%	63.5	2067	0.19	13.52	1.34
230	44	1.50	24	$197,699,757.06	16.52%	0.27	0.57	0.51	61.3%	54.0	2307	0.14	9.73	1.29
1232	62	1.75	25	$187,647,692.22	15.85%	0.27	0.56	0.59	59.4%	54.0	1944	0.10	7.02	1.33
1287	63	1.75	25	$165,089,704.12	14.21%	0.25	0.53	0.49	57.8%	67.3	1937	0.06	4.73	1.30
407	47	1.75	25	$172,309,110.44	14.75%	0.24	0.54	0.33	61.2%	61.9	2039	0.16	11.26	1.31
352	46	1.75	25	$167,903,501.15	14.42%	0.24	0.54	0.48	60.0%	61.9	2042	0.15	10.40	1.30
319	45	2.25	25	$151,118,744.76	13.09%	0.23	0.52	0.41	56.2%	61.9	1755	0.12	7.33	1.28
176	43	1.50	25	$158,082,438.32	13.66%	0.23	0.51	0.60	59.3%	61.9	2312	0.10	7.56	1.27

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 76.6%.**

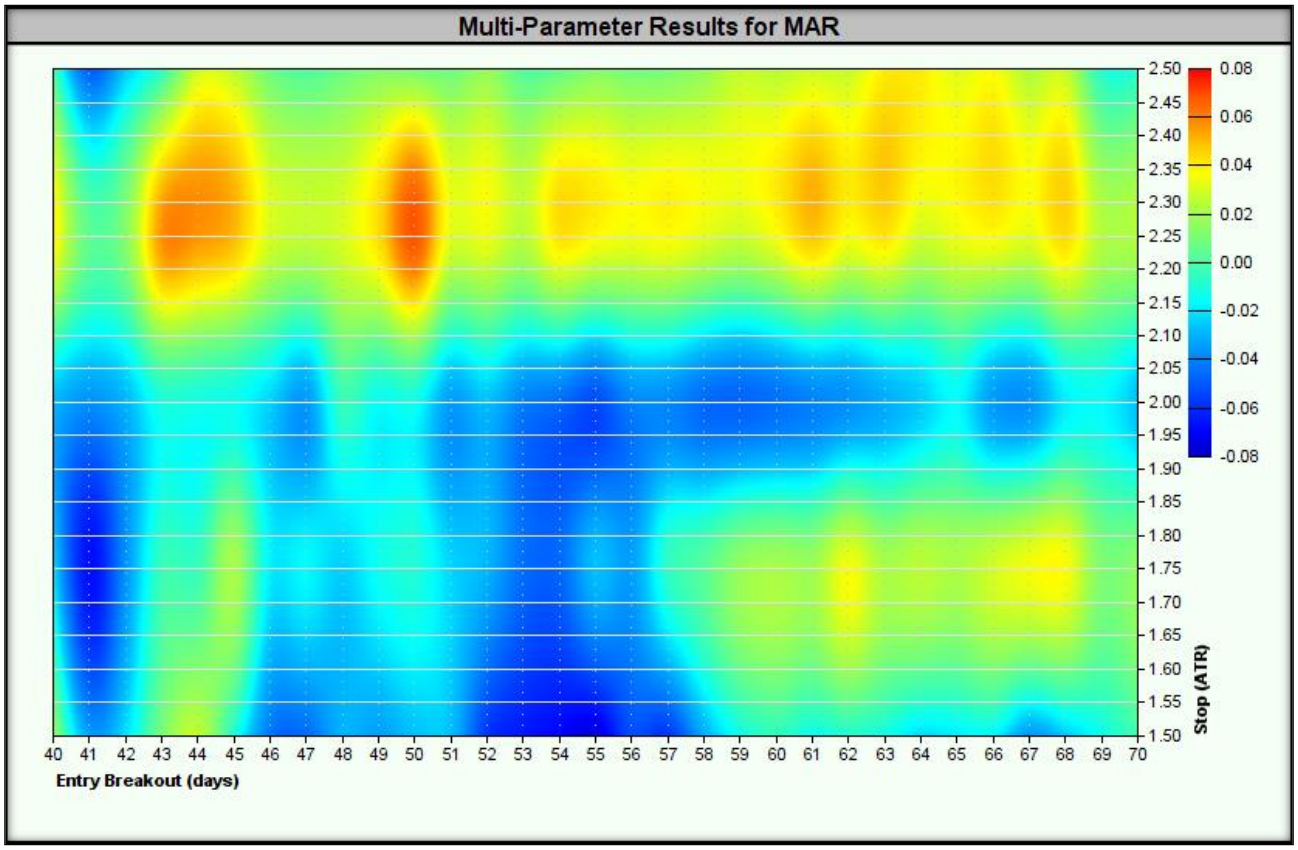
Test	Entry Breakout (days)	Stop (ATR)	Exit Breakout (days)	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD	Longest DD	Trades	R3	RAR [%]	%PF
830	55	1.50	19	$19,978,007.90	-9.70%	-0.13	-0.17	-0.47	76.6%	75.3	2686	-0.16	-10.41	0.94
553	50	1.50	17	$21,567,497.55	-8.93%	-0.12	-0.15	-0.50	73.9%	75.3	2863	-0.21	-9.90	0.95
555	50	1.50	19	$29,996,029.42	-5.52%	-0.07	-0.01	-0.28	73.8%	75.3	2720	-0.12	-6.71	1.01
775	54	1.50	19	$26,356,890.91	-6.87%	-0.09	-0.04	-0.32	73.8%	75.3	2685	-0.10	-6.85	0.99
554	50	1.50	18	$22,432,699.95	-8.53%	-0.12	-0.14	-0.45	73.5%	107.5	2817	-0.35	-9.63	0.95
716	53	1.50	15	$23,367,690.64	-8.11%	-0.11	-0.14	-0.40	73.2%	107.5	2983	-0.32	-8.93	0.94
940	57	1.50	19	$28,322,418.96	-6.13%	-0.08	-0.01	-0.29	73.2%	75.6	2642	-0.09	-6.19	1.00
498	49	1.50	17	$21,427,091.02	-8.99%	-0.12	-0.16	-0.56	73.1%	107.5	2852	-0.34	-9.29	0.94
936	57	1.50	15	$22,961,135.40	-8.29%	-0.11	-0.14	-0.44	73.0%	107.5	2939	-0.32	-8.89	0.93
71	41	1.75	19	$21,685,433.83	-8.87%	-0.12	-0.26	-0.54	72.7%	107.5	2523	-0.29	-7.87	0.90
829	55	1.50	18	$21,215,642.48	-9.09%	-0.13	-0.15	-0.45	72.6%	107.5	2759	-0.32	-8.80	0.93

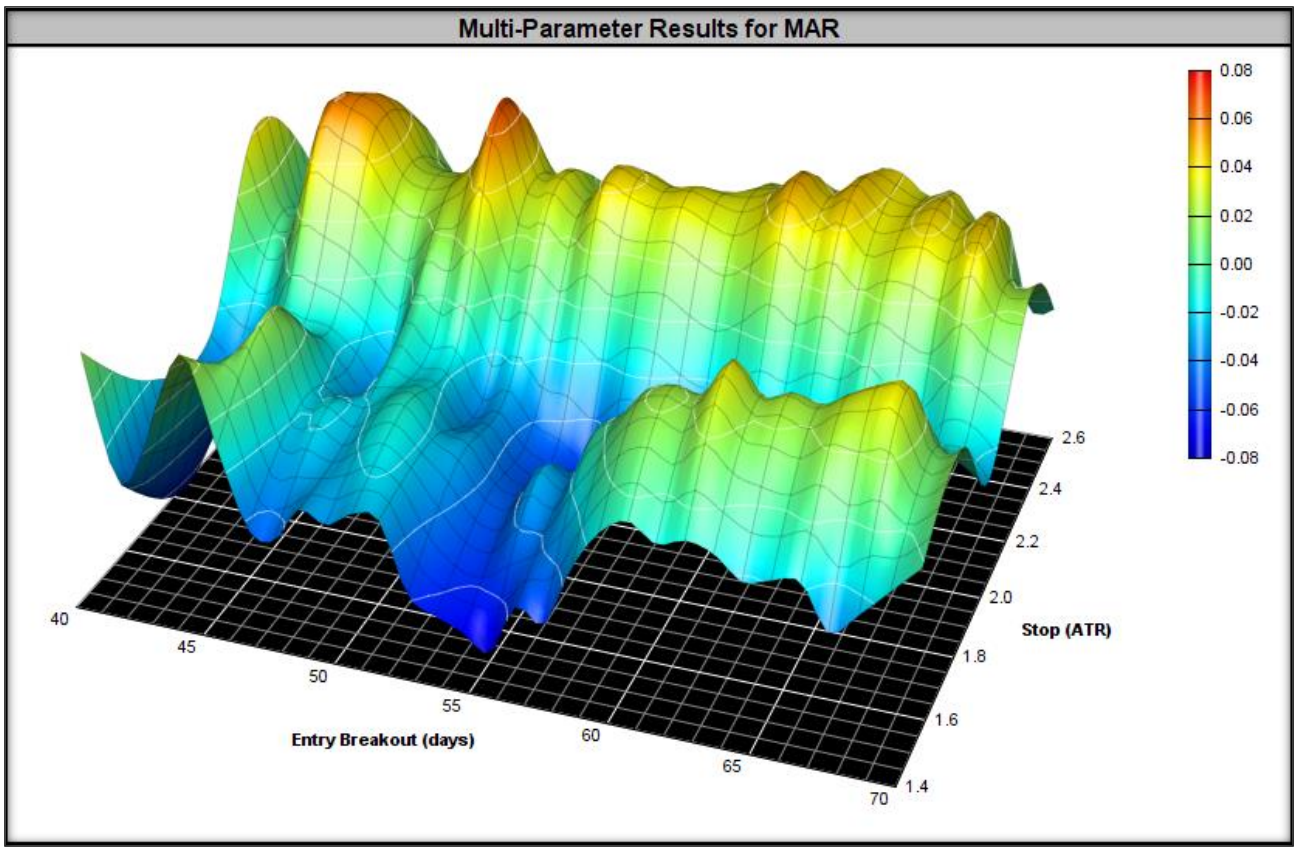
In summary, the strategy **failed the stability test** over a wide range of optimized parameters because:

- **MAR value** – which indicates low stability of the strategy in various market conditions.

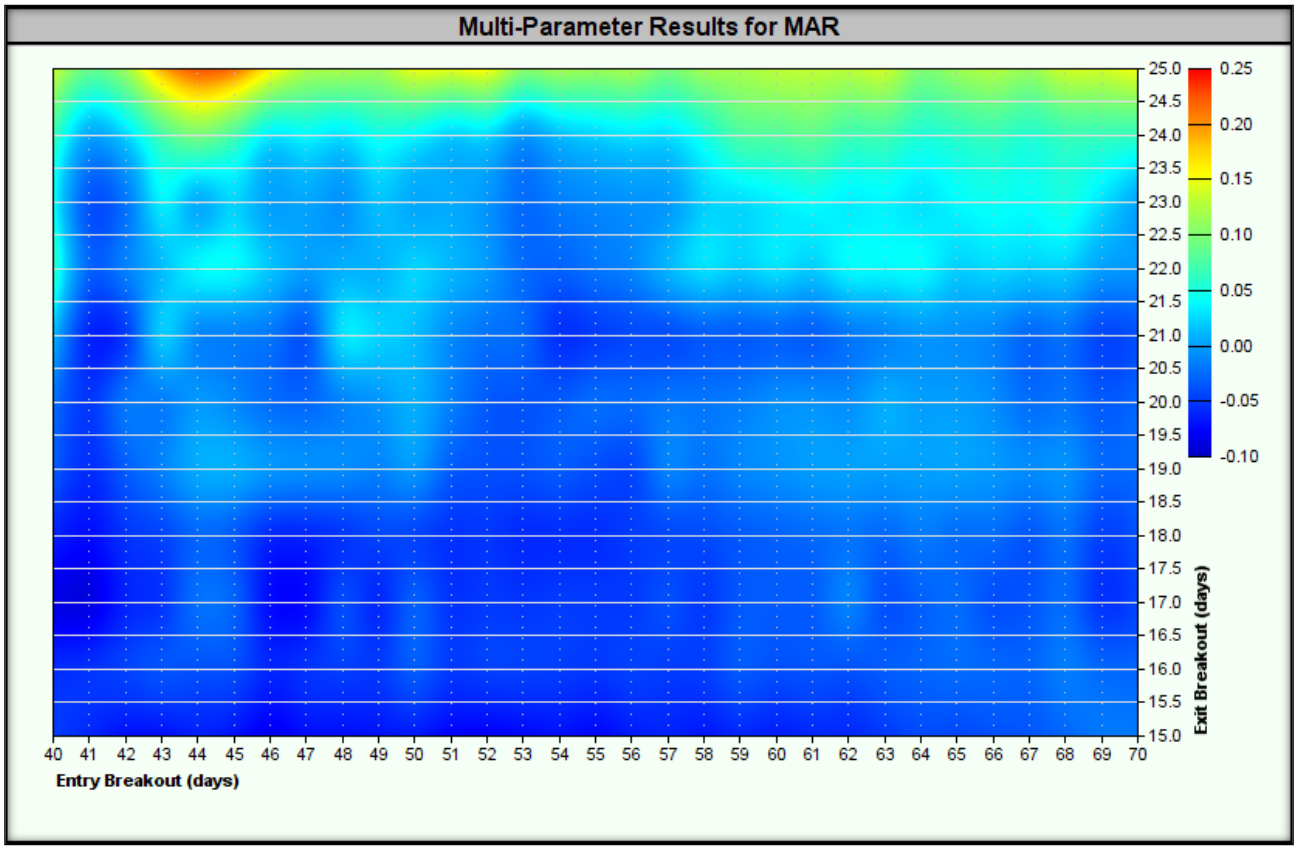
Therefore, **<u>further testing of the strategy is not justified,</u>** as its use in real transactions **is highly doubtful.**

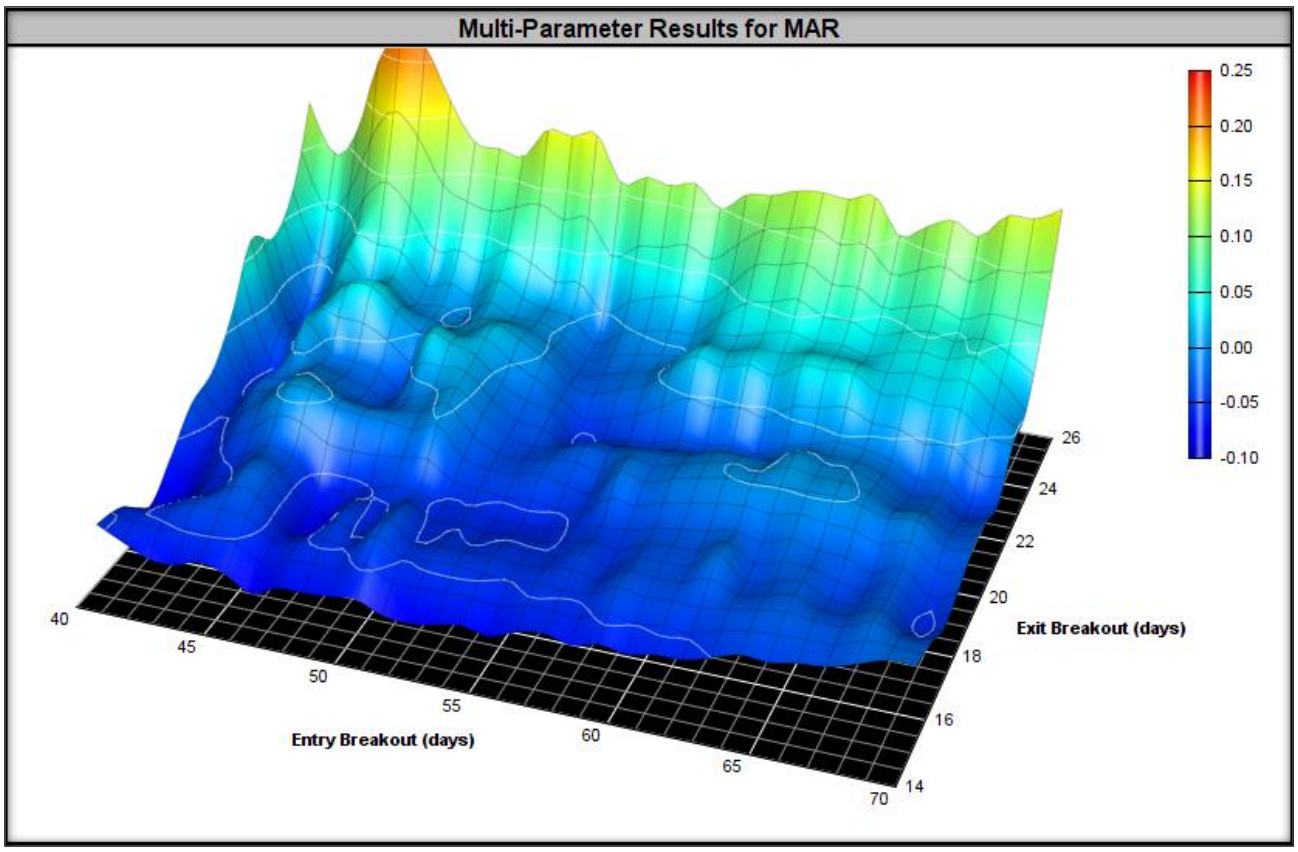
Heatmaps for the tested ranges are shown below.

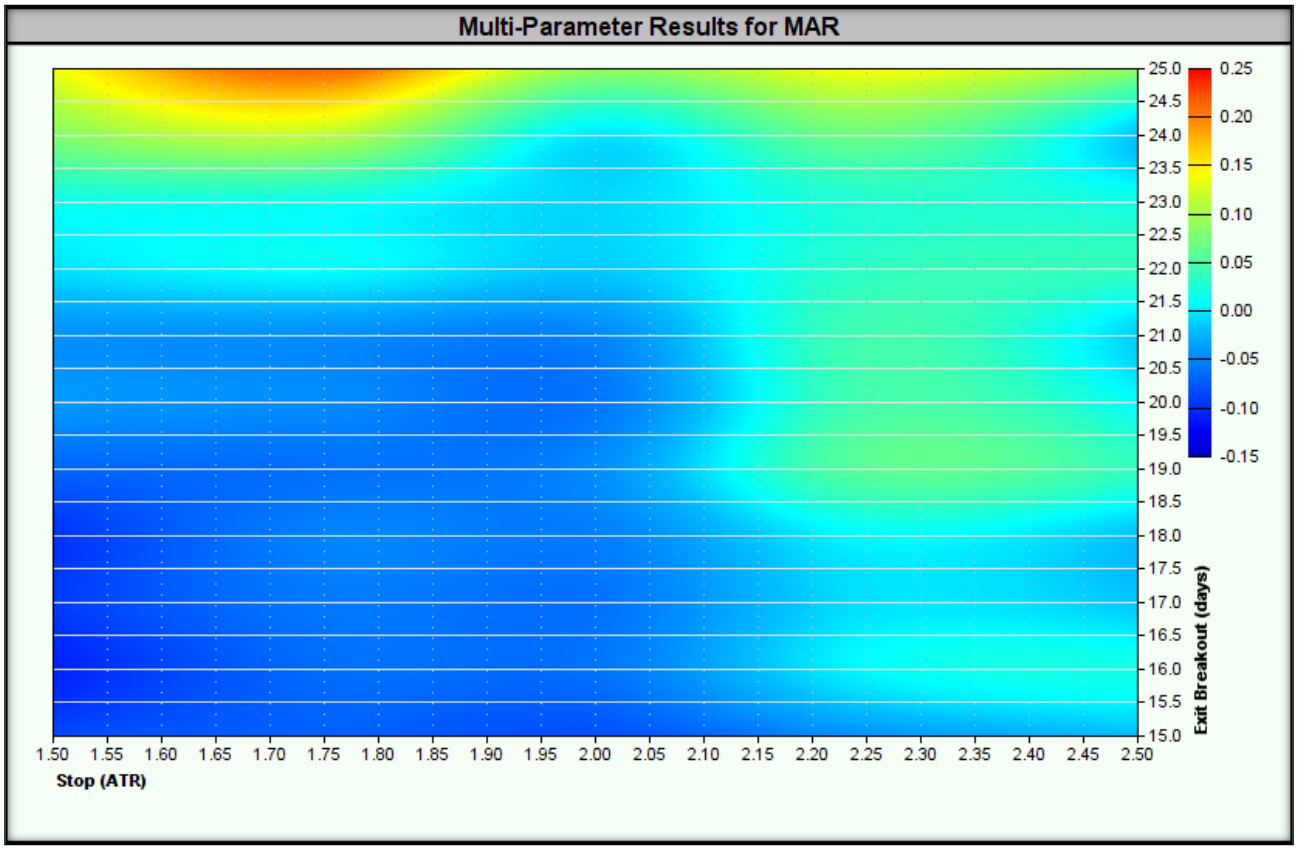


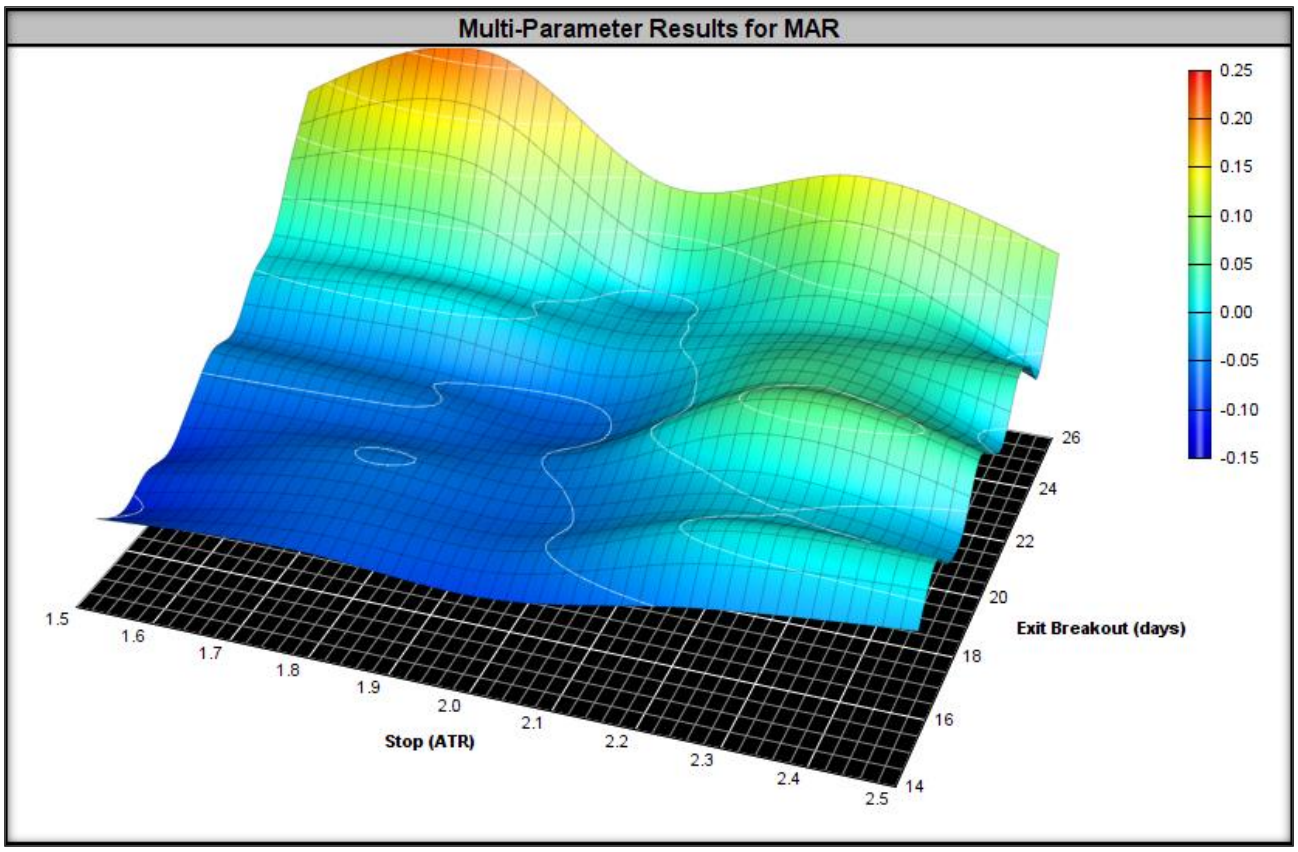


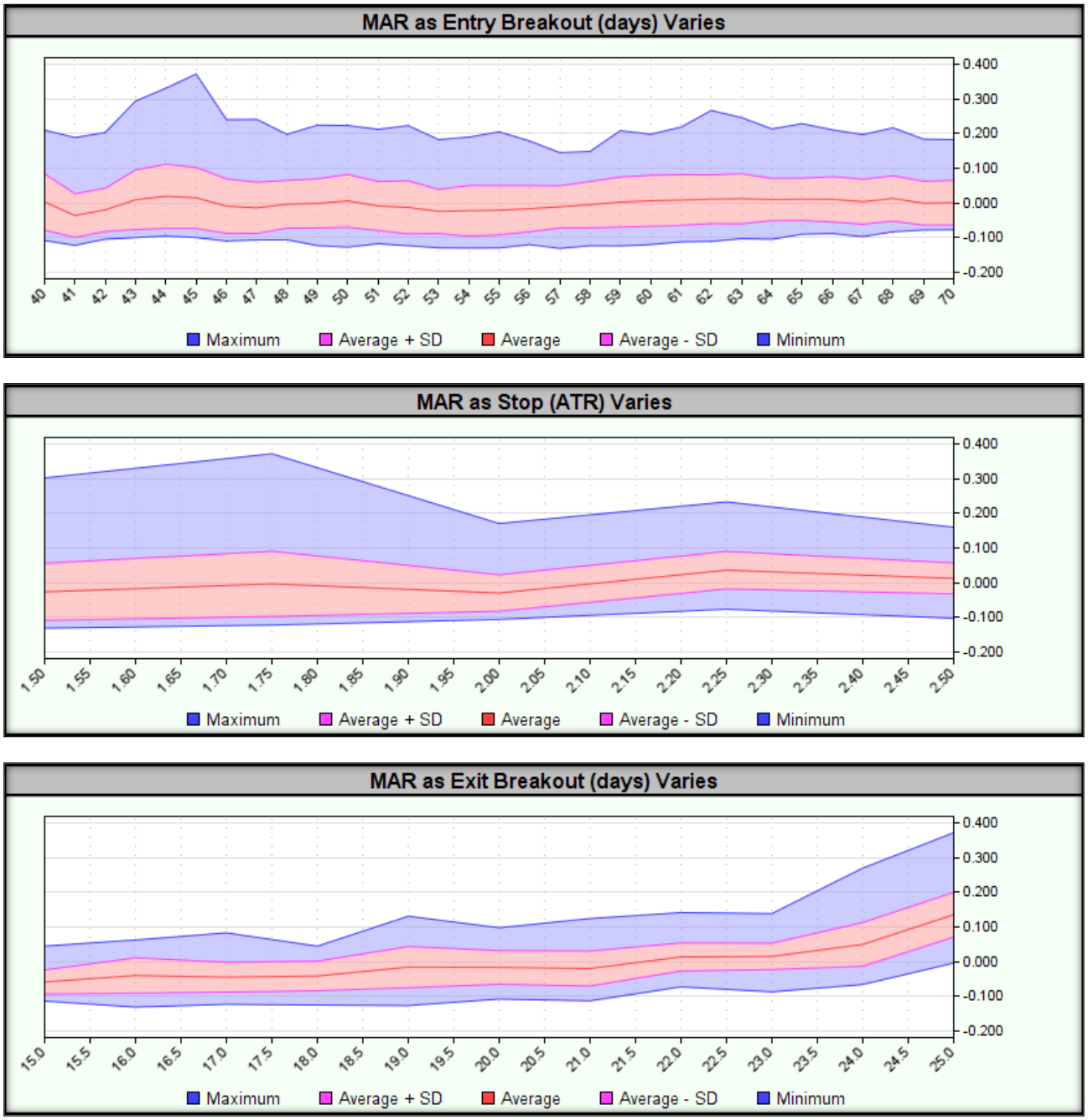
contact@tradingedge.pro
+48-698-630-421


Multi-Parameter Results for MAR
Entry Breakout (days)
Exit Breakout (days)


Multi-Parameter Results for MAR
Entry Breakout (days)
Exit Breakout (days)


Multi-Parameter Results for MAR
Stop (ATR)
Exit Breakout (days)


Multi-Parameter Results for MAR
Stop (ATR)
Exit Breakout (days)



2. **Monte Carlo simulation**

The step was omitted due to **failure of previous stability tests.**

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

The step was omitted due to **failure of previous stability tests.**

4. **Long/short stability**

The step was omitted due to **failure of previous stability tests.**

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

The step was omitted due to **failure of previous stability tests.**

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

The step was omitted due to **failure of previous stability tests.**

7. **Strategy Risk Management**

The step was omitted 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 in real-world market conditions.** It provides **reliable measures of profit and risk** after the optimization process and allows you 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 more **reliable and realistic measures 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, minimizing **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)**.
    - This step adjusts the parameters 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 Performance Efficiency (WFE) is a key metric that assesses a strategy's potential to perform under real-world market conditions. WFE compares:

- **The rate of return achieved in the in-sample window** (where parameters were optimized)
- **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 to be **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 beyond 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 step was omitted 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 simple. 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 implementation** is **the consistent execution of all signals, without exception. Larry Williams noted:** *"Trading strategies work. Traders do not."*

Before making **a final decision to implement a strategy,** it's important to verify **whether it actually adds value** to the overall portfolio performance. It doesn't make sense to implement a strategy that **generates similar signals** or **has a similar equity curve.**

Key criteria for evaluating strategies 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 or **none of them are met.**

Once you decide to add a strategy to your portfolio, **the question arises:** *Should you implement the strategy immediately 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 detect **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 approximately half the maximum drawdown** observed in historical data. **Only after this threshold is reached 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.