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Methodology

[TradingEdge.Pro's](#) methodology describes a multi-step process for building and validating trading strategies, structured into two parts: strategy development and testing, and practical use. In the testing phase, a strategy is defined as a set of objective rules, validated through initial tests, optimised, and assessed for stability (robustness), and then evaluated using Walk-Forward Analysis. The detailed testing assumptions (including the instrument universe, in-sample/out-of-sample periods, data sources, transaction costs, and execution rules) are described in the "[Testing Specification](#)" document. The full methodology and metric definitions are available on the TradingEdge.Pro "[Methodology](#)" page.



Vol Trade v.1

Investment Strategy Testing Summary

Vol Trade v.1 strategy is a swing trading technique based on **volatility contraction** and **range extension** in the direction of the prevailing trend. In its long version, it combines a **trend filter** (close above the long-term moving average) with the condition that **short-term volatility** falls to a **fraction of long-term volatility** and **remains there for a set number of sessions**. After such a period of low volatility, a **strong bullish candle** (the largest since the contraction began) generates a signal, which simultaneously sets a **new local high**.

The strategy **does not use stop loss orders**; the exit occurs when **short-term volatility exceeds long-term volatility** (volatility regime shift).

Although the strategy's logic seems sound, **it fails the Monte Carlo test**. This means the strategy loses its profitability and generates significantly larger drawdowns when tested under suboptimal conditions. 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.



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Step 1: Formulate an investment strategy

Vol Trade v.1 strategy joins an **ongoing trend** when the market transitions from a **low-volatility regime** to an **impulse**. The trend context is confirmed by a **long-term moving average** – long positions are only considered when the price closes **above** this average. The preparatory condition is **sustained short-term volatility below the long-term level** for **several sessions**. The breakout is confirmed by a **candle with the largest range since the contraction**, which establishes a **new local extreme** and closes in the direction of the prevailing trend. Entry is made **at the open of the following day**.

Exiting the position occurs **only** when **the volatility regime changes** – **short-term volatility above long-term**. The lack of a stop loss emphasizes the need for conservative position sizing and consistent exposure management.

The strategy uses:

- **Trend Filter (SMA Long)** – selection of direction according to the dominant movement;
- **Variation ratio** – $\text{VolShort/VolLong} \leq \text{threshold}$ for a specified number of sessions (contraction);
- **Range expansion + extreme** – the signal candle is the widest since the beginning of the contraction and establishes a local high;
- **Entry T+1** – opening a position at the start of the next session;
- **Regime Change Reach** – close when short-term volatility \geq long-term volatility.

Characteristics – strengths and weaknesses:

- **Quantitative, simple rules** (trend, contraction, breakout) – facilitate automation and testing;
- **Entry after confirmation** – reducing “false starts” typical of catching traffic early;
- **Lack of stop loss increases the risk of drawdowns and gaps** – strict control of position size is necessary;
- **Selectivity** – the required maintenance of contractions may limit the number of transactions;
- **Sensitivity to the definition of variability** – parameter sensitivity analysis recommended.

Vol Trade v.1 strategy, while simple, provides a **solid foundation for building algorithmic portfolios**. However, it requires **discipline and strict adherence to risk management methods**.



Step 2: Determine investment principles

Below is the pseudocode for the **Vol Trade v.1 strategy** on daily data:

1. Calculating Indicators:

- a. **XXX-MALong** – XXX day moving average closing price.
- b. **XXX-VolLong** – XXX day variability (sum of squared deviations).
- c. **YY-VolShort** – YY day variability (sum of squared deviations).
- d. **WW-VolRatio** – VolShort/VolLong variability ratio below WW%.
- e. **ZZ-HighestHigh** – ZZ daily highest high.
- f. **ZZ-MaxRange** – maximum daily range (high–low) in the last ZZ sessions.

2. Generating Entry Signals – Long Position:

- a. **Trend:** closing price above MALong.
- b. **Volatility contraction:** for ZZ of subsequent VolShort/VolLong sessions below WW%.
- c. **Extension and extremum:** today's price range (high-low) is greater than MaxRange and today's high forms the highest high since ZZ days (HighestHigh) and today's candle is bullish.
- d. **Entry:** Once the conditions are met, a long position is opened at the opening of the next session.

3. Generating Output Signals:

- a. **Volatility regime change:** close all positions at the opening of the next session when VolShort > VolLong.

4. Daily Monitoring:

- a. Calculate MALong, VolShort, VolLong, VolRatio, HighestHigh and MaxRange every day.
- b. The system verifies entry/exit conditions and sets appropriate orders for the opening of the next session; it monitors the volatility regime.

5. Additional Notes:

- a. **No Short Positions:** The strategy focuses solely 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 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 a **hypothetical stop loss order located 2 x ATR (40 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 DAX futures contract. At the end of February 2015, prices remained in an **uptrend** (price above the long-term average), and **short-term volatility remained below long-term volatility for several sessions ("Historic Volatility" panel)**. During this time, a **volatility contraction** was formed (the first three candles in the left-hand rectangle; **short-term volatility remains below 80% of long-term volatility**). A **buy signal requires that after such a period of low volatility, a breakout candle** appears (the widest since the beginning of the contraction), which simultaneously **establishes a new local high**. This condition was met (the third candle in the left-hand rectangle), which **generated a signal to open a long position**. According to the strategy's rules, **the position was open at the opening of the next session** (fourth candle in the rectangle on the left). The strategy **does not use stop loss orders**. **The system worked correctly.**

The strategy calls for **an exit when short-term volatility exceeds long-term volatility**. This signal appeared at the end of March 2015 (the first candle in the right-hand rectangle), so the position was closed at the opening of the next session (the second candle in the right-hand rectangle). **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 **baseline parameters** that, in my opinion, should align with the strategy's stated goals.

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.

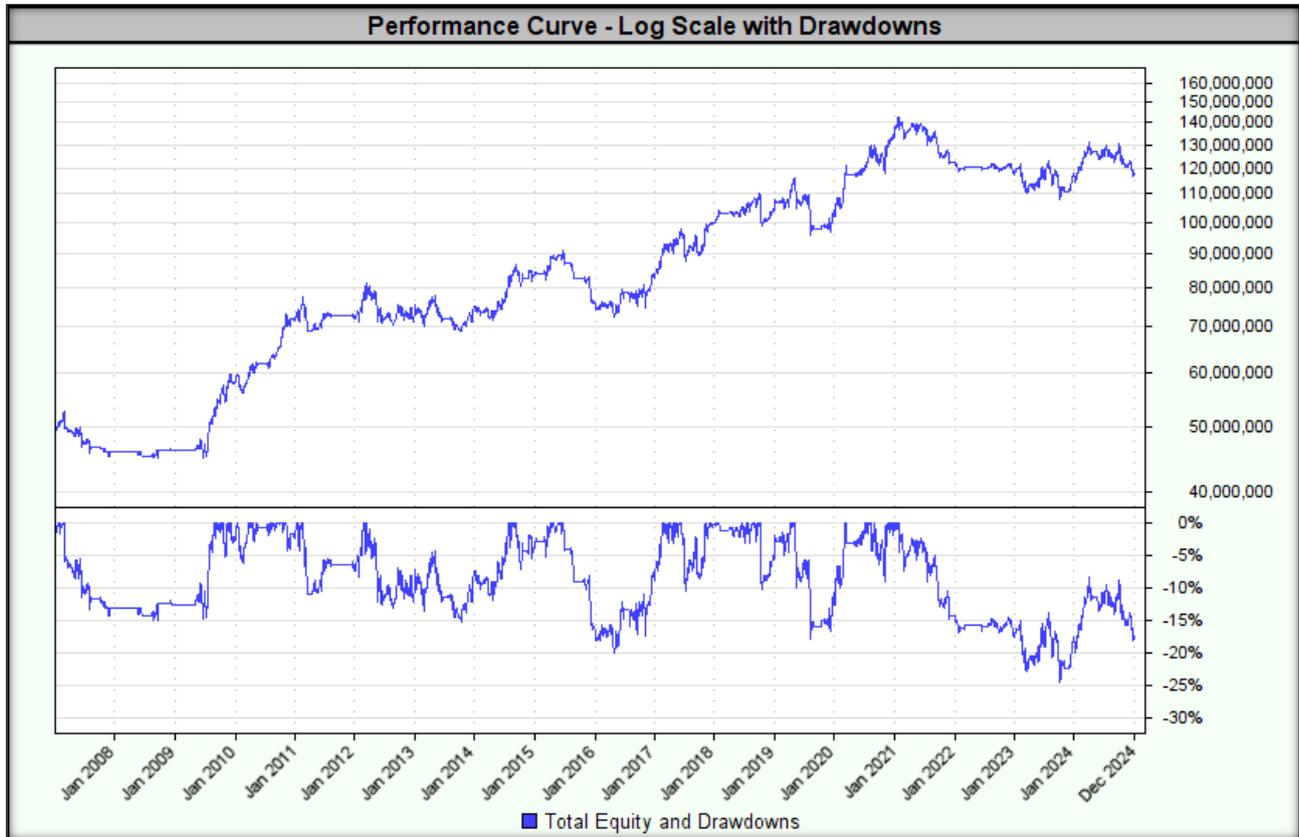
Our basic expectation is that the strategy generates **positive results**, even if they are at a low level.

Tested base parameters:

- **MALong** – 200-day moving average closing price.
- **VolLong** – 200-day volatility (sum of squared deviations).
- **VolShort** – 15-day volatility (sum of squared deviations).
- **VolRatio** – the variability ratio: VolShort/VolLong is at most 80%.
- **Volatility contraction**: for 3 consecutive VolShort/VolLong sessions it is at most 80%.
- **HighestHigh** – 3 day highest high.
- **MaxRange** – maximum daily range (High-Low) in the last 3 sessions.
- **How to open a position** – once the conditions are met, a long position is opened at the opening of the next session.
- **Stop loss** – lack.
- **Closing a position** – all positions are closed at the opening of the next session when VolShort > VolLong.
- **Position size** – corresponding to a risk of 1.0% of the total capital, with a hypothetical stop loss order located 2 x ATR (40 days) away from the position opening point.
- **Direction of position** – only long positions (buy).

The test result is shown below.

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.



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Indicators/Measures	Concluding a transaction at the opening price
CAGR%	4.9%
MAR Ratio	0.20
RAR%	6.2%
R-Cubed	0.15
Robust Sharpe Ratio	0.59
Max Drawdown	24.5%
Wins	53.7%
Losses	46.3%
Average Win%	1.83%
Average Loss%	1.40%
Win/Loss Ratio	1.30
Average Trade Duration (days)	67
Percent Profit Factor	1.51
SQN	-
Number of transactions	296

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**.



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 even **stable**.

1. Stability across a wide range of optimized parameters

This version of the **Vol Trade v.1** strategy utilizes the **Grid Search** method to **optimize parameters**. This method **fully optimizes all specified parameters by creating a wide range of possible combinations**. Our goal is to find **parameter ranges that will keep the strategy stable (robust)**, allowing us to assess its suitability in real-world 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 **in-sample data**. To do this, we define **ranges of parameter values** so that **the ratio of the highest to lowest value of the range is at least 150%**.

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

- **VolShort:** range **11-17 days (step: 1)**;
- **MALong & VolLong:** range **135-200 days (step: 5)**;
- **VolRatio:** range **70%-90% (step: 2.5 pp)**;
- **Volatility Contraction & HighestHigh & MaxRange:** **2-3 days range (step: 1)**.

The lowest MAR value of **0.06** was achieved for the following parameters:

- **VolShort:** 17 days;
- **MALong & VolLong:** 140 days;
- **VolRatio:** 75%;



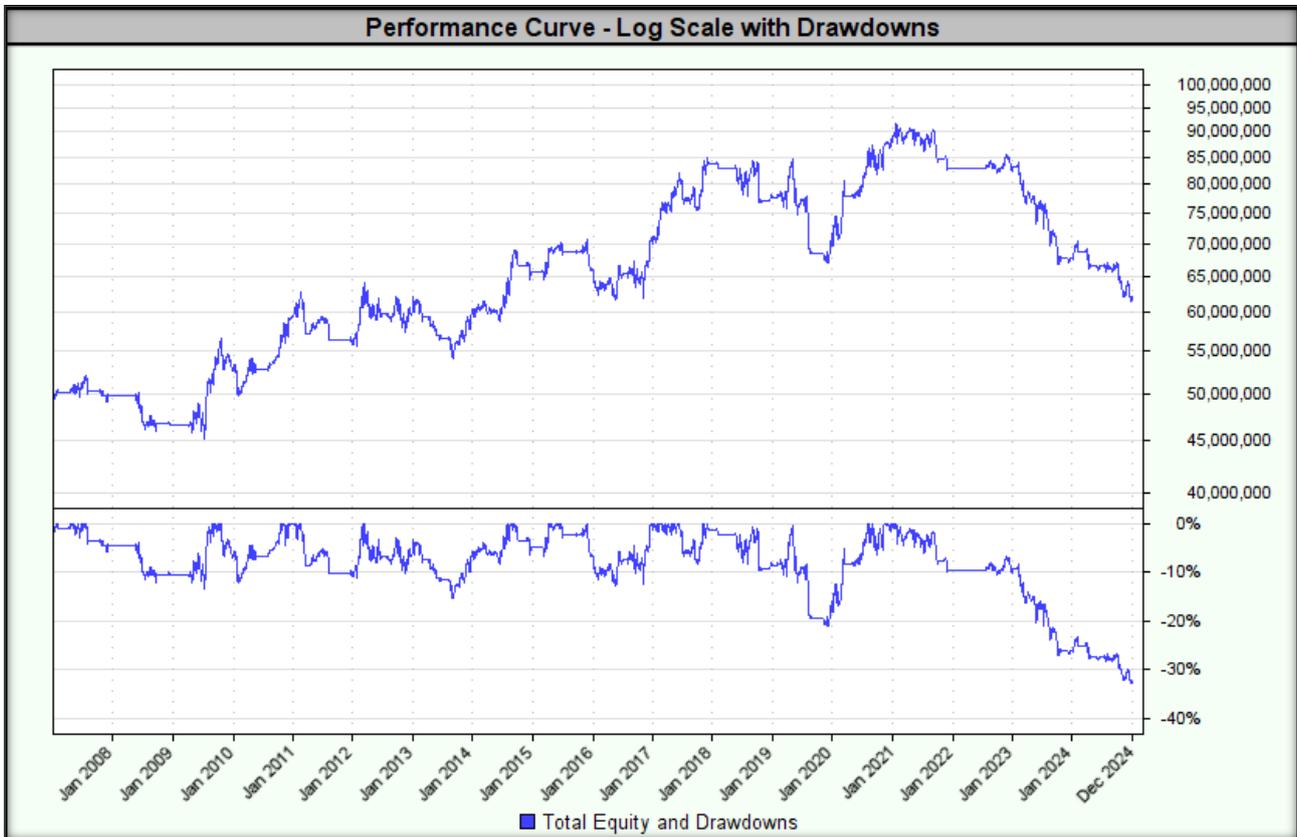
- **Volatility Contraction & HighestHigh & MaxRange: 3 days.**

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.

Test	Volatility Short (Bars)	Volatility Long (bars)	Volatility Threshold (Vol Short/Vol Long)	Low volatility for # of days	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD
1536	17	140	75.0%	3	\$61,761,295.59	1.18%	0.04	0.17	0.10	32.8%
1518	17	135	75.0%	3	\$64,239,917.99	1.40%	0.04	0.20	0.13	31.8%
1730	17	195	70.0%	3	\$64,126,749.81	1.39%	0.04	0.19	0.12	31.3%
1604	17	160	70.0%	3	\$61,873,957.38	1.19%	0.05	0.17	0.12	25.5%
1534	17	140	72.5%	3	\$66,947,271.24	1.63%	0.05	0.22	0.14	33.9%
1712	17	190	70.0%	3	\$66,878,700.83	1.63%	0.05	0.21	0.13	33.0%
1588	17	155	72.5%	3	\$66,489,908.74	1.60%	0.05	0.21	0.15	30.8%
1748	17	200	70.0%	3	\$66,633,022.84	1.61%	0.06	0.21	0.14	28.6%
1732	17	195	72.5%	3	\$67,019,228.24	1.64%	0.06	0.21	0.14	28.5%
1694	17	185	70.0%	3	\$70,019,828.47	1.89%	0.06	0.24	0.15	31.9%
1622	17	165	70.0%	3	\$64,853,920.48	1.46%	0.06	0.20	0.14	23.8%
1606	17	160	72.5%	3	\$69,047,726.54	1.81%	0.06	0.23	0.16	29.4%

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

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.



The highest MAR value of **0.44** was achieved for the following parameters:

- **VolShort: 11 days;**
- **MALong & VolLong: 200 days;**
- **VolRatio: 80%;**
- **Volatility Contraction & HighestHigh & MaxRange: 2 days.**

The highest MAR value was accompanied by a **drawdown of 17.0%.**

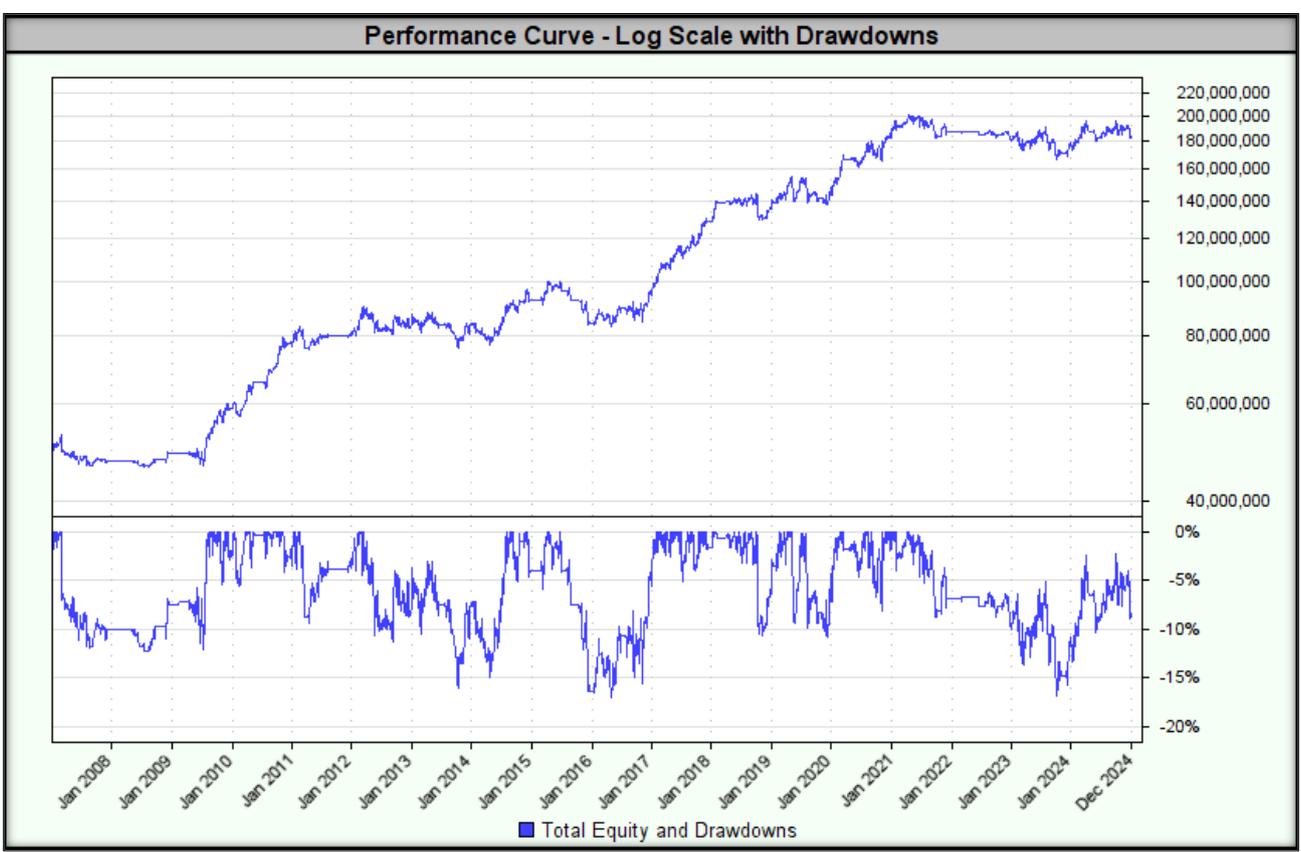


Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.

Test	Volatility Short (Bars)	Volatility Long (bars)	Volatility Threshold (Vol Short/Vol Long)	Low volatility for # of days	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD
243	11	200	80.0%	2	\$182,852,932.14	7.47%	0.44	0.77	0.58	17.0%
169	11	180	77.5%	2	\$172,611,841.73	7.13%	0.41	0.73	0.56	17.2%
225	11	195	80.0%	2	\$177,492,426.34	7.29%	0.41	0.75	0.58	17.7%
203	11	190	75.0%	2	\$148,643,056.10	6.24%	0.40	0.68	0.53	15.6%
207	11	190	80.0%	2	\$182,017,790.73	7.44%	0.40	0.75	0.60	18.8%
936	14	180	90.0%	3	\$176,438,717.52	7.26%	0.39	0.71	0.57	18.5%
189	11	185	80.0%	2	\$172,790,509.06	7.13%	0.39	0.71	0.58	18.3%
221	11	195	75.0%	2	\$146,868,774.26	6.17%	0.39	0.68	0.52	15.9%
737	13	195	90.0%	2	\$203,336,977.99	8.11%	0.39	0.77	0.63	20.8%
1205	15	185	90.0%	2	\$205,708,747.20	8.18%	0.39	0.76	0.60	21.2%
953	14	185	90.0%	2	\$192,791,094.47	7.79%	0.39	0.73	0.63	20.2%
1241	15	195	90.0%	2	\$190,661,080.19	7.72%	0.38	0.72	0.59	20.1%

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

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For all combinations of tested parameter ranges, the highest drawdown was 33.9%.

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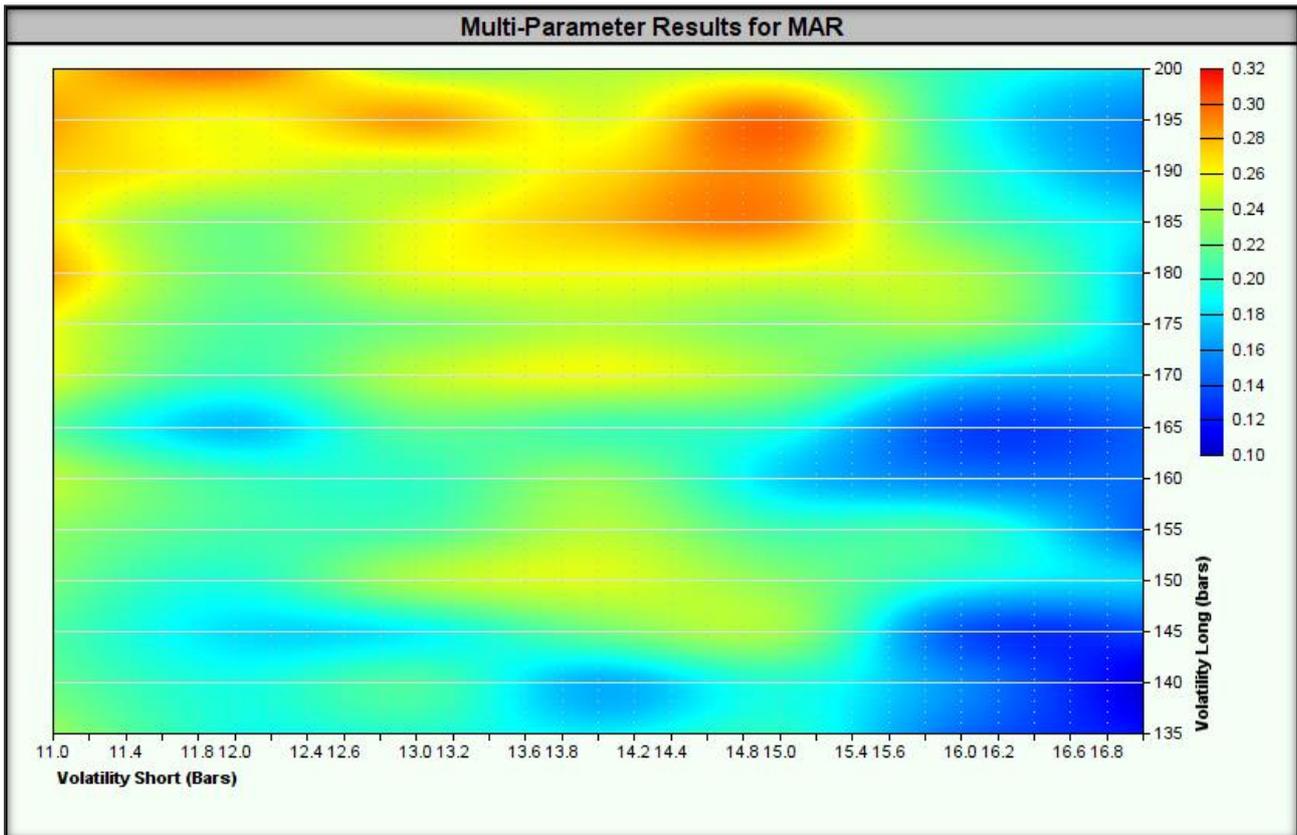
Test	Volatility Short (Bars)	Volatility Long (bars)	Volatility Threshold (Vol Short/Vol Long)	Low volatility for # of days	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD
1655	17	170	90.0%	2	\$139,142,276.76	5.85%	0.18	0.54	0.43	32.5%
53	11	145	90.0%	2	\$167,621,648.71	6.95%	0.21	0.70	0.57	32.6%
1536	17	140	75.0%	3	\$61,761,295.59	1.18%	0.04	0.17	0.10	32.8%
1313	16	145	90.0%	2	\$135,797,059.37	5.71%	0.17	0.55	0.43	32.9%
1535	17	140	75.0%	2	\$78,052,725.18	2.51%	0.08	0.29	0.22	33.0%
1712	17	190	70.0%	3	\$66,878,700.83	1.63%	0.05	0.21	0.13	33.0%
36	11	140	90.0%	3	\$133,893,269.88	5.63%	0.17	0.59	0.43	33.2%
54	11	145	90.0%	3	\$129,136,685.75	5.41%	0.16	0.56	0.43	33.4%
35	11	140	90.0%	2	\$167,104,476.95	6.93%	0.21	0.70	0.57	33.5%
1533	17	140	72.5%	2	\$81,232,449.58	2.73%	0.08	0.33	0.23	33.6%
1517	17	135	75.0%	2	\$85,070,499.24	3.00%	0.09	0.34	0.25	33.7%
1534	17	140	72.5%	3	\$66,947,271.24	1.63%	0.05	0.22	0.14	33.9%

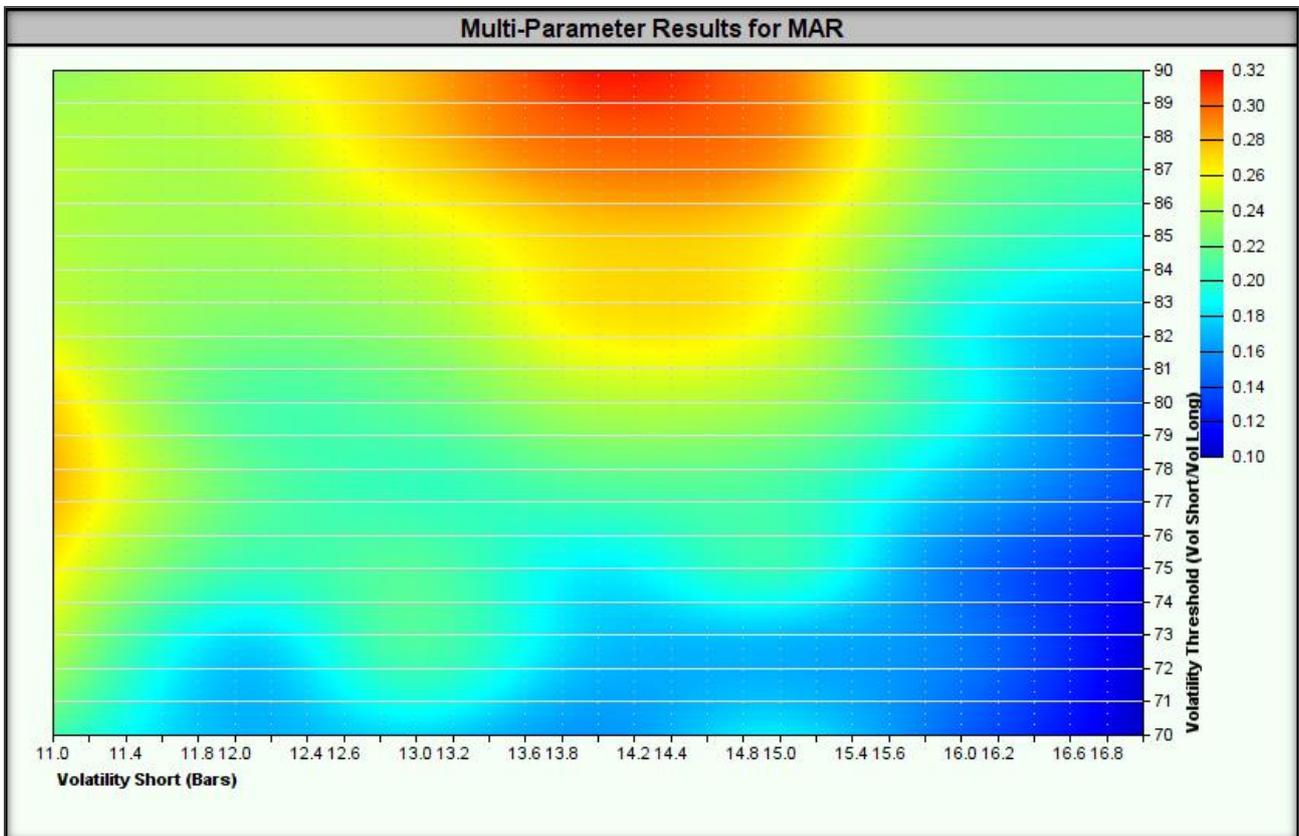
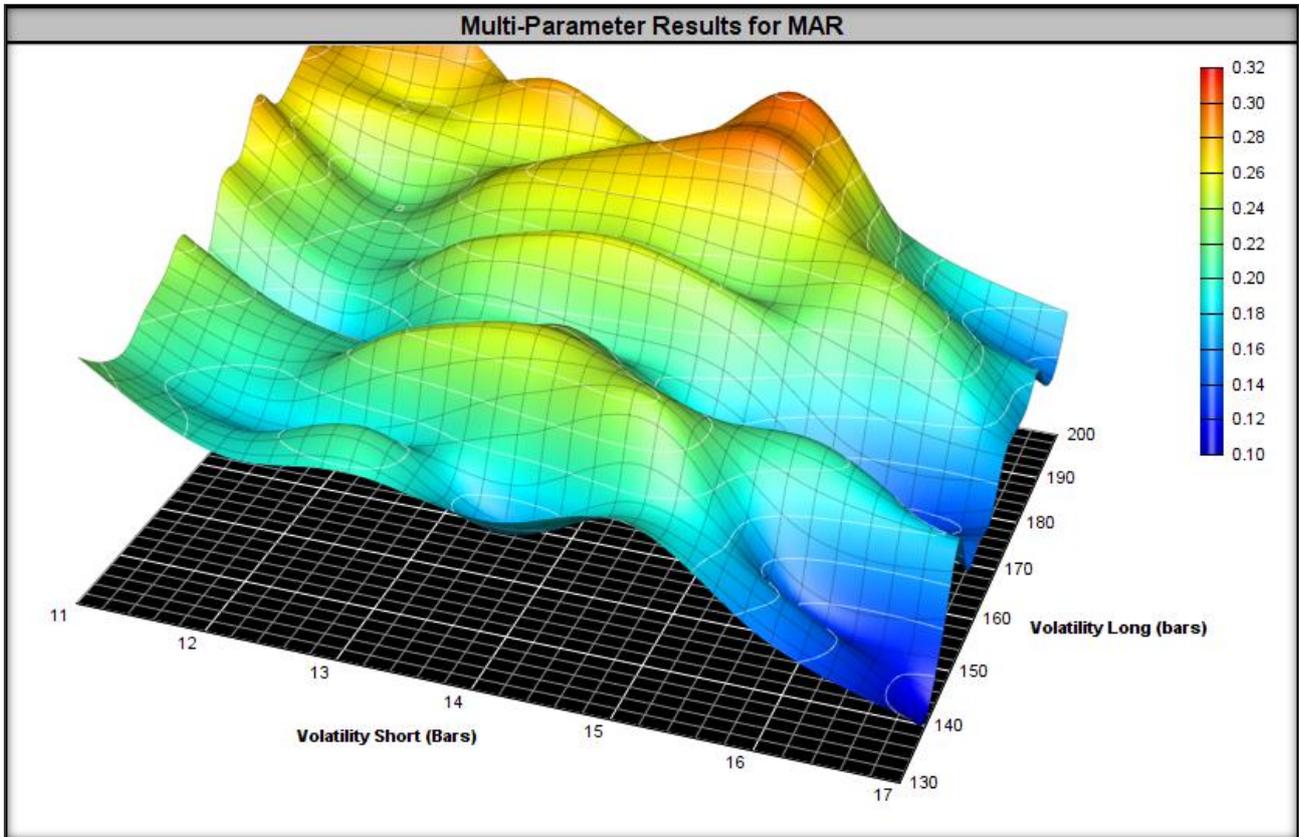


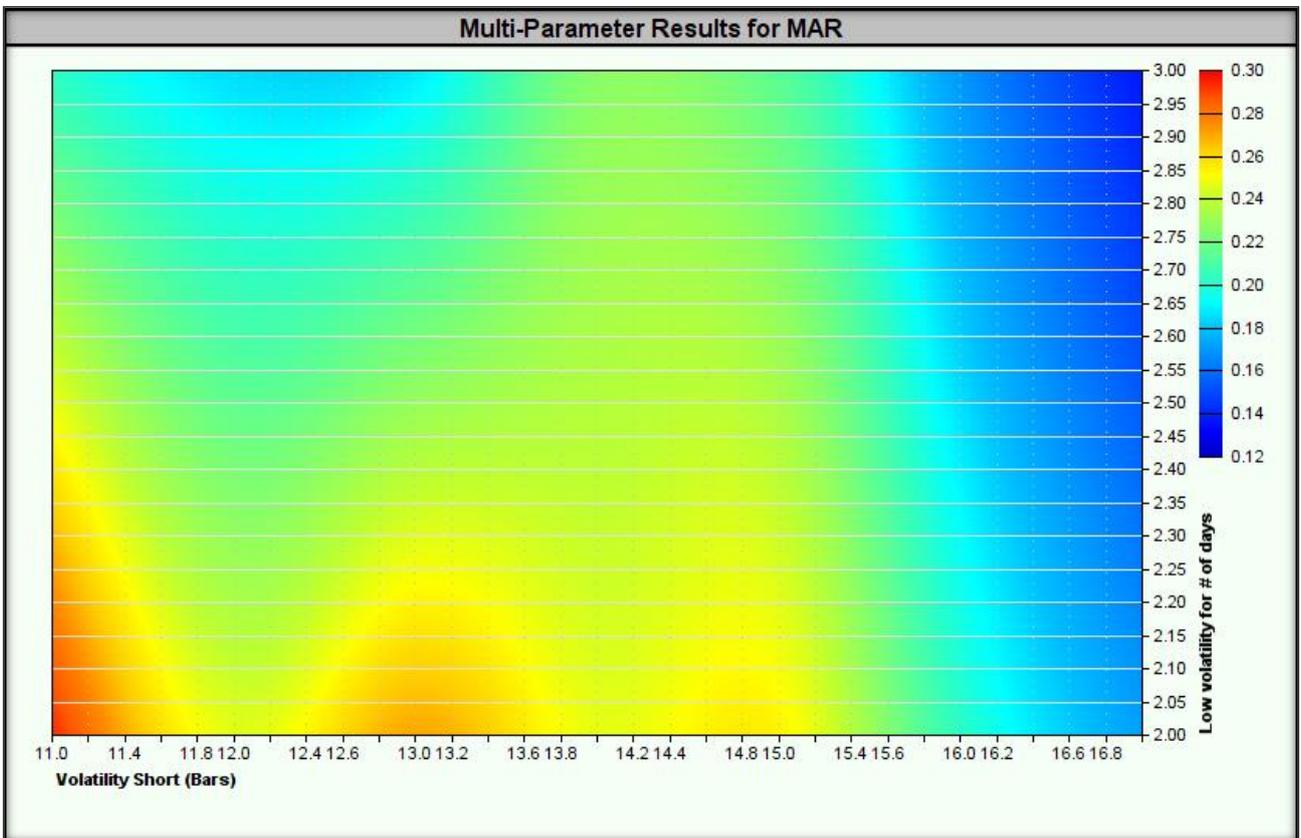
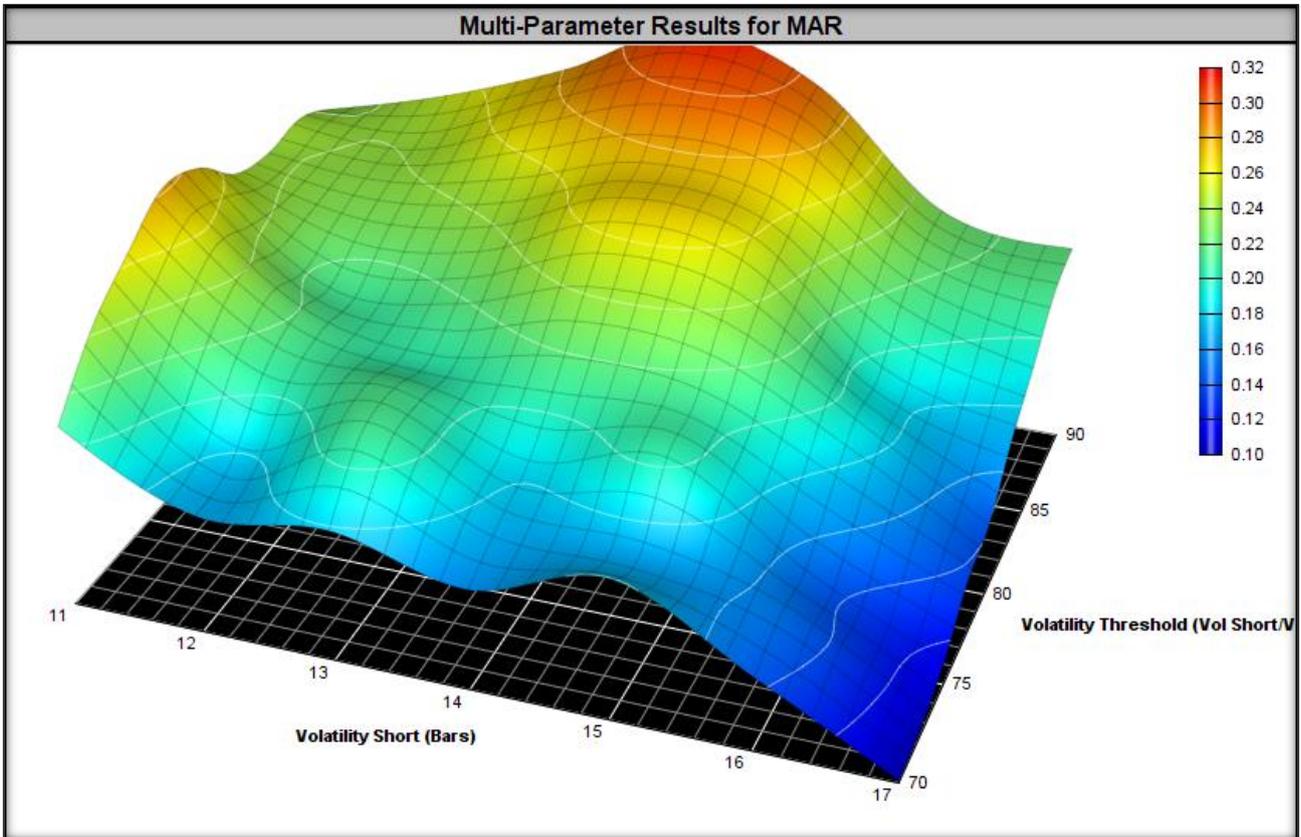
In summary, the strategy passed the stability test over a wide range of optimized parameters on in-sample data because:

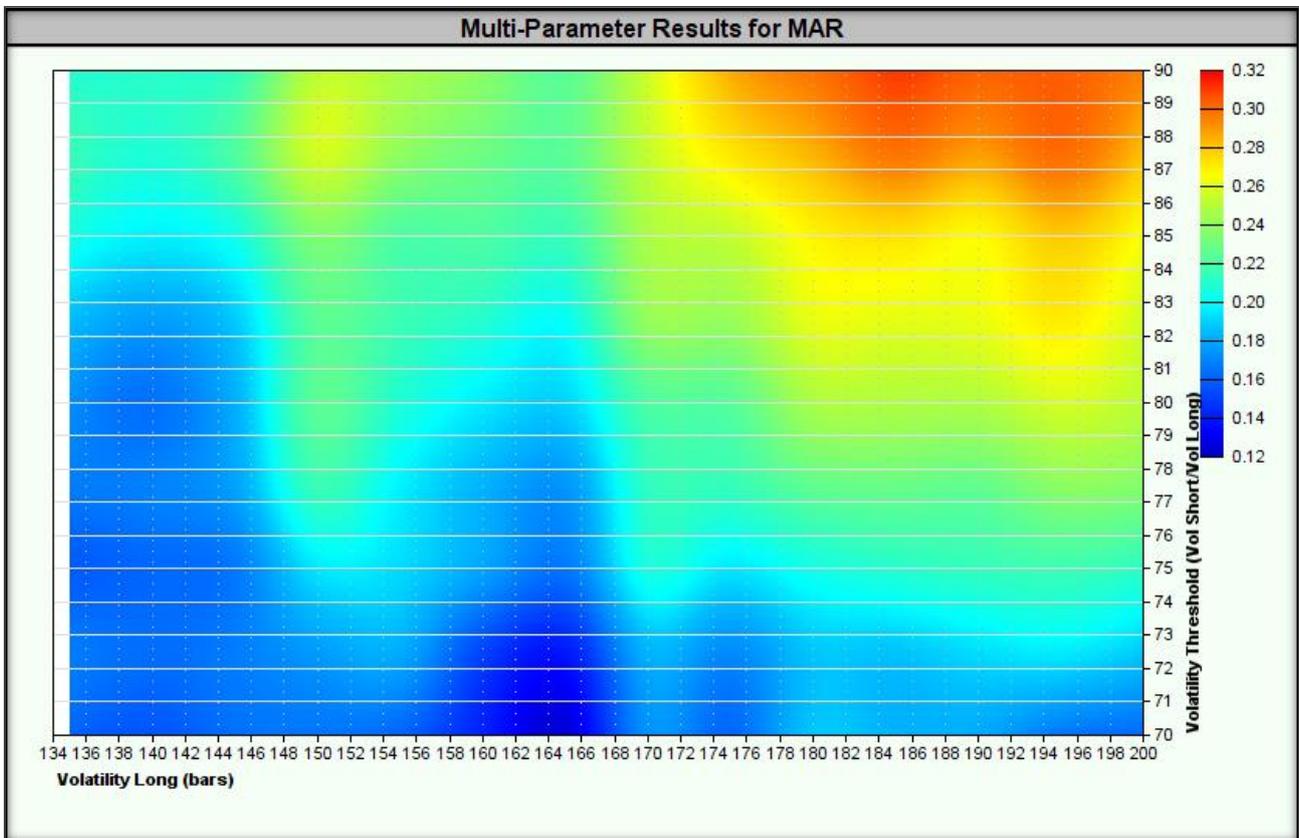
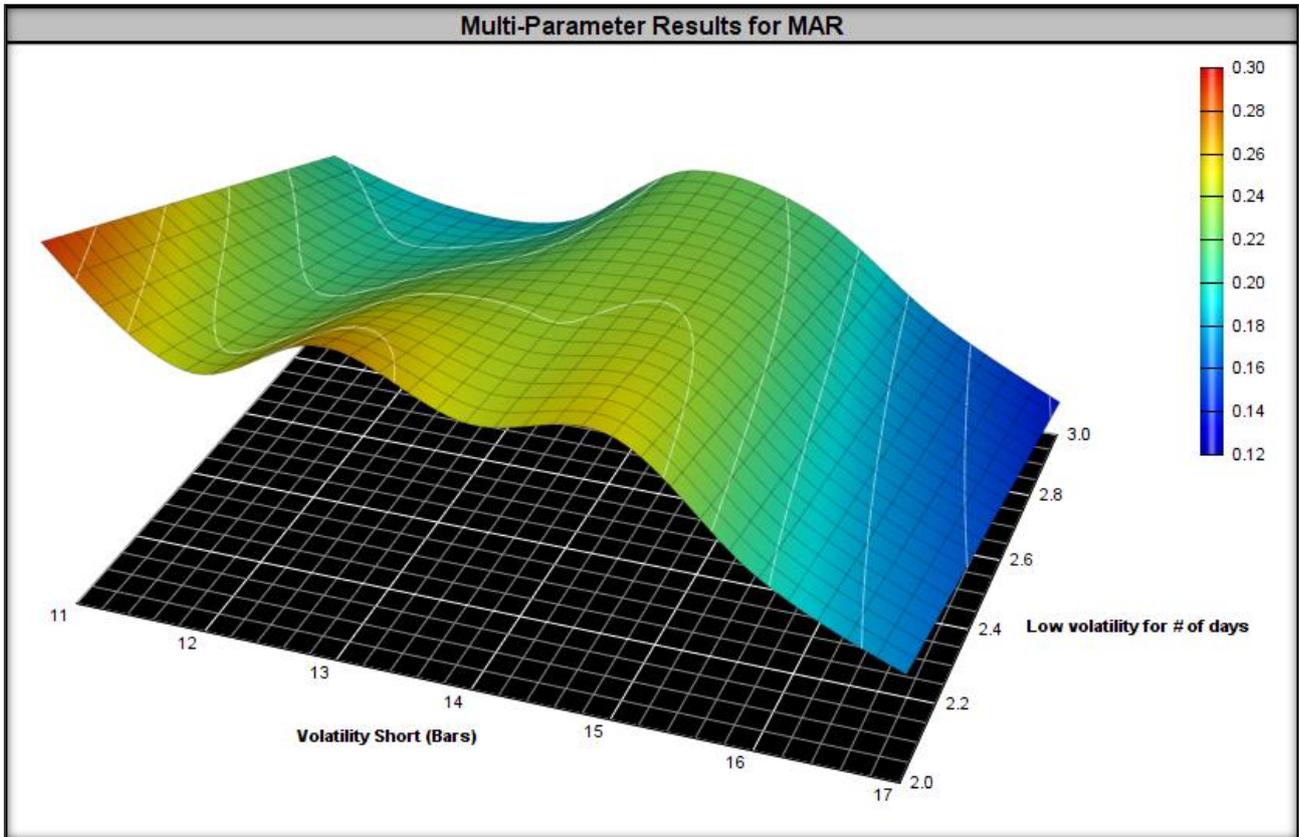
- All test results showed a positive MAR value – which indicates the stability of the strategy in various market conditions.
- The maximum drawdown did not exceed 250% of the drawdown value for the result with the highest MAR (33.9% vs. 17.0%) – which means an acceptable risk of deep capital drawdowns.

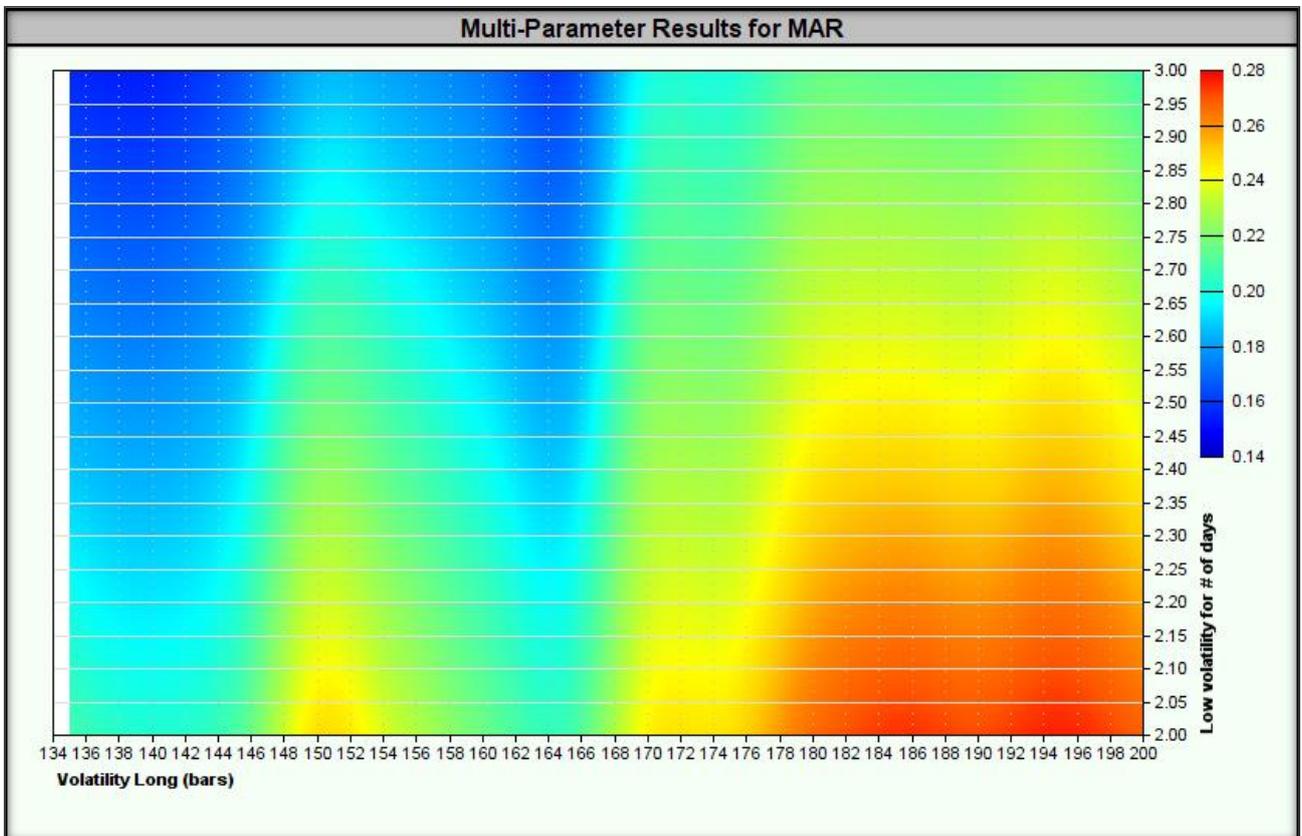
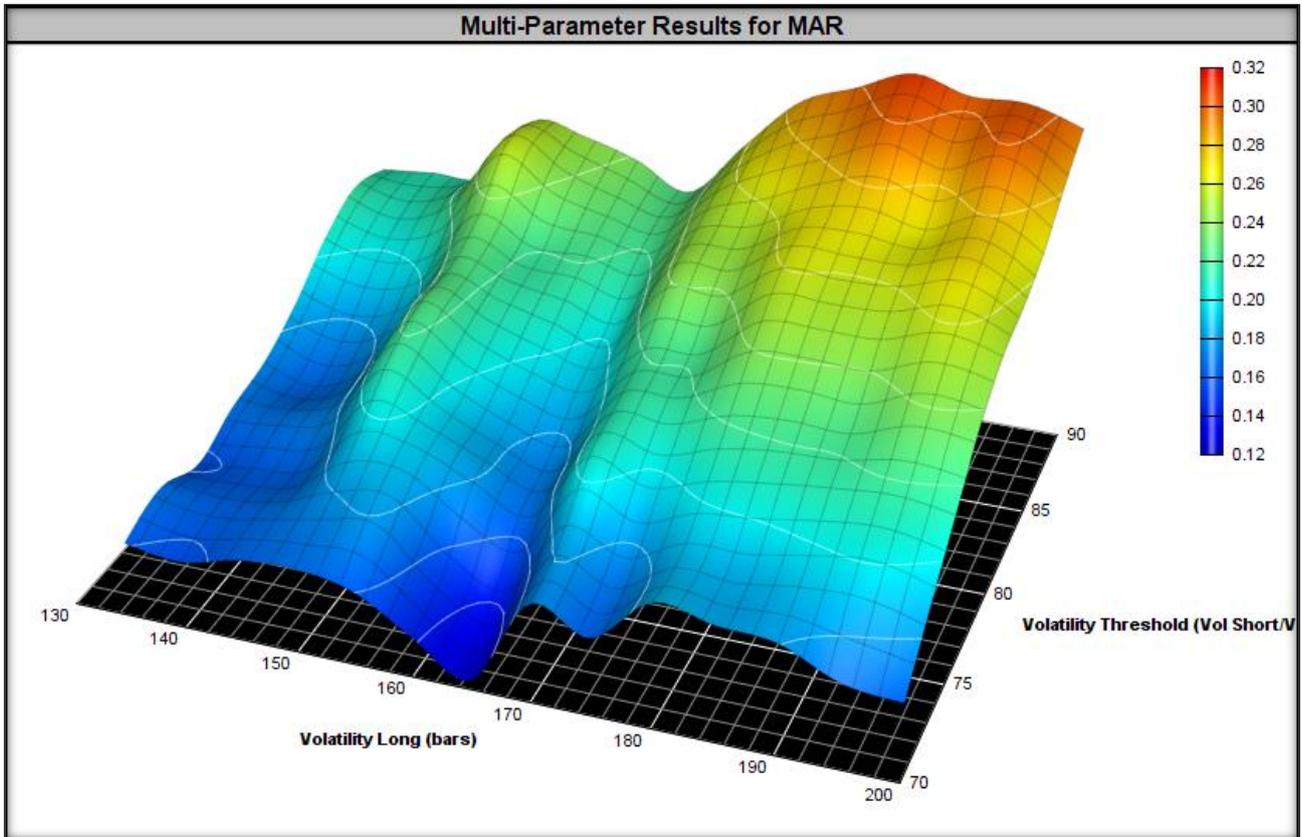
Heatmaps for the tested ranges are shown below.

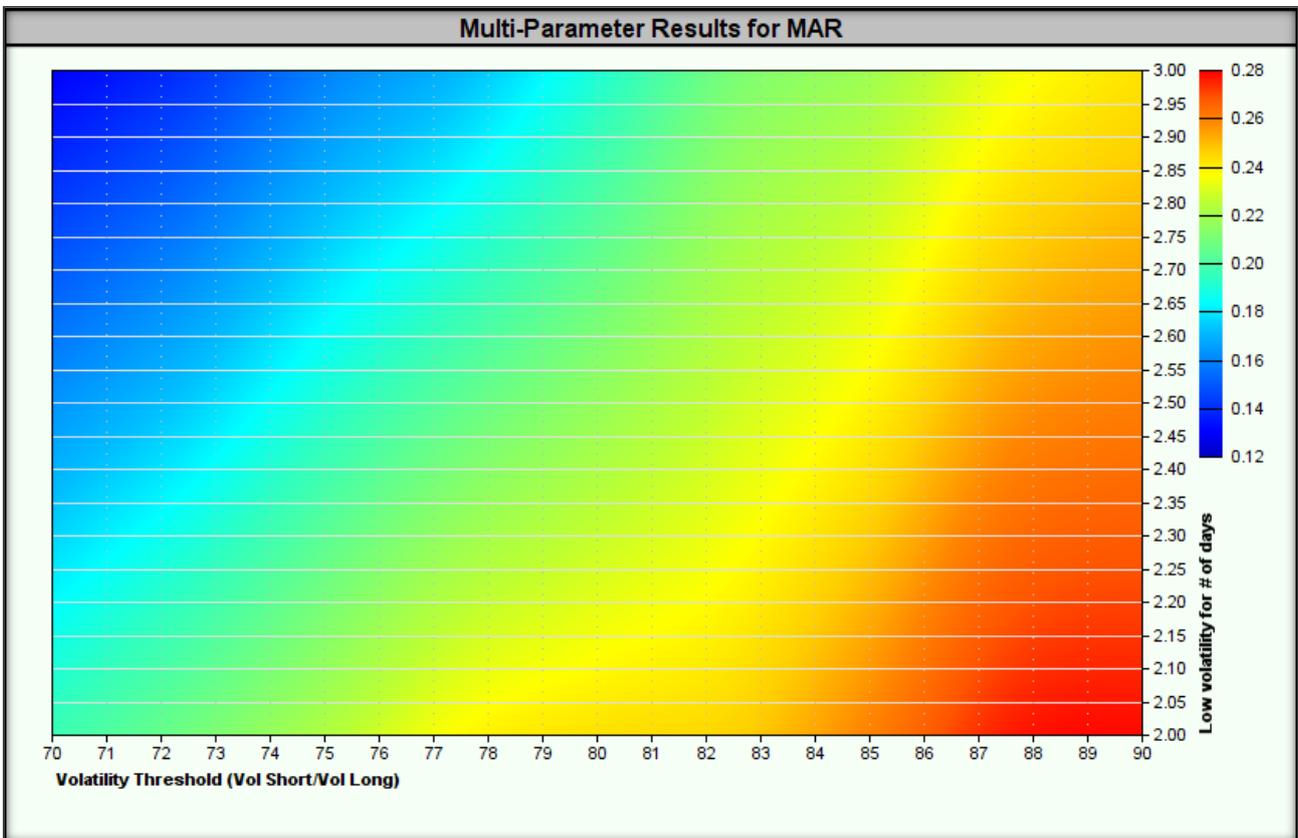
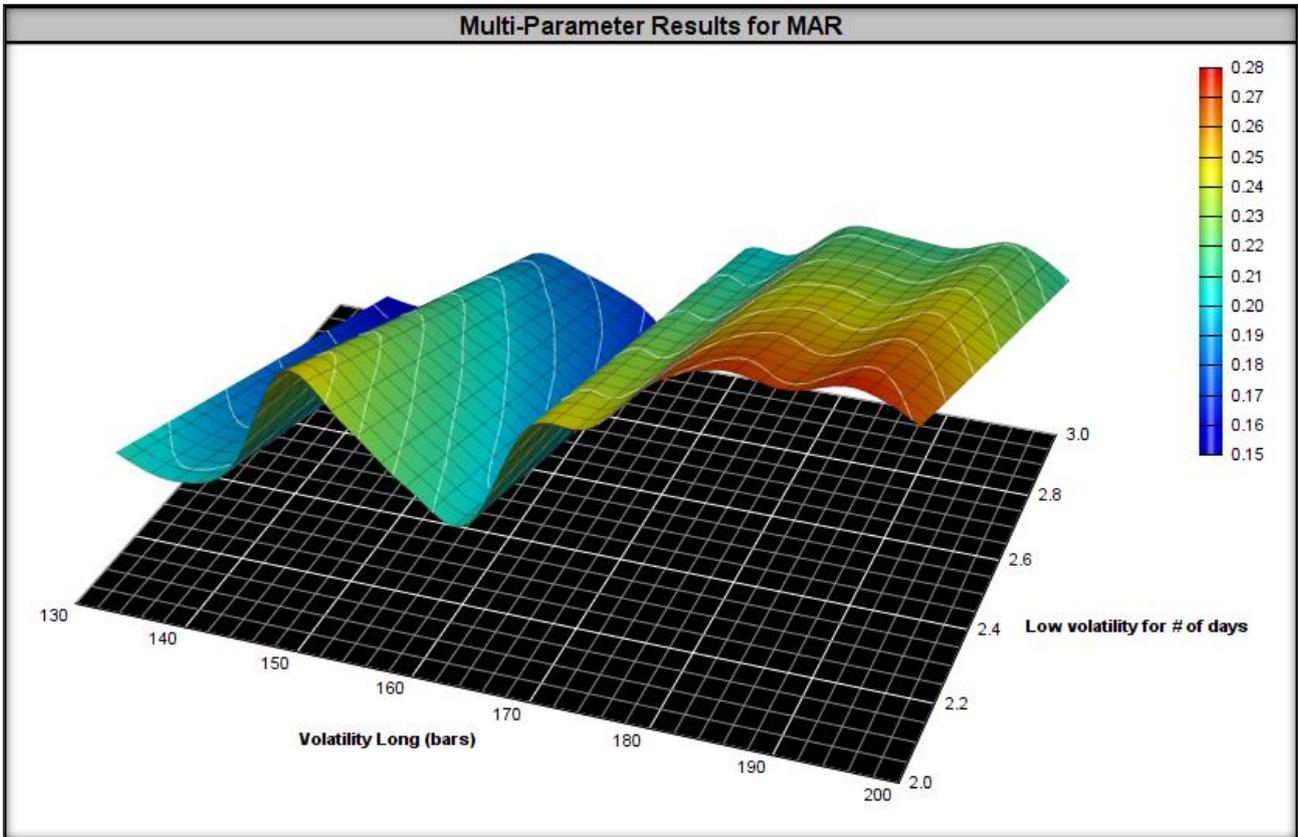


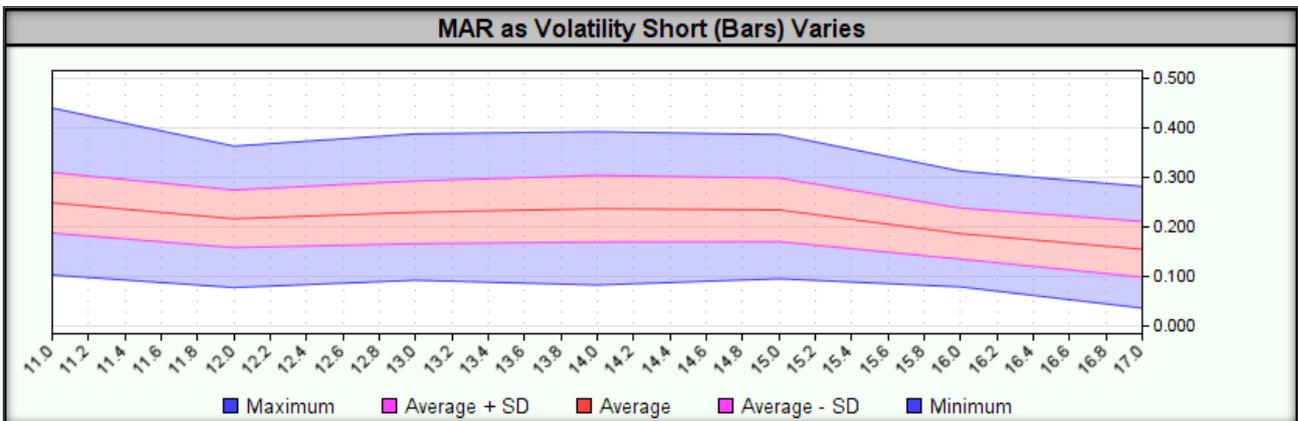
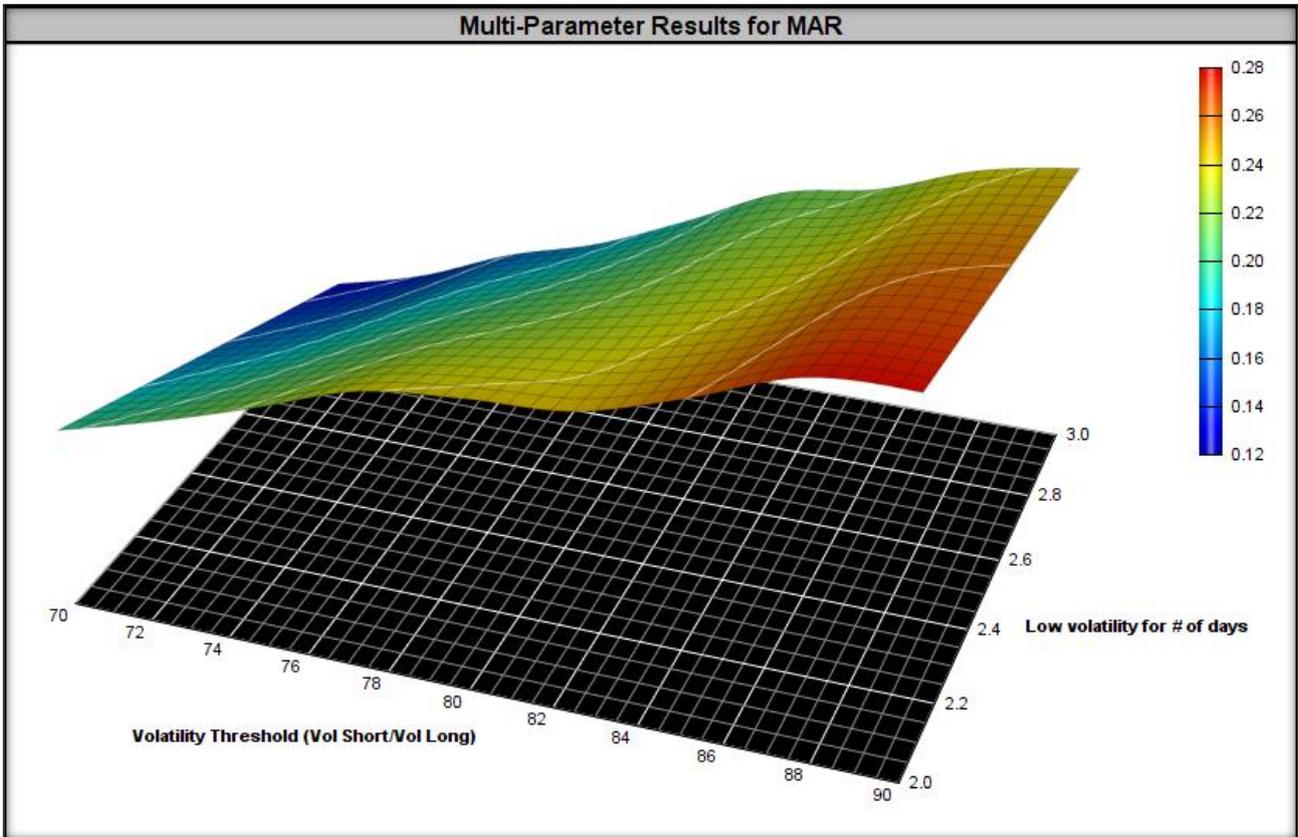


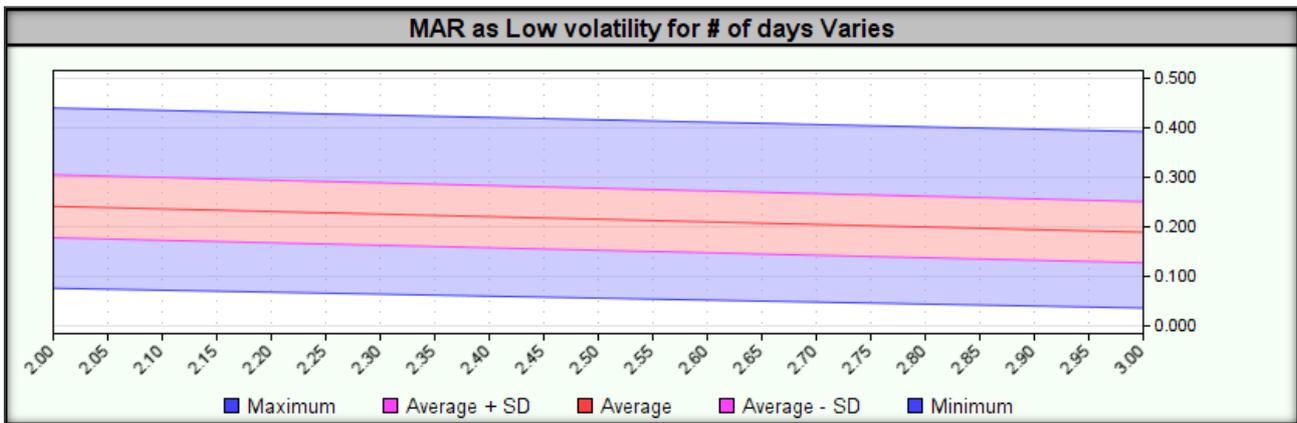
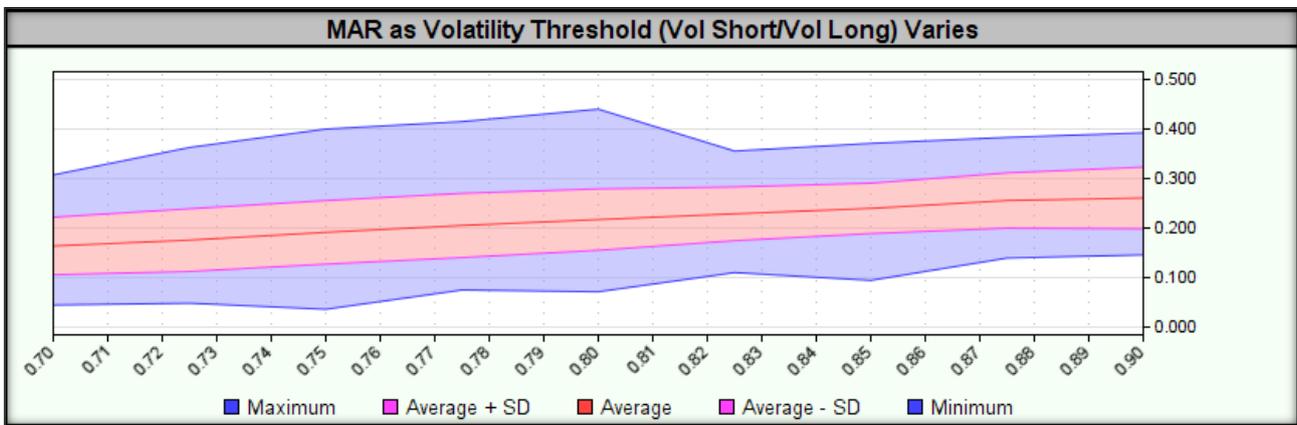
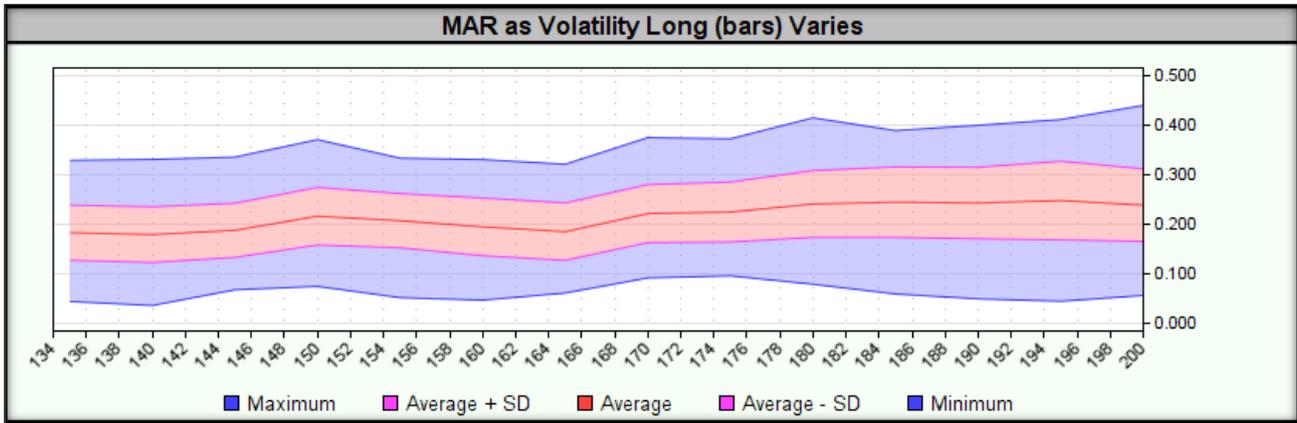












After passing the stability tests on **in-sample data**, it is time perform the same on **out-of-sample data**. For this purpose, we use **the same range of parameters** as on in-sample data:

- **VolShort:** range 11-17 days (step: 1);
- **MALong & VolLong:** range 135-200 days (step: 5);
- **VolRatio:** range 70%-90% (step: 2.5 pp);
- **Volatility Contraction & HighestHigh & MaxRange:** 2-3 days range (step: 1).

The lowest MAR value of 0.07 was achieved for the following parameters:



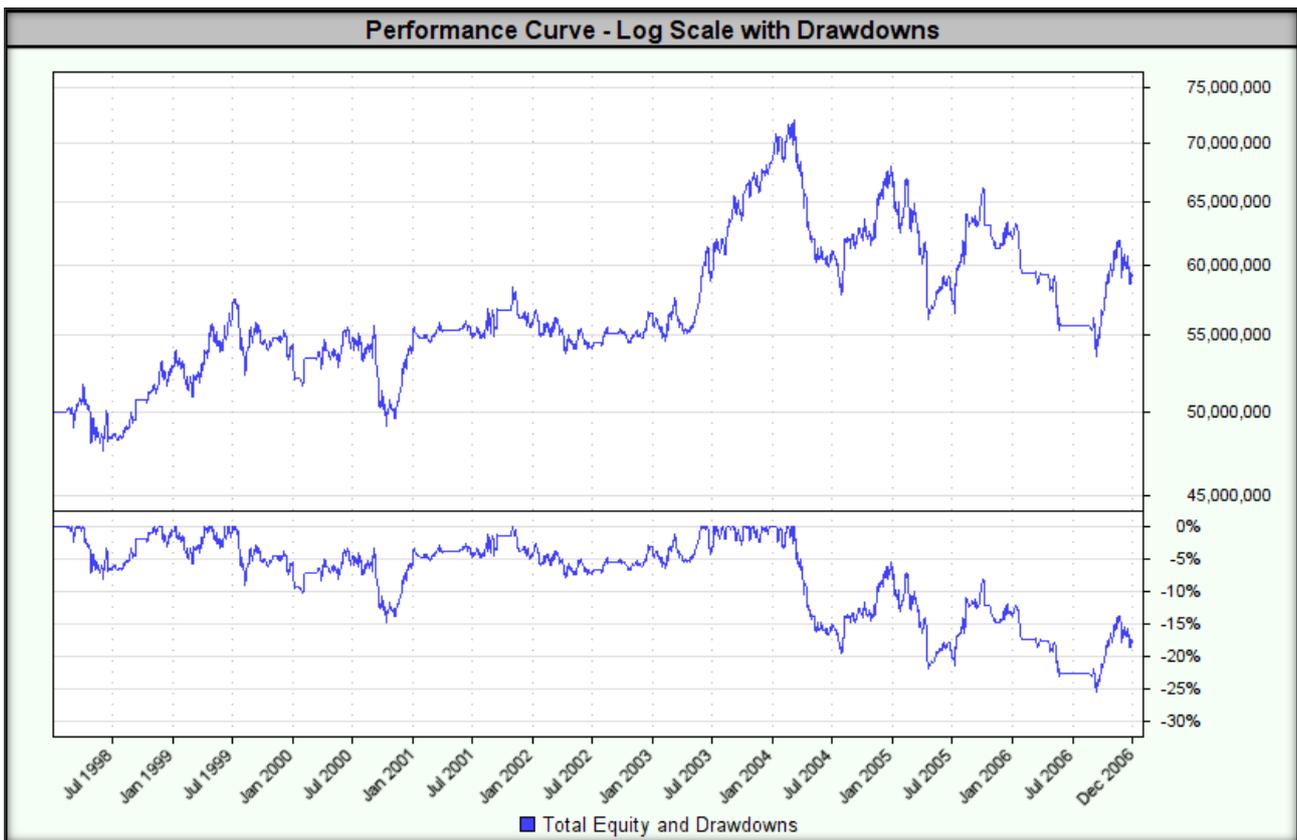
- **VolShort:** 17 days;
- **MALong & VolLong:** 170 days;
- **VolRatio:** 82.5%;
- **Volatility Contraction & HighestHigh & MaxRange:** 3 days.

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.

Test	Volatility Short (Bars)	Volatility Long (bars)	Volatility Threshold (Vol Short/Vol Long)	Low volatility for # of days	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD
1650	17	170	82.5%	3	\$59,230,190.79	1.90%	0.07	0.24	0.24	25.6%
1418	16	175	85.0%	3	\$60,498,172.05	2.14%	0.08	0.27	0.25	25.7%
1416	16	175	82.5%	3	\$59,956,703.05	2.04%	0.09	0.26	0.25	24.0%
1400	16	170	85.0%	3	\$58,956,835.63	1.85%	0.09	0.24	0.26	21.6%
1614	17	160	82.5%	3	\$61,525,030.27	2.33%	0.09	0.29	0.27	27.0%
1616	17	160	85.0%	3	\$62,071,082.10	2.43%	0.09	0.30	0.26	28.0%
1414	16	175	80.0%	3	\$60,079,557.66	2.06%	0.09	0.27	0.28	22.8%
1632	17	165	82.5%	3	\$61,144,201.03	2.26%	0.09	0.28	0.28	24.9%
1434	16	180	82.5%	3	\$59,994,065.52	2.05%	0.09	0.26	0.26	22.0%
1436	16	180	85.0%	3	\$61,027,147.41	2.24%	0.10	0.28	0.27	23.1%
1394	16	170	77.5%	3	\$60,387,788.92	2.12%	0.10	0.28	0.32	20.7%
1452	16	185	82.5%	3	\$62,426,452.49	2.50%	0.10	0.31	0.29	24.2%
1432	16	180	80.0%	3	\$61,114,402.54	2.26%	0.11	0.28	0.29	21.3%

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

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.



The highest MAR value of **0.81** was achieved for the following parameters:

- **VolShort:** 12 days;
- **MALong & VolLong:** 150 days;
- **VolRatio:** 72.5%;



- **Volatility Contraction & HighestHigh & MaxRange: 3 days.**

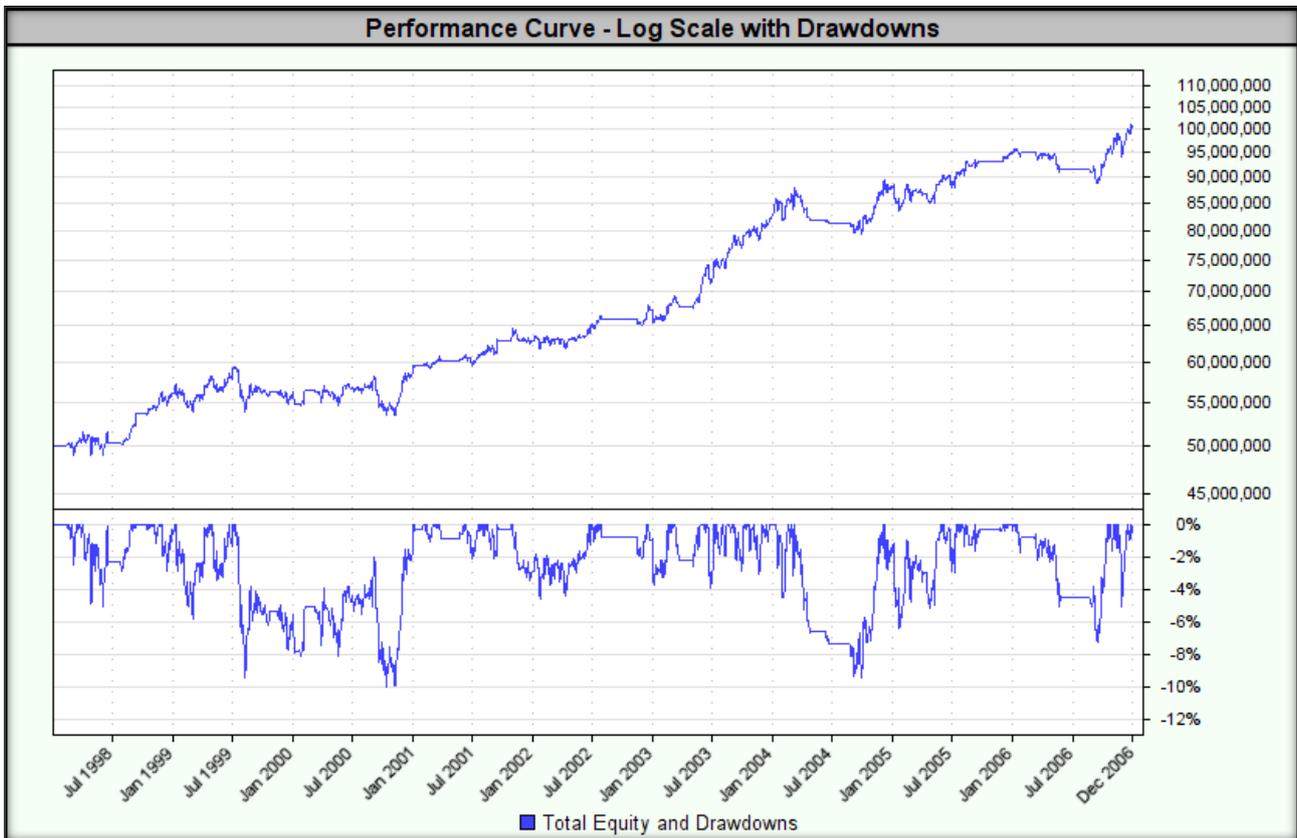
The highest MAR value was accompanied by a drawdown of 10.0%.

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.

Test	Volatility Short (Bars)	Volatility Long (bars)	Volatility Threshold (Vol Short/Vol Long)	Low volatility for # of days	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD
310	12	150	72.5%	3	\$100,476,725.72	8.07%	0.61	1.11	1.31	10.0%
308	12	150	70.0%	3	\$102,006,785.41	8.25%	0.78	1.12	1.35	10.9%
328	12	155	72.5%	3	\$97,712,827.29	7.74%	0.68	1.05	1.17	11.4%
793	14	145	70.0%	2	\$89,557,305.01	6.70%	0.67	0.89	0.96	10.0%
815	14	150	75.0%	2	\$90,340,766.89	6.80%	0.66	0.83	0.88	10.3%
811	14	150	70.0%	2	\$88,451,675.13	6.55%	0.65	0.86	0.96	10.0%
797	14	145	75.0%	2	\$89,014,330.48	6.63%	0.63	0.82	0.91	10.5%
290	12	145	70.0%	3	\$94,875,779.56	7.38%	0.62	1.02	1.21	11.9%
775	14	140	70.0%	2	\$85,980,737.24	6.21%	0.62	0.83	0.91	10.0%
326	12	155	70.0%	3	\$96,899,799.41	7.64%	0.62	1.05	1.14	12.4%
346	12	160	72.5%	3	\$92,260,908.98	7.05%	0.61	0.95	0.95	11.5%
1573	17	150	77.5%	2	\$90,548,747.58	6.83%	0.61	0.83	1.08	11.1%
58	11	150	72.5%	3	\$91,597,152.67	6.96%	0.60	0.97	1.01	11.5%

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

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.



For all combinations of tested parameter ranges, the highest drawdown was 28.0%.

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.

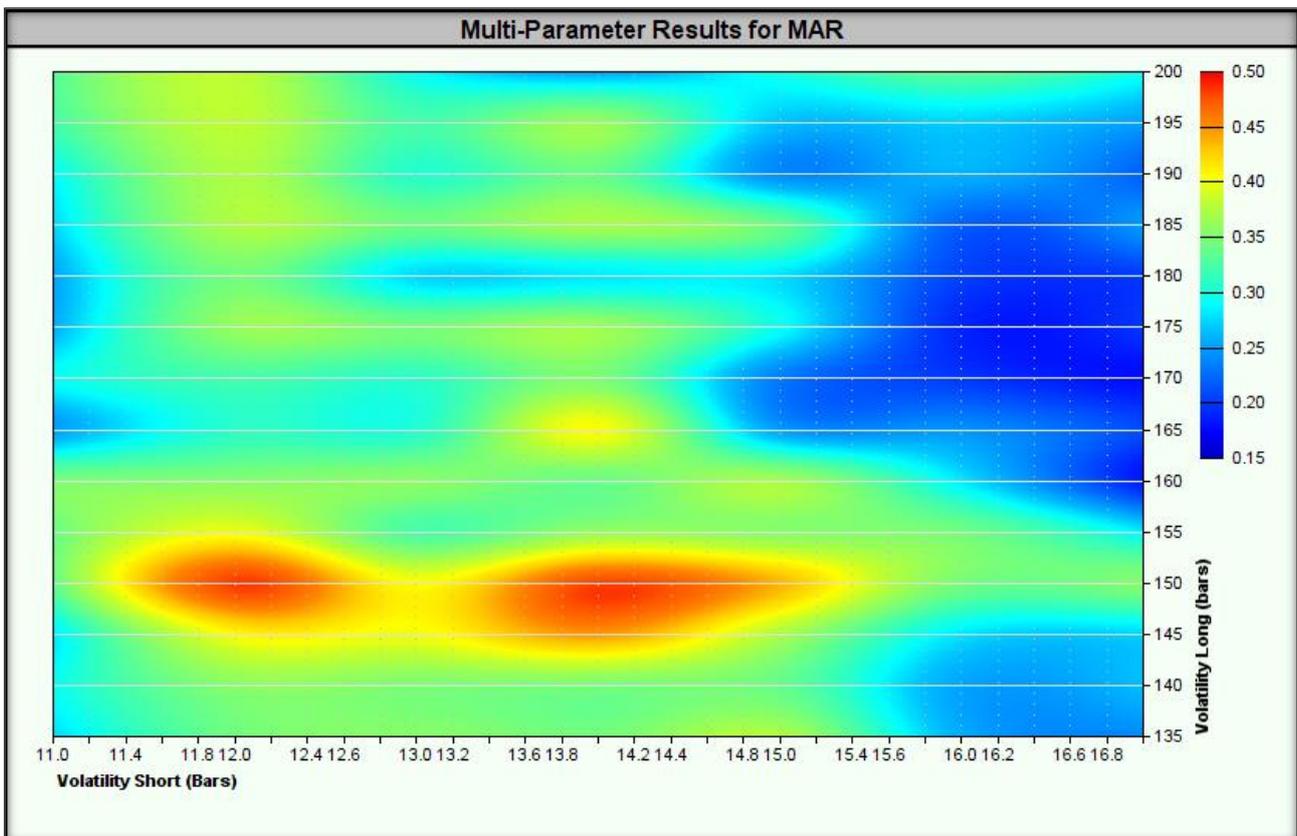


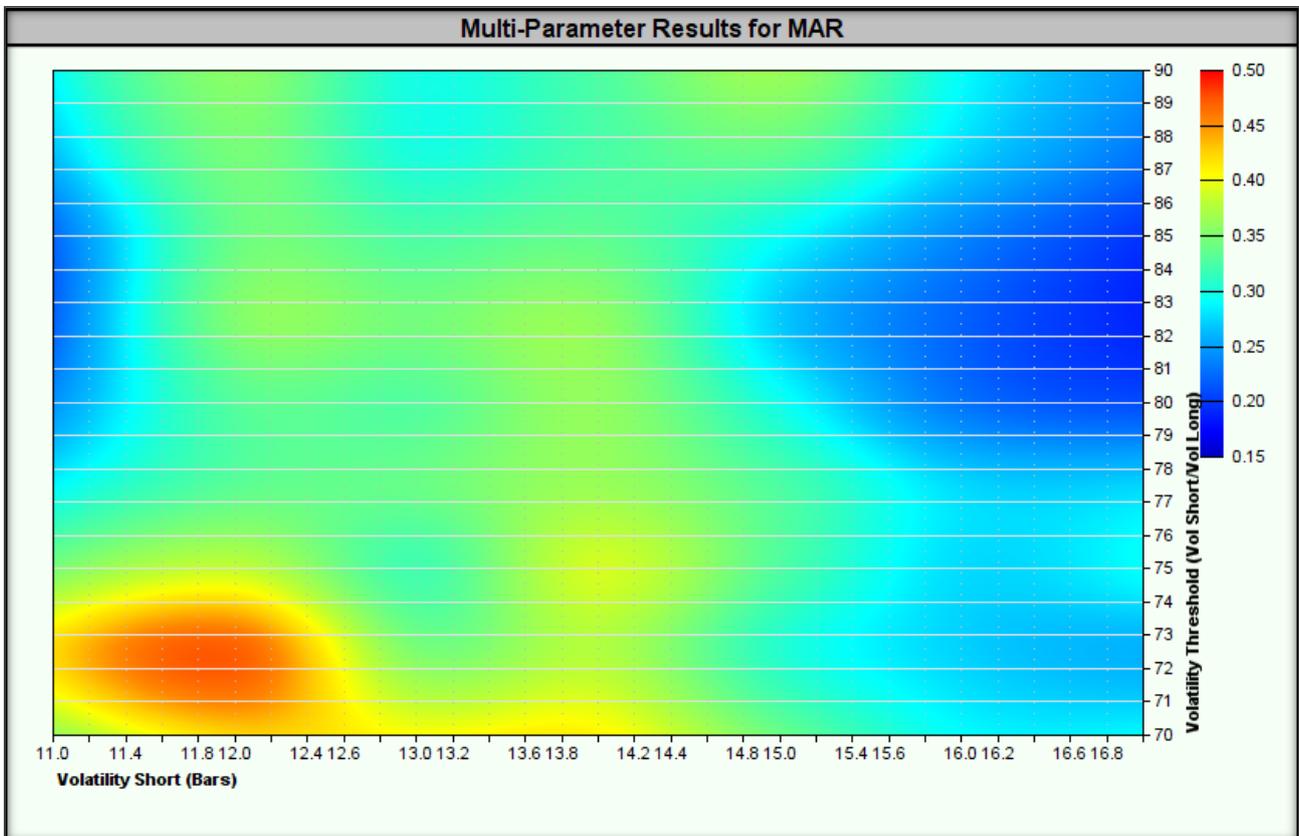
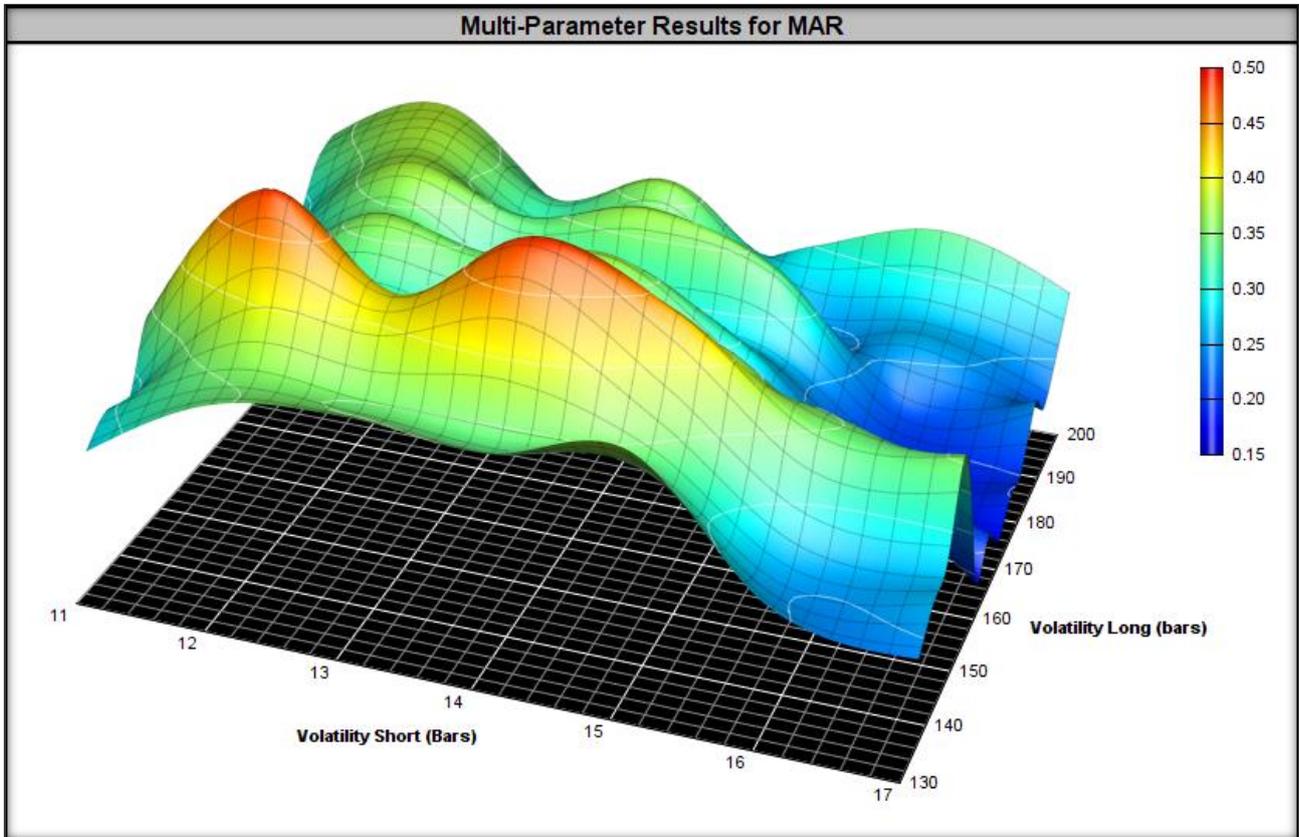
Test	Volatility Short (Bars)	Volatility Long (bars)	Volatility Threshold (Vol Short/Vol Long)	Low volatility for # of days	End Balance	CAGR%	MAR	Sharpe	Ann. Sharpe	Max TE DD
1616	17	160	85.0%	3	\$62,071,082.10	2.43%	0.09	0.30	0.26	28.0%
1614	17	160	82.5%	3	\$61,525,030.27	2.33%	0.09	0.29	0.27	27.0%
1684	17	180	80.0%	3	\$65,311,552.33	3.02%	0.11	0.35	0.32	26.7%
1686	17	180	82.5%	3	\$68,980,605.24	3.64%	0.14	0.41	0.39	26.1%
1688	17	180	85.0%	3	\$69,606,268.87	3.75%	0.15	0.42	0.40	25.8%
1418	16	175	85.0%	3	\$60,498,172.05	2.14%	0.08	0.27	0.25	25.7%
1650	17	170	82.5%	3	\$59,230,190.79	1.90%	0.07	0.24	0.24	25.6%
1720	17	190	80.0%	3	\$69,612,140.21	3.75%	0.15	0.42	0.36	25.1%
1652	17	170	85.0%	3	\$65,364,163.10	3.03%	0.12	0.35	0.34	25.1%
1241	15	195	90.0%	2	\$95,908,367.77	7.51%	0.30	0.72	0.96	25.1%
1223	15	190	90.0%	2	\$88,058,349.75	6.50%	0.26	0.65	0.73	25.0%
1632	17	165	82.5%	3	\$61,144,201.03	2.26%	0.09	0.28	0.28	24.9%
1668	17	175	82.5%	3	\$64,640,170.55	2.90%	0.12	0.34	0.33	24.8%

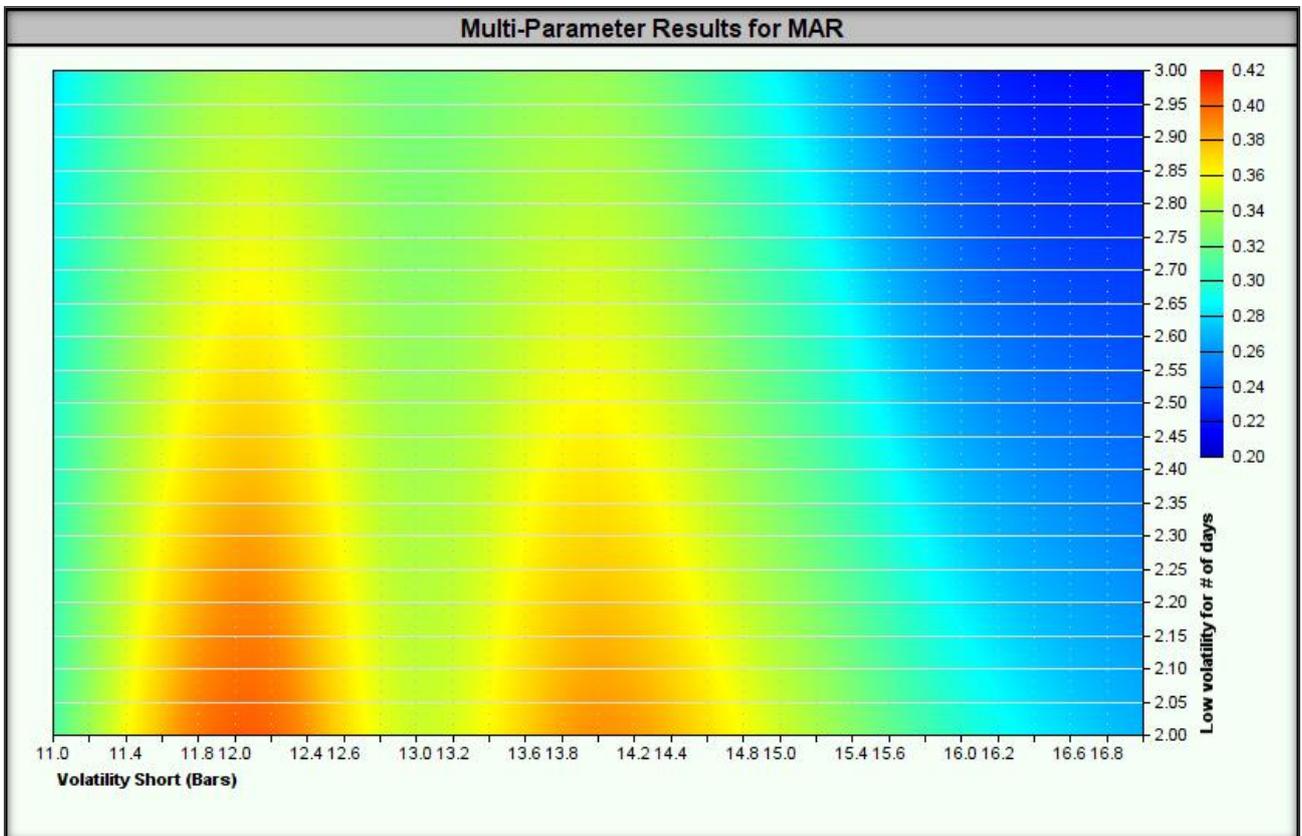
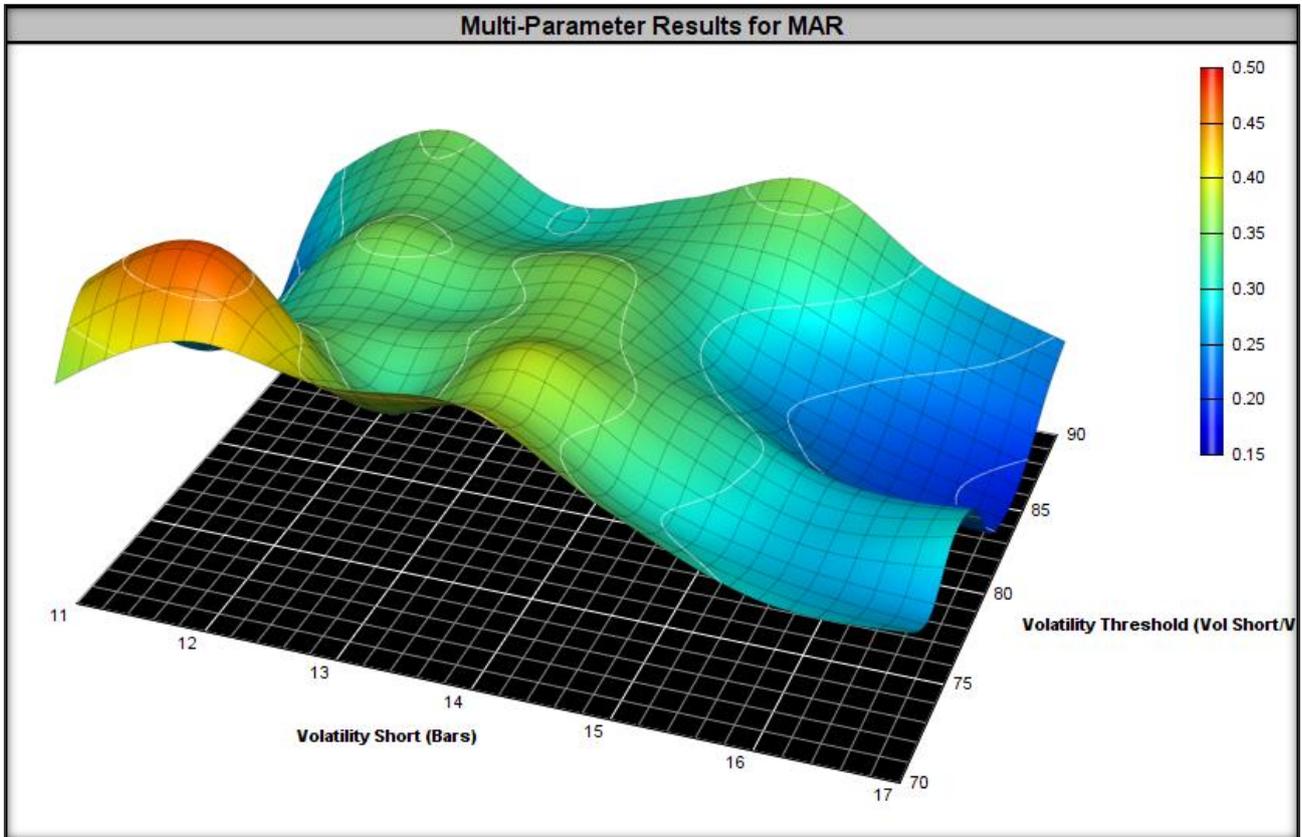
In summary, the strategy passed the stability test over a wide range of optimized parameters on out-of-sample data because:

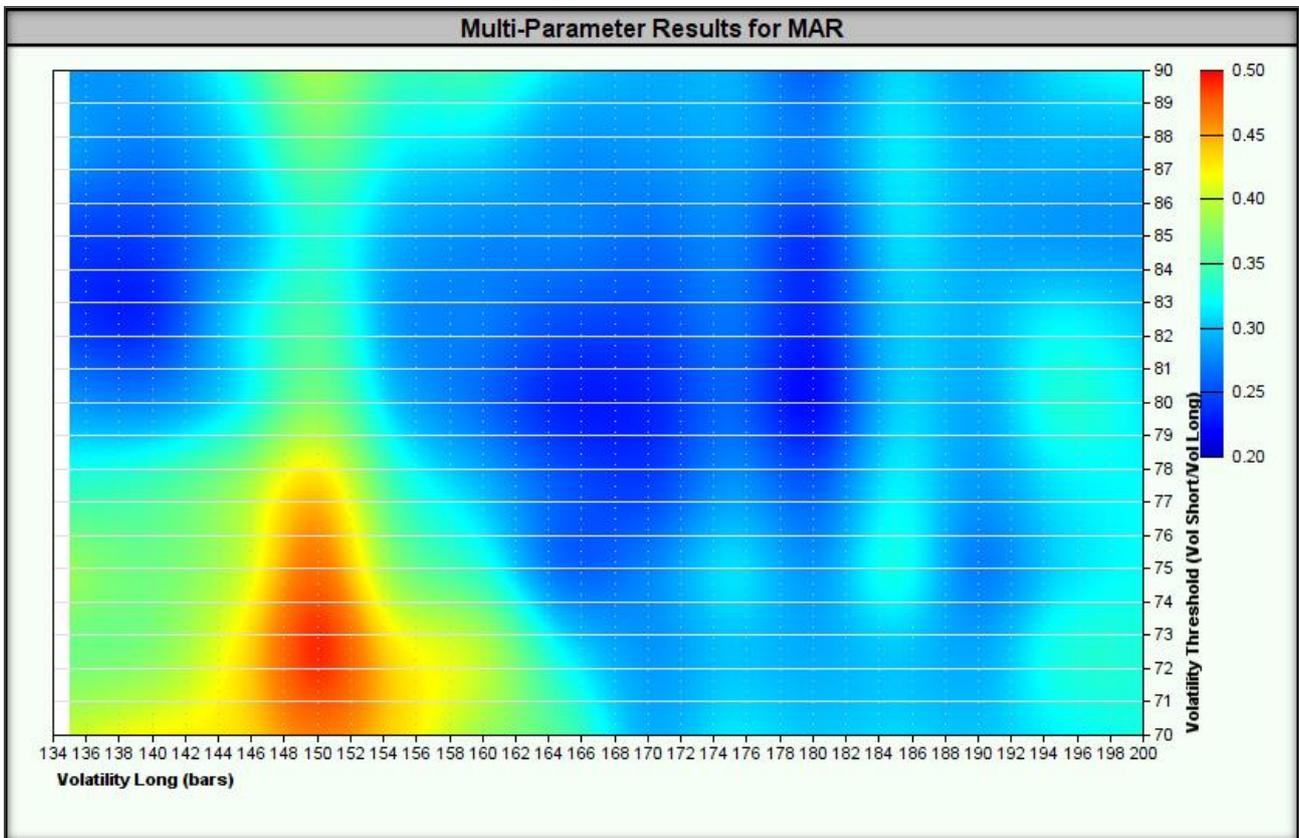
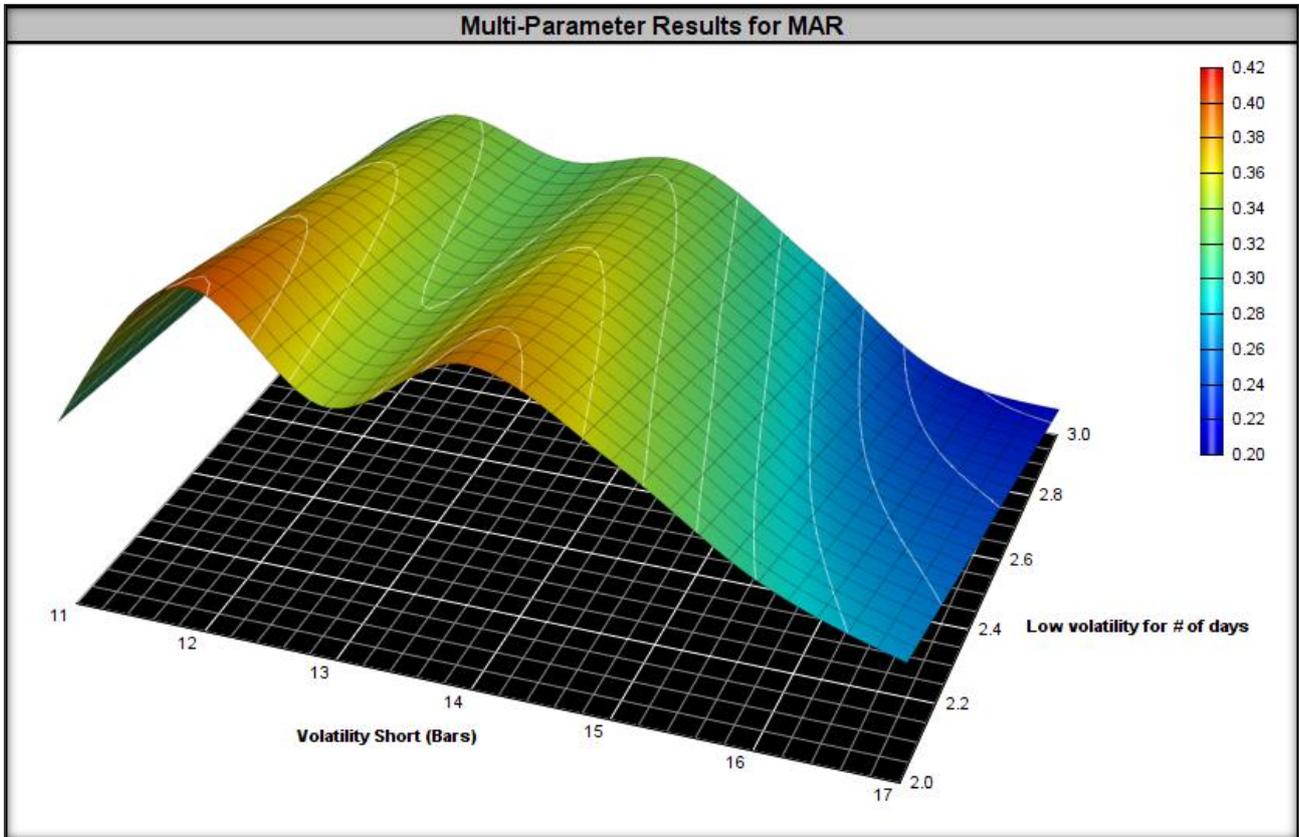
- All test results showed a positive MAR value – which indicates the stability of the strategy in various market conditions.
- The maximum drawdown on out-of-sample data did not exceed 150% of the maximum drawdown value on in-sample data (28.0% vs. 33.9%) – which means an acceptable risk of capital drawdown.
- The decrease in the maximum MAR value on out-of-sample data was less than 50% compared to the in-sample test results (0.81 vs. 0.44) – indicating that the strategy can achieve good results in a variety of market conditions.

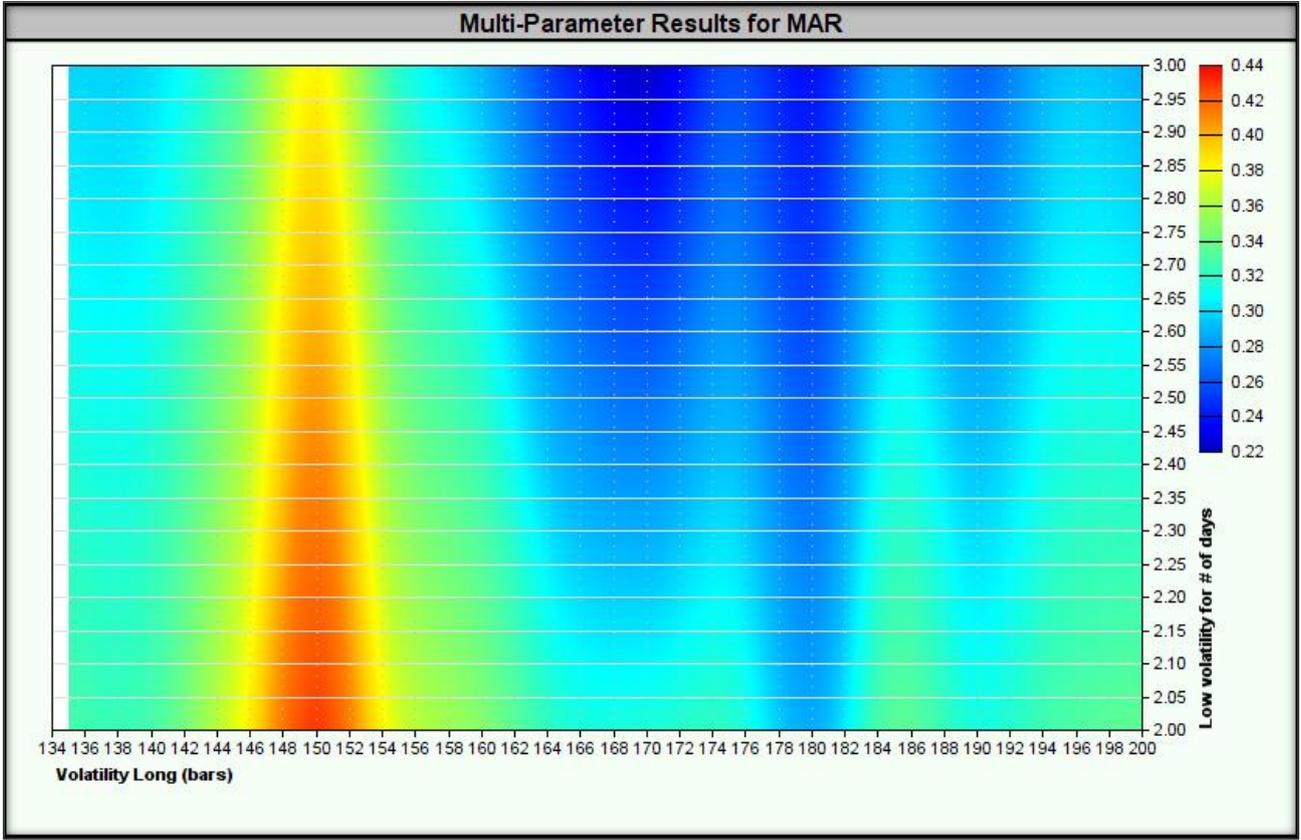
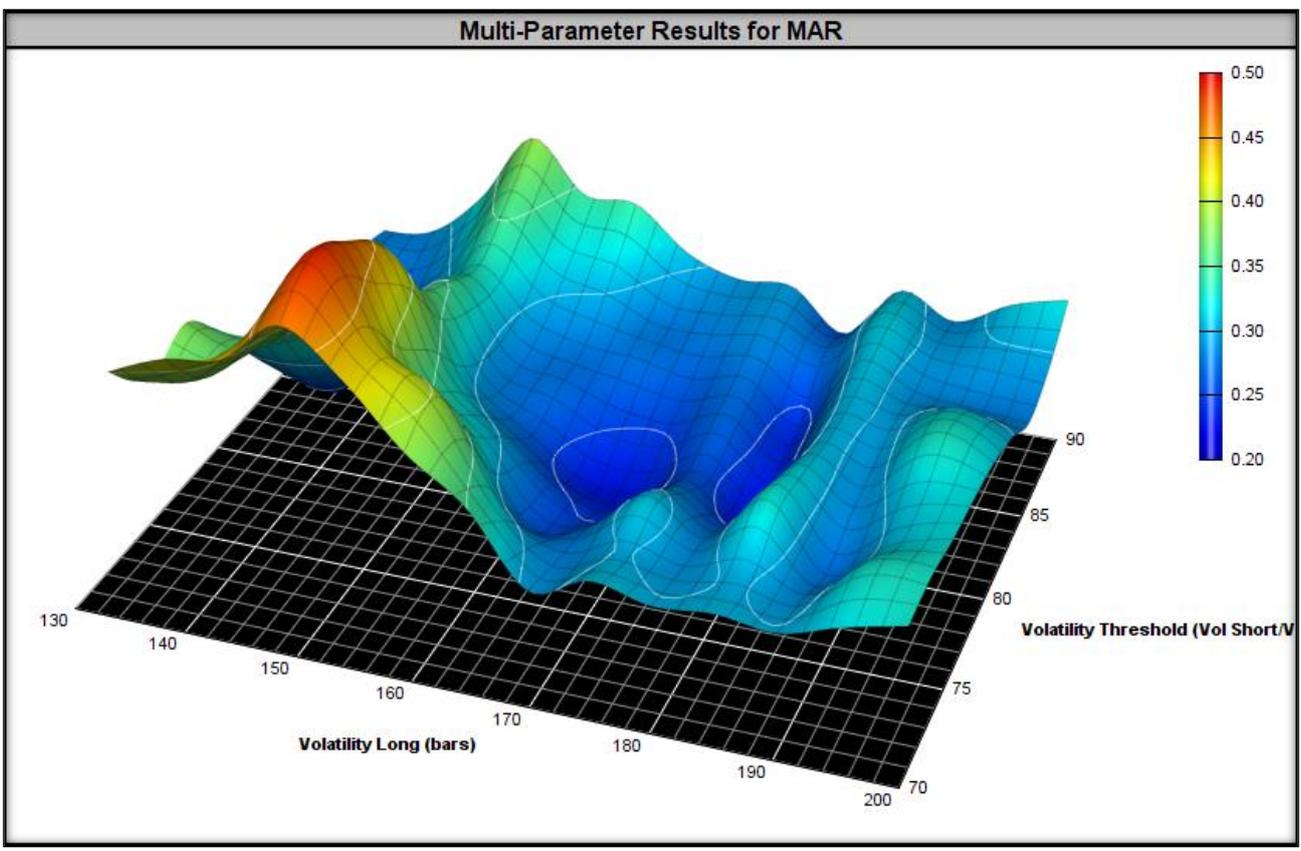
Heatmaps for the tested ranges are shown below.

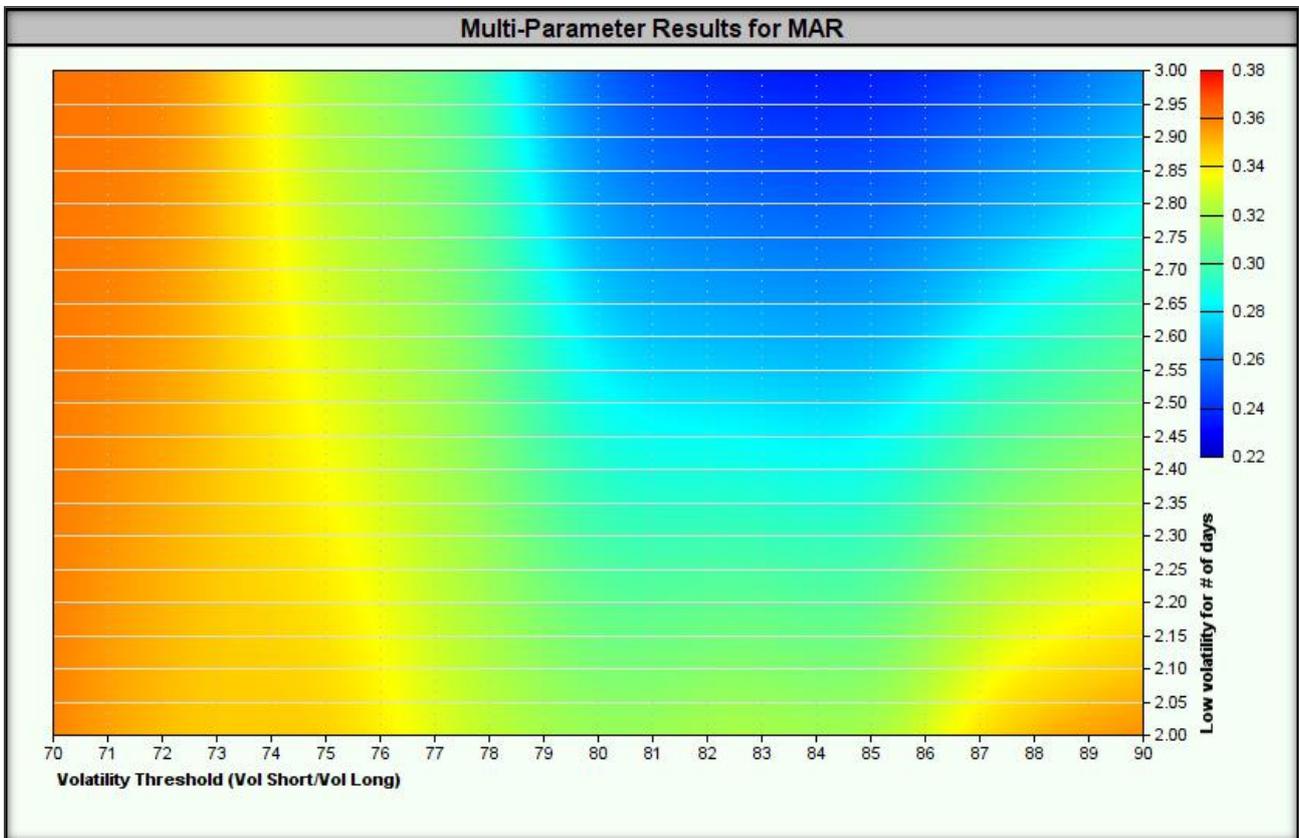
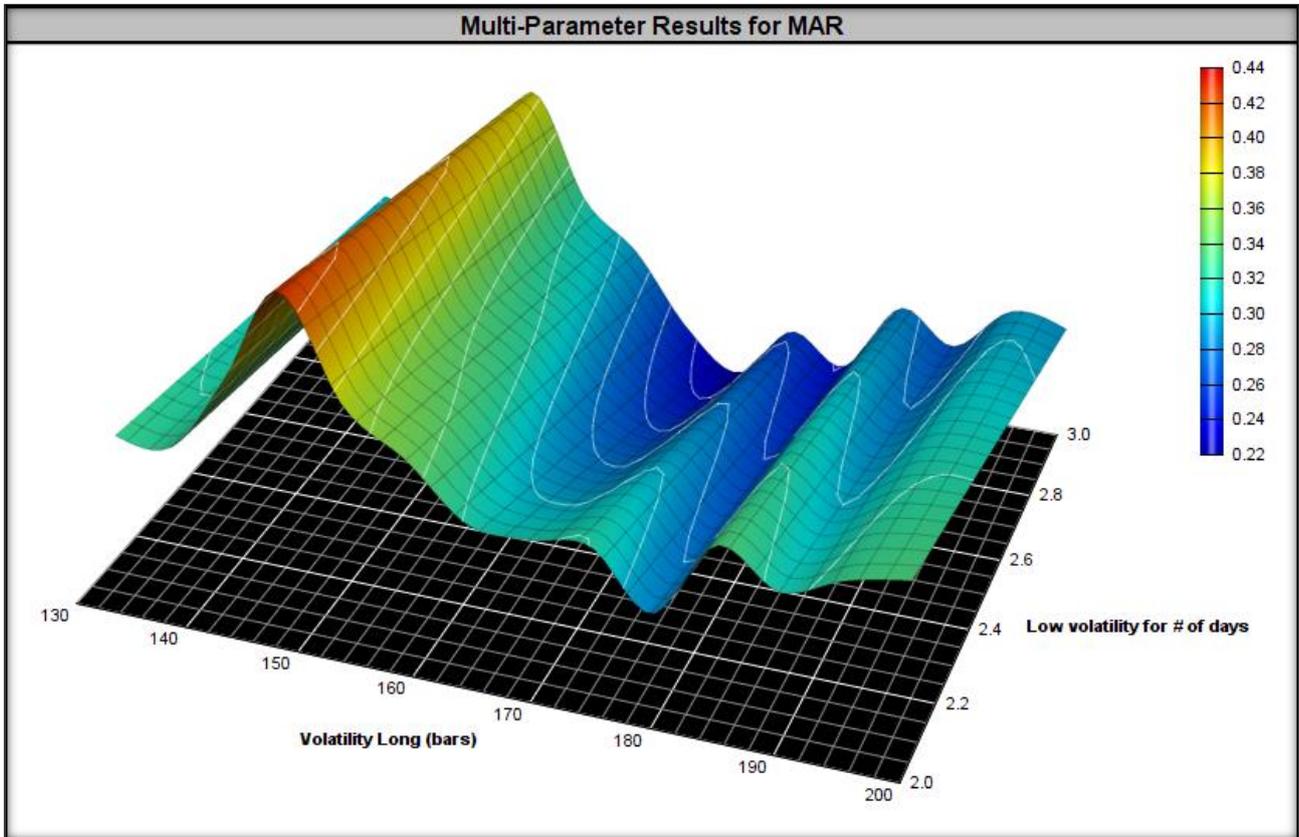


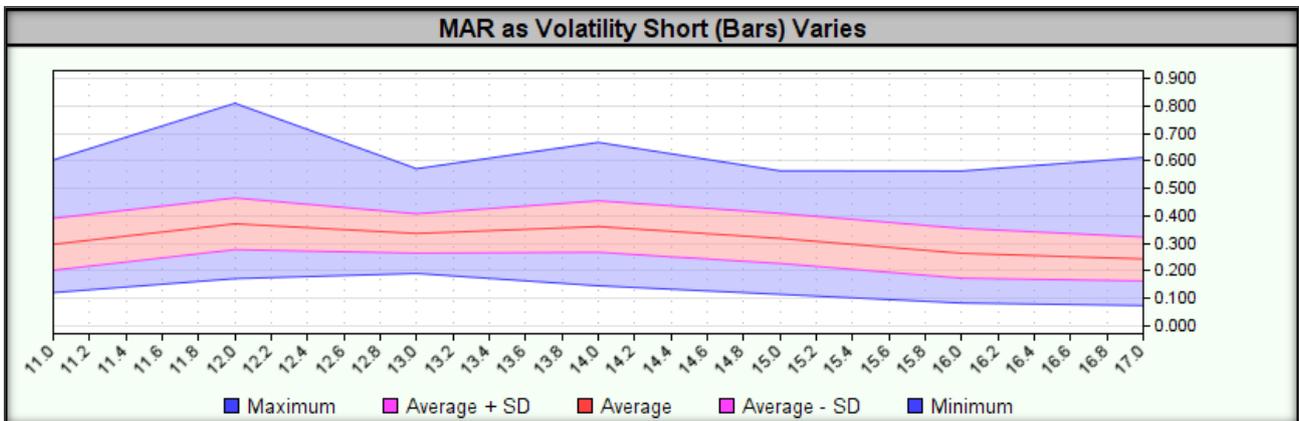
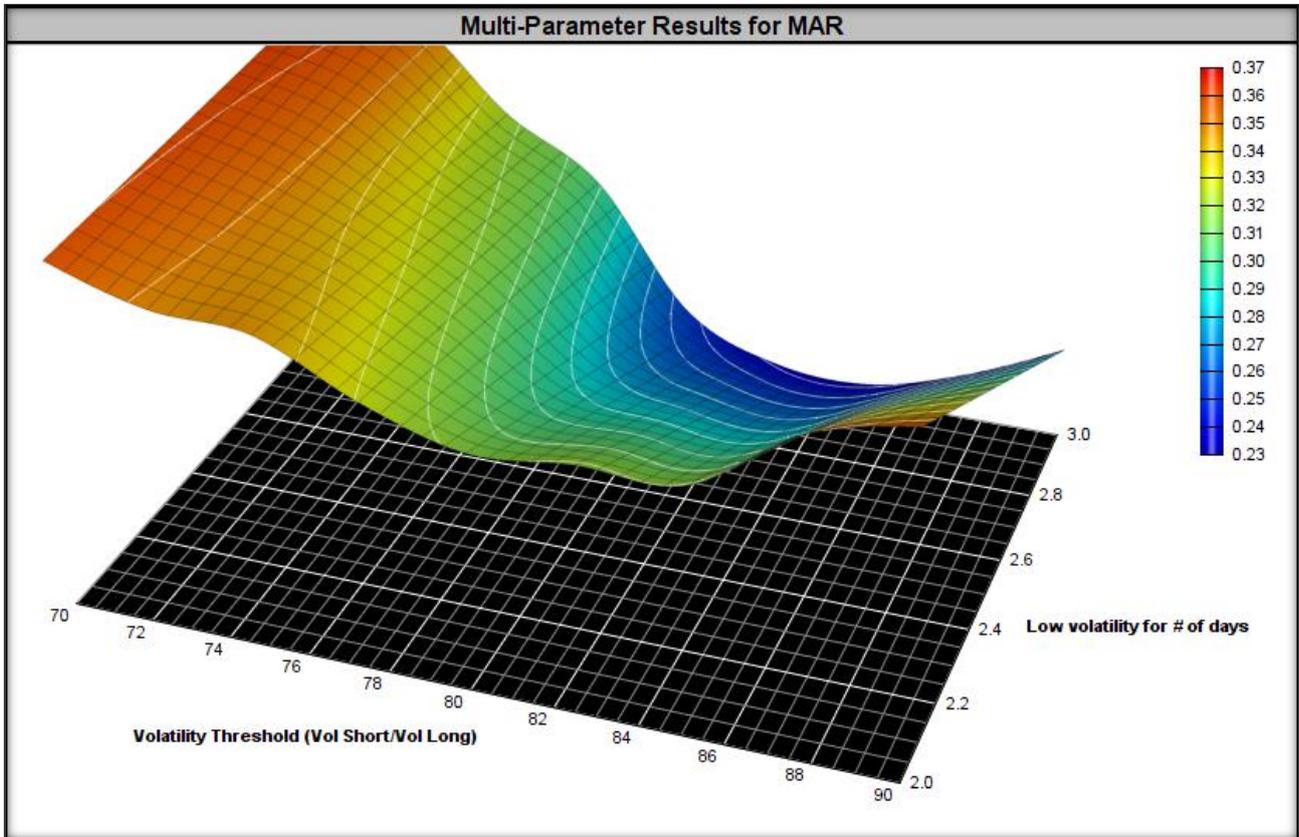


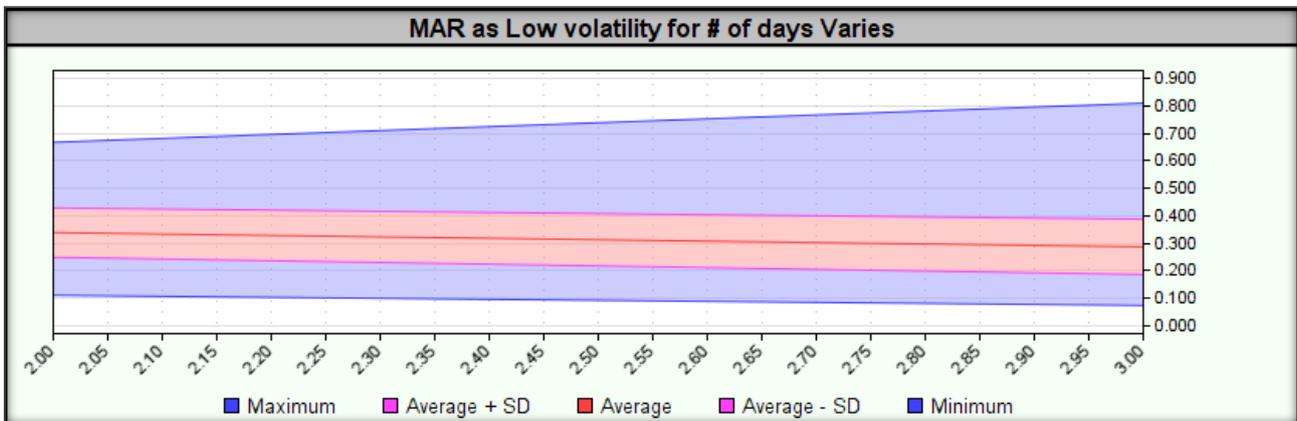
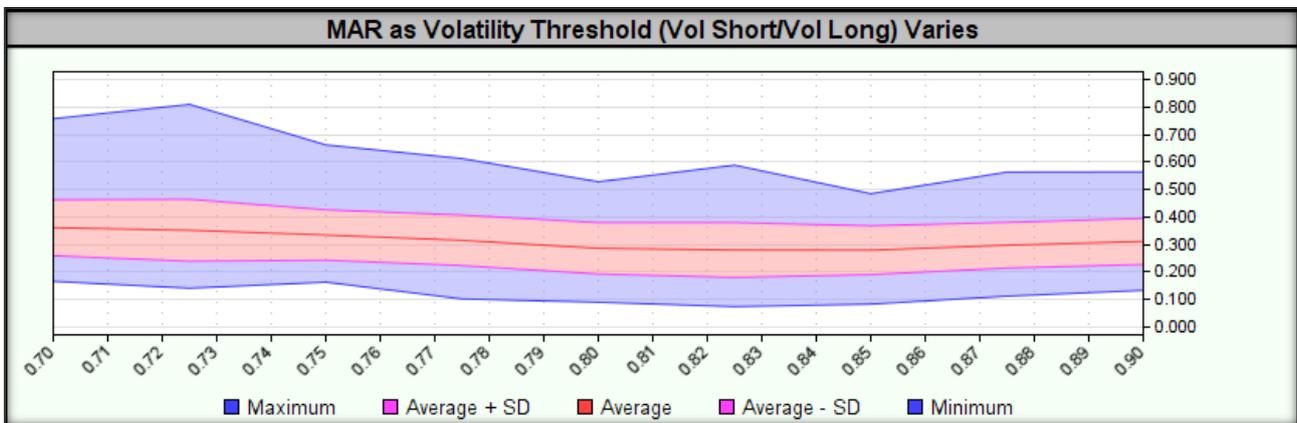
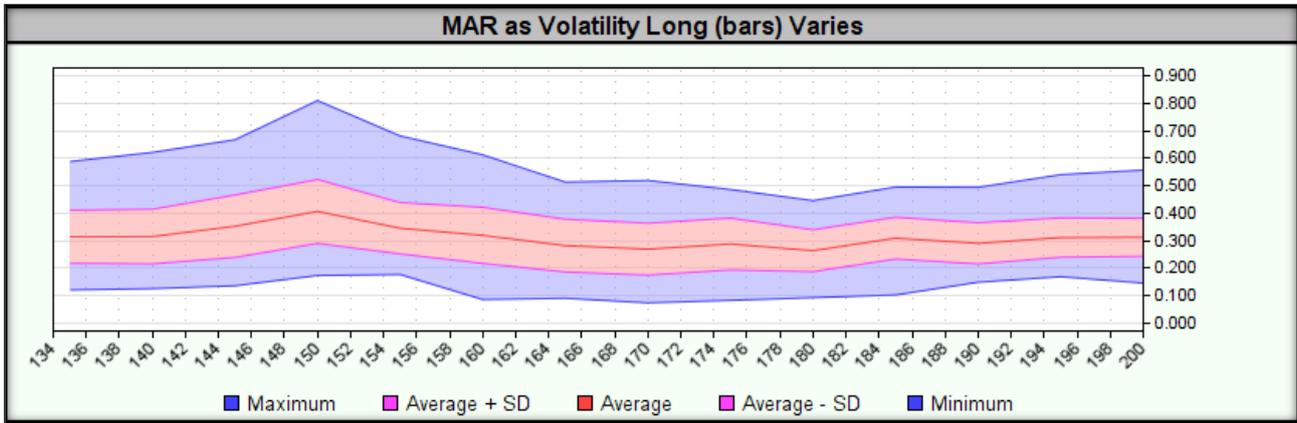












Once the stability test has passed across a wide range of optimized parameters, we can proceed to **stability testing using Monte Carlo simulation**. The conditions for passing this test are similar to those required in the step above.

2. Monte Carlo simulation

Monte Carlo simulation involves running multiple simulations to examine how a strategy might perform under various market scenarios. A key goal of this method is to assess the potential **drawdown** of an optimized strategy. **Monte Carlo simulation** better reflects possible equity curve fluctuations and the depth of potential **drawdown**, allowing for a more realistic risk assessment. It also provides an ideal opportunity to



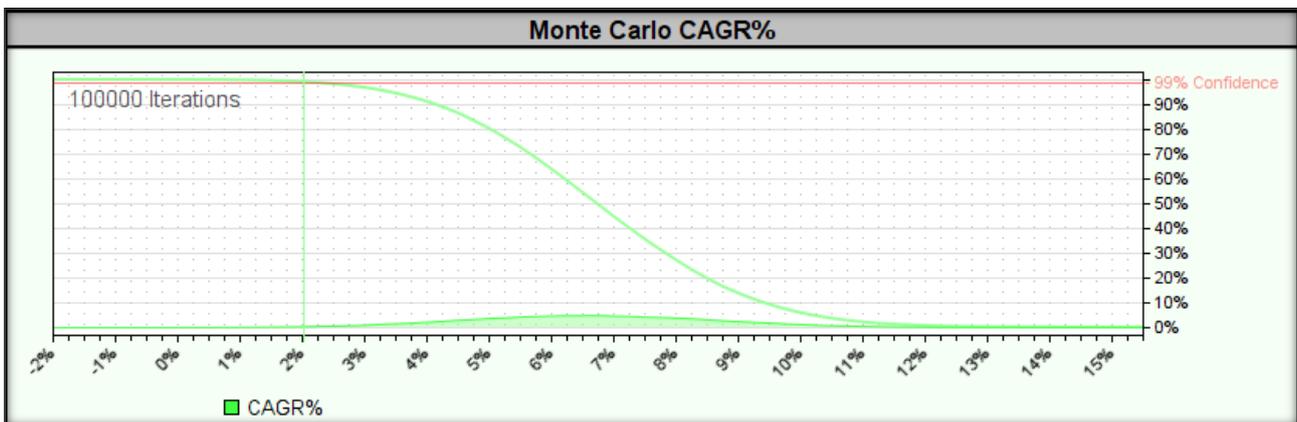
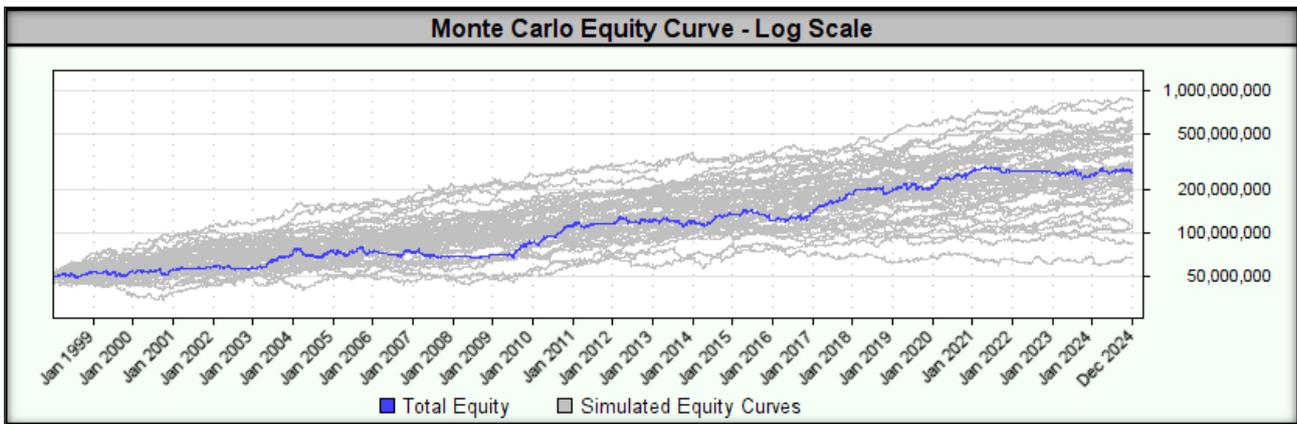
compare **the drawdown** obtained in tests on optimized parameter ranges with the results of **the Monte Carlo simulation**, using a **99% confidence interval**.

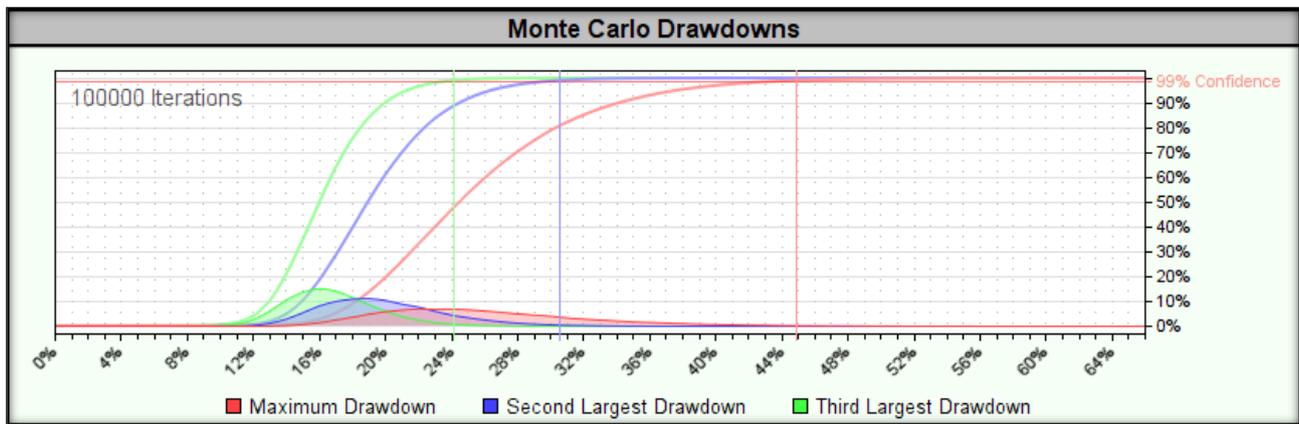
A strategy considered to be **stable (robust)** should achieve a **drawdown in a Monte Carlo simulation** that does not exceed **250% of the drawdown size from total tests in-sample and out-of-sample** (for parameters optimized on IS data). Furthermore, the **MAR indicator** should remain positive within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

For data covering the period from **January 1, 1998 to December 31, 2024**, a **Monte Carlo simulation** was performed using **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.

Historical or simulated results do not guarantee that similar outcomes will be achieved in the future.





- **CAGR%** – In 99% of simulations achieved a rate of return equal to or higher than 2%.
- **Drawdown** – 99% of simulations achieved a drawdown of 45% or less. For parameters optimized on in-sample data, the drawdown was 17.0%.

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

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

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



Step 6: Using the strategy in real time

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