trend-following-rsi-minute-level-crypto-part-1-trading-strategy

October 8, 2025

1 Combining Trend Following With RSI Using Crypto Data

1.1 Python Imports

[1]:
```
# Standard Library
import datetime
import io
import os
import random
import sys
import warnings

from datetime import datetime, timedelta
from pathlib import Path

# Data Handling
import numpy as np
import pandas as pd

# Data Visualization
import matplotlib.dates as mdates
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import seaborn as sns
from matplotlib.ticker import FormatStrFormatter, FuncFormatter, MultipleLocator

# Data Sources
import yfinance as yf

# Statistical Analysis
import statsmodels.api as sm

# Machine Learning
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler

# Suppress warnings
warnings.filterwarnings("ignore")
```

1.2 Add Directories To Path

[2]:
```
# Add the source subdirectory to the system path to allow import config from␣
 ↪settings.py
try:
    # Works for .py files
    current_directory = Path(__file__).resolve().parent
except NameError:
    # Fallback for notebooks / interactive shells
    current_directory = Path(os.getcwd()).resolve()

website_base_directory = current_directory.parent.parent.parent
src_directory = website_base_directory / "src"
sys.path.append(str(src_directory)) if str(src_directory) not in sys.path else␣
 ↪None

# Import settings.py
from settings import config

# Add configured directories from config to path
SOURCE_DIR = config("SOURCE_DIR")
sys.path.append(str(Path(SOURCE_DIR))) if str(Path(SOURCE_DIR)) not in sys.path␣
 ↪else None

# Add other configured directories
BASE_DIR = config("BASE_DIR")
CONTENT_DIR = config("CONTENT_DIR")
POSTS_DIR = config("POSTS_DIR")
PAGES_DIR = config("PAGES_DIR")
PUBLIC_DIR = config("PUBLIC_DIR")
SOURCE_DIR = config("SOURCE_DIR")
DATA_DIR = config("DATA_DIR")
DATA_MANUAL_DIR = config("DATA_MANUAL_DIR")

# Print system path
for i, path in enumerate(sys.path):
    print(f"{i}: {path}")
```

```
0: /usr/lib/python313.zip
1: /usr/lib/python3.13
2: /usr/lib/python3.13/lib-dynload
3:
4: /home/jared/python-virtual-envs/general_313/lib/python3.13/site-packages
5: /home/jared/Cloud_Storage/Dropbox/Websites/jaredszajkowski.github.io/src
```

1.3 Track Index Dependencies

[3]:
```
# Create file to track markdown dependencies
dep_file = Path("index_dep.txt")
dep_file.write_text("")
```

[3]:
```
0
```

1.4 Python Functions

[4]:
```
from add_rsi_ma_bb import add_rsi_ma_bb
from analyze_trades import analyze_trades
from backtest_rsi_multi_asset_strategy import backtest_rsi_multi_asset_strategy
from compute_daily_performance import compute_daily_performance
from create_signals import create_signals
from df_info import df_info
from df_info_markdown import df_info_markdown
from export_track_md_deps import export_track_md_deps
from load_crypto_data import load_crypto_data
from load_data import load_data
from pandas_set_decimal_places import pandas_set_decimal_places
from plot_multi_asset_equity_and_drawdown import␣
 ↪plot_multi_asset_equity_and_drawdown
from summary_stats import summary_stats
```

2 Initial Variables

[5]:
```
TICKERS = ["BTC-USD"]
MA_DAYS = [7]
INITIAL_CAPITAL = 10_000
RSI_PERIOD = 20
RSI_THRESHOLD = 20
TRAILING_STOP_PCT = 0.02
ORDER_ENTRY = "limit"
USE_BBANDS = True
BB_WINDOW = 20
BB_NUM_STD = 2.0
BB_RULE = "touch_lower"  # {"touch_lower", "cross_up_from_below", "below_lower"}
START_DATE = "2025-01-01"
END_DATE = "2025-07-31"
```

[6]:
```
# Set decimal places
pandas_set_decimal_places(2)
```

2.1 Load Crypto Data

[7]:
```
crypto_prices_df = load_crypto_data(
    tickers=TICKERS,
    base_directory=DATA_DIR,
    start_date=START_DATE,
    end_date=END_DATE,
)

crypto_prices_df
```

[7]:

	Date	BTC-USD_low	BTC-USD_high	BTC-USD_open	BTC-USD_close	BTC-USD_volume
0	2025-01-01 00:00:00	93324.33	93408.72	93347.59	93408.63	3.58
1	2025-01-01 00:01:00	93388.22	93440.00	93408.63	93440.00	4.56
2	2025-01-01 00:02:00	93426.80	93507.45	93440.00	93489.12	15.22
3	2025-01-01 00:03:00	93426.90	93489.13	93489.13	93477.31	8.17
4	2025-01-01 00:04:00	93427.16	93474.93	93474.93	93458.33	3.30
…	…	…	…	…	…	…
303836	2025-07-30 23:56:00	117856.59	117880.00	117856.59	117867.34	0.27
303837	2025-07-30 23:57:00	117836.00	117867.37	117867.35	117836.00	1.36
303838	2025-07-30 23:58:00	117829.75	117836.01	117836.00	117830.15	0.70
303839	2025-07-30 23:59:00	117830.14	117830.15	117830.15	117830.15	0.78
303840	2025-07-31 00:00:00	117830.15	117869.50	117830.15	117833.75	1.23

[303841 rows x 6 columns]

2.2 Add RSI, MA, BB

[8]:
```
crypto_prices_technical_df = add_rsi_ma_bb(
    tickers=TICKERS,
    data=crypto_prices_df,
    rsi_period=RSI_PERIOD,
    ma_days=MA_DAYS,
    bb_window=BB_WINDOW,
```

```
    bb_num_std=BB_NUM_STD,
)

crypto_prices_technical_df
```

[8]:

	Date	BTC-USD_low	BTC-USD_high	BTC-USD_open	\
0	2025-01-01 00:00:00	93324.33	93408.72	93347.59	
1	2025-01-01 00:01:00	93388.22	93440.00	93408.63	
2	2025-01-01 00:02:00	93426.80	93507.45	93440.00	
3	2025-01-01 00:03:00	93426.90	93489.13	93489.13	
4	2025-01-01 00:04:00	93427.16	93474.93	93474.93	
…	…	…	…	…	
303836	2025-07-30 23:56:00	117856.59	117880.00	117856.59	
303837	2025-07-30 23:57:00	117836.00	117867.37	117867.35	
303838	2025-07-30 23:58:00	117829.75	117836.01	117836.00	
303839	2025-07-30 23:59:00	117830.14	117830.15	117830.15	
303840	2025-07-31 00:00:00	117830.15	117869.50	117830.15	

	BTC-USD_close	BTC-USD_volume	BTC-USD_close_prev	BTC-USD_RSI	\
0	93408.63	3.58	NaN	NaN	
1	93440.00	4.56	93408.63	100.00	
2	93489.12	15.22	93440.00	100.00	
3	93477.31	8.17	93489.12	98.11	
4	93458.33	3.30	93477.31	95.07	
…	…	…	…	…	
303836	117867.34	0.27	117856.60	64.10	
303837	117836.00	1.36	117867.34	60.30	
303838	117830.15	0.70	117836.00	59.60	
303839	117830.15	0.78	117830.15	59.60	
303840	117833.75	1.23	117830.15	59.92	

	BTC-USD_RSI_prev	BTC-USD_MA_7d	BTC-USD_MA_7d_prev	\
0	NaN	93408.63	NaN	
1	NaN	93424.32	93408.63	
2	100.00	93445.92	93424.32	
3	100.00	93453.76	93445.92	
4	98.11	93454.68	93453.76	
…	…	…	…	
303836	63.35	117993.77	117993.85	
303837	64.10	117993.68	117993.77	
303838	60.30	117993.58	117993.68	
303839	59.60	117993.49	117993.58	
303840	59.60	117993.40	117993.49	

	BTC-USD_BB_MID_prev	BTC-USD_BB_STD_prev	BTC-USD_BB_UPPER_prev	\
0	NaN	NaN	NaN	
1	NaN	NaN	NaN	

```
2                       NaN                  NaN                       NaN
3                       NaN                  NaN                       NaN
4                       NaN                  NaN                       NaN
…                       …                    …                         …
303836            117789.88                79.61                 117949.11
303837            117800.17                75.35                 117950.87
303838            117807.09                71.69                 117950.47
303839            117813.50                67.40                 117948.30
303840            117819.52                62.87                 117945.27

        BTC-USD_BB_LOWER_prev  BTC-USD_BB_Z_prev
0                         NaN                NaN
1                         NaN                NaN
2                         NaN                NaN
3                         NaN                NaN
4                         NaN                NaN
…                         …                  …
303836              117630.66               0.84
303837              117649.47               0.89
303838              117663.72               0.40
303839              117678.70               0.25
303840              117693.77               0.17

[303841 rows x 16 columns]
```

2.3 Create Signals

[9]:
```
signals_df = create_signals(
    tickers=TICKERS,
    data=crypto_prices_technical_df,
    use_rsi=True,
    rsi_threshold=RSI_THRESHOLD,
    use_ma=True,
    ma_days=MA_DAYS,
    use_bbands=USE_BBANDS,
    bb_rule=BB_RULE,
)

signals_df
```

[9]:
```
                  Date      open      high       low     close  close_prev  \
0  2025-01-05 08:02:00  98100.00  98112.02  98072.34  98072.35    98105.39
1  2025-01-05 08:03:00  98072.35  98096.66  97934.43  97975.45    98072.35
2  2025-01-05 08:04:00  97975.45  98012.31  97932.20  97947.22    97975.45
3  2025-01-05 08:05:00  97940.09  97989.60  97932.20  97933.42    97947.22
4  2025-01-05 08:06:00  97946.43  98012.63  97932.20  98003.88    97933.42
..                 …         …         …         …         …          …
```

```
84 2025-07-17 20:06:00 118598.54 118724.51 118598.53 118628.10   118598.54
85 2025-07-28 07:06:00 119100.00 119121.59 119069.00 119071.52   119099.99
86 2025-07-28 07:07:00 119071.52 119087.01 118965.47 118965.49   119071.52
87 2025-07-28 07:08:00 118965.49 119018.39 118929.75 118940.00   118965.49
88 2025-07-28 07:09:00 118940.01 118970.36 118911.11 118957.25   118940.00

      asset  ma_passes  allocation_pct      bb_rule  bb_mid_prev  bb_up_prev  \
0   BTC-USD          1            1.00  touch_lower     98270.67    98376.47
1   BTC-USD          1            1.00  touch_lower     98258.25    98393.51
2   BTC-USD          1            1.00  touch_lower     98241.00    98422.84
3   BTC-USD          1            1.00  touch_lower     98222.28    98442.26
4   BTC-USD          1            1.00  touch_lower     98203.55    98454.41
..      …        …              …          …           …          …
84  BTC-USD          1            1.00  touch_lower    119094.52   119525.60
85  BTC-USD          1            1.00  touch_lower    119443.45   119655.58
86  BTC-USD          1            1.00  touch_lower    119421.85   119689.04
87  BTC-USD          1            1.00  touch_lower    119394.70   119727.19
88  BTC-USD          1            1.00  touch_lower    119366.99   119752.68

    bb_low_prev  bb_z_prev
0      98164.87      -3.12
1      98122.99      -2.75
2      98059.16      -2.92
3      98002.30      -2.50
4      97952.68      -2.15
..          …          …
84    118663.45      -2.30
85    119231.33      -3.24
86    119154.66      -2.62
87    119062.20      -2.58
88    118981.29      -2.21

[89 rows x 14 columns]
```

2.4 Run Backtest

[10]:
```
trades_df = backtest_rsi_multi_asset_strategy(
    tickers=TICKERS,
    prices=crypto_prices_technical_df,
    signals=signals_df,
    initial_capital=INITIAL_CAPITAL,
    rsi_threshold=RSI_THRESHOLD,
    trailing_stop_pct=TRAILING_STOP_PCT,
    ma_days=MA_DAYS,
    order_entry=ORDER_ENTRY,
    trading_fees=True,
    trade_taker_fee=0.0020,
```

```
    trade_maker_fee=0.0010,
)

trades_df
```

[10]:

	asset	entry_time	entry_type	entry_price	exit_time	exit_type	exit_price	quantity	allocation_pct	pnl	return
0	BTC-USD	2025-01-05 08:02:00	limit	98105.39	2025-01-07 11:41:00	trailing stop	100681.27	0.10	1.00	231.81	0.02
1	BTC-USD	2025-01-07 11:42:00	limit	100668.90	2025-01-07 15:07:00	trailing stop	98948.87	0.10	1.00	-204.96	-0.02
2	BTC-USD	2025-01-18 03:42:00	limit	103330.59	2025-01-19 09:21:00	trailing stop	103390.00	0.10	1.00	-24.30	-0.00
3	BTC-USD	2025-01-19 21:29:00	limit	104569.14	2025-01-19 22:03:00	trailing stop	103093.73	0.10	1.00	-170.69	-0.02
4	BTC-USD	2025-03-03 06:41:00	limit	92098.84	2025-03-03 14:38:00	trailing stop	91840.23	0.11	1.00	-56.99	-0.01
5	BTC-USD	2025-03-03 14:58:00	limit	89380.57	2025-03-03 18:07:00	trailing stop	89429.23	0.11	1.00	-23.99	-0.00
6	BTC-USD	2025-03-06 17:02:00	limit	88726.66	2025-03-07 00:15:00	trailing stop	89454.40	0.11	1.00	50.51	0.01
7	BTC-USD	2025-03-14 20:22:00	limit	83858.35	2025-03-16 11:16:00	trailing stop	82996.62	0.12	1.00	-129.79	-0.01
8	BTC-USD	2025-03-16 19:17:00	limit	82816.04	2025-03-18 01:33:00	trailing stop	83063.29	0.12	1.00	-0.20	-0.00
9	BTC-USD	2025-03-20 10:16:00	limit	85375.52	2025-03-20 15:54:00	trailing stop	84780.94	0.11	1.00	-96.14	-0.01
10	BTC-USD	2025-03-22 06:34:00	limit	84138.15	2025-03-25 01:30:00	trailing stop	84138.15	0.12	1.00	0.00	0.00
11	BTC-USD	2025-03-25 01:31:00	limit	86932.96	2025-03-26 13:58:00	trailing stop	86215.44	0.12	1.00	-86.15	-0.01
12	BTC-USD	2025-03-28 04:41:00	limit	86215.44	2025-03-28 14:07:00	trailing stop	86215.44	0.12	1.00	0.00	0.00
13	BTC-USD	2025-04-10 07:35:00	limit	81370.40	2025-04-10 13:43:00	trailing stop	81370.40	0.12	1.00	0.00	0.00
14	BTC-USD	2025-04-13 19:40:00	limit	83555.83	2025-04-14 15:40:00	trailing stop	83555.83	0.12	1.00	0.00	0.00
15	BTC-USD	2025-04-21 11:17:00	limit	86913.63	2025-04-21 17:02:00	trailing stop	86913.63	0.12	1.00	0.00	0.00
16	BTC-USD	2025-04-21 17:04:00	limit	86743.90	2025-04-22 21:49:00	trailing stop	86743.90	0.12	1.00	0.00	0.00
17	BTC-USD	2025-04-24 21:29:00	limit	93110.21	2025-04-26 11:42:00	trailing stop	93110.21	0.11	1.00	0.00	0.00
18	BTC-USD	2025-05-03 23:28:00	limit	96019.87	2025-05-04 23:30:00	trailing stop	96019.87	0.11	1.00	0.00	0.00
19	BTC-USD	2025-05-21 17:29:00	limit	107202.23	2025-05-23 11:48:00	trailing stop	107202.23	0.10	1.00	0.00	0.00
20	BTC-USD	2025-05-23 11:49:00	limit	109693.02	2025-05-23 12:15:00	trailing stop	109693.02	0.10	1.00	0.00	0.00
21	BTC-USD	2025-06-16 22:43:00	limit	107854.92	2025-06-17 10:38:00	trailing stop	107854.92	0.10	1.00	0.00	0.00
22	BTC-USD	2025-06-28 13:28:00	limit	107254.84	2025-07-01 09:20:00	trailing stop	107254.84	0.10	1.00	0.00	0.00
23	BTC-USD	2025-07-02 11:38:00	limit	107593.15	2025-07-04 13:34:00	trailing stop	107593.15	0.10	1.00	0.00	0.00
24	BTC-USD	2025-07-12 20:54:00	limit	117247.93	2025-07-14 14:42:00	trailing stop	117247.93	0.09	1.00	0.00	0.00
25	BTC-USD	2025-07-15 11:17:00	limit	116541.20	2025-07-15 14:54:00	trailing stop	116541.20	0.09	1.00	0.00	0.00
26	BTC-USD	2025-07-15 14:56:00	limit	115981.01	2025-07-17 01:50:00	trailing stop	115981.01	0.09	1.00	0.00	0.00
27	BTC-USD	2025-07-17 20:06:00	limit	118598.54	2025-07-18 08:41:00	trailing stop	118598.54	0.09	1.00	0.00	0.00
28	BTC-USD	2025-07-28 07:06:00	limit	119099.99	2025-07-30 18:49:00	trailing stop	119099.99	0.09	1.00	0.00	0.00

10	trailing stop	87028.55	0.11	1.00	299.26	0.03
11	trailing stop	86812.65	0.11	1.00	-43.22	-0.00
12	trailing stop	84617.36	0.11	1.00	-211.15	-0.02
13	trailing stop	80750.93	0.12	1.00	-101.85	-0.01
14	trailing stop	84101.70	0.11	1.00	33.47	0.00
15	trailing stop	86804.11	0.11	1.00	-40.63	-0.00
16	exit at open (gap)	91955.78	0.11	1.00	541.25	0.06
17	trailing stop	94056.81	0.11	1.00	71.76	0.01
18	trailing stop	94386.26	0.11	1.00	-202.07	-0.02
19	trailing stop	109760.00	0.09	1.00	206.29	0.02
20	trailing stop	107715.51	0.09	1.00	-212.40	-0.02
21	trailing stop	105884.10	0.09	1.00	-210.37	-0.02
22	trailing stop	106624.00	0.09	1.00	-86.00	-0.01
23	trailing stop	108378.20	0.09	1.00	41.15	0.00
24	trailing stop	120766.45	0.08	1.00	260.09	0.03
25	trailing stop	116095.06	0.09	1.00	-67.60	-0.01
26	trailing stop	117732.10	0.08	1.00	118.79	0.01
27	trailing stop	118578.78	0.08	1.00	-31.54	-0.00
28	trailing stop	116899.08	0.08	1.00	-212.94	-0.02

	cash	entry_fee	exit_fee	cumulative_pnl	equity	cumulative_return
0	10231.81	9.99	20.50	231.81	10231.81	0.02
1	10026.84	10.22	20.09	26.84	10026.84	0.00
2	10002.54	10.02	20.05	2.54	10002.54	0.00
3	9831.86	9.99	19.70	-168.14	9831.86	-0.02
4	9774.86	9.82	19.59	-225.14	9774.86	-0.02
5	9750.88	9.77	19.54	-249.12	9750.88	-0.02
6	9801.39	9.74	19.64	-198.61	9801.39	-0.02
7	9671.60	9.79	19.38	-328.40	9671.60	-0.03
8	9671.40	9.66	19.38	-328.60	9671.40	-0.03
9	9575.26	9.66	19.19	-424.74	9575.26	-0.04
10	9874.52	9.57	19.79	-125.48	9874.52	-0.01
11	9831.30	9.86	19.70	-168.70	9831.30	-0.02
12	9620.15	9.82	19.28	-379.85	9620.15	-0.04
13	9518.30	9.61	19.07	-481.70	9518.30	-0.05
14	9551.77	9.51	19.14	-448.23	9551.77	-0.04
15	9511.14	9.54	19.06	-488.86	9511.14	-0.05
16	10052.39	9.50	20.15	52.39	10052.39	0.01
17	10124.15	10.04	20.29	124.15	10124.15	0.01
18	9922.08	10.11	19.88	-77.92	9922.08	-0.01
19	10128.37	9.91	20.30	128.37	10128.37	0.01
20	9915.97	10.12	19.87	-84.03	9915.97	-0.01
21	9705.60	9.91	19.45	-294.40	9705.60	-0.03
22	9619.60	9.70	19.28	-380.40	9619.60	-0.04
23	9660.75	9.61	19.36	-339.25	9660.75	-0.03
24	9920.84	9.65	19.88	-79.16	9920.84	-0.01
25	9853.24	9.91	19.75	-146.76	9853.24	-0.01

26	9972.03	9.84	19.98	-27.97	9972.03	-0.00
27	9940.49	9.96	19.92	-59.51	9940.49	-0.01
28	9727.55	9.93	19.49	-272.45	9727.55	-0.03

2.5 Calc Trading Volumes

[11]:
```
entry_trades_df = trades_df[["entry_time", "entry_price", "quantity"]]
entry_trades_df["entry_trading_volume"] = entry_trades_df["entry_price"] *␣
 ↪entry_trades_df["quantity"]
entry_trades_df = entry_trades_df.resample("D", on="entry_time").sum()
entry_trades_df = entry_trades_df[["entry_trading_volume"]]
```

[12]:
```
exit_trades_df = trades_df[["exit_time", "exit_price", "quantity"]]
exit_trades_df["exit_trading_volume"] = exit_trades_df["exit_price"] *␣
 ↪exit_trades_df["quantity"]
exit_trades_df = exit_trades_df.resample("D", on="exit_time").sum()
exit_trades_df = exit_trades_df[["exit_trading_volume"]]
```

[13]:
```
all_trades_df = entry_trades_df.join(exit_trades_df, how="outer")
all_trades_df["total_trading_volume"] = all_trades_df["entry_trading_volume"].
 ↪fillna(0) + all_trades_df["exit_trading_volume"].fillna(0)
all_trades_df["rolling_30d_volume"] = all_trades_df.
 ↪rolling(window="30D")["total_trading_volume"].sum()
all_trades_df.head(45)
```

[13]:

	entry_trading_volume	exit_trading_volume	total_trading_volume	\
2025-01-05	9990.01	NaN	9990.01	
2025-01-06	0.00	NaN	0.00	
2025-01-07	10221.58	20299.25	30520.83	
2025-01-08	0.00	0.00	0.00	
2025-01-09	0.00	0.00	0.00	
2025-01-10	0.00	0.00	0.00	
2025-01-11	0.00	0.00	0.00	
2025-01-12	0.00	0.00	0.00	
2025-01-13	0.00	0.00	0.00	
2025-01-14	0.00	0.00	0.00	
2025-01-15	0.00	0.00	0.00	
2025-01-16	0.00	0.00	0.00	
2025-01-17	0.00	0.00	0.00	
2025-01-18	10016.83	0.00	10016.83	
2025-01-19	9992.55	19874.14	29866.69	
2025-01-20	0.00	0.00	0.00	
2025-01-21	0.00	0.00	0.00	
2025-01-22	0.00	0.00	0.00	
2025-01-23	0.00	0.00	0.00	
2025-01-24	0.00	0.00	0.00	
2025-01-25	0.00	0.00	0.00	

2025-01-26	0.00	0.00	0.00
2025-01-27	0.00	0.00	0.00
2025-01-28	0.00	0.00	0.00
2025-01-29	0.00	0.00	0.00
2025-01-30	0.00	0.00	0.00
2025-01-31	0.00	0.00	0.00
2025-02-01	0.00	0.00	0.00
2025-02-02	0.00	0.00	0.00
2025-02-03	0.00	0.00	0.00
2025-02-04	0.00	0.00	0.00
2025-02-05	0.00	0.00	0.00
2025-02-06	0.00	0.00	0.00
2025-02-07	0.00	0.00	0.00
2025-02-08	0.00	0.00	0.00
2025-02-09	0.00	0.00	0.00
2025-02-10	0.00	0.00	0.00
2025-02-11	0.00	0.00	0.00
2025-02-12	0.00	0.00	0.00
2025-02-13	0.00	0.00	0.00
2025-02-14	0.00	0.00	0.00
2025-02-15	0.00	0.00	0.00
2025-02-16	0.00	0.00	0.00
2025-02-17	0.00	0.00	0.00
2025-02-18	0.00	0.00	0.00

	rolling_30d_volume
2025-01-05	9990.01
2025-01-06	9990.01
2025-01-07	40510.84
2025-01-08	40510.84
2025-01-09	40510.84
2025-01-10	40510.84
2025-01-11	40510.84
2025-01-12	40510.84
2025-01-13	40510.84
2025-01-14	40510.84
2025-01-15	40510.84
2025-01-16	40510.84
2025-01-17	40510.84
2025-01-18	50527.67
2025-01-19	80394.36
2025-01-20	80394.36
2025-01-21	80394.36
2025-01-22	80394.36
2025-01-23	80394.36
2025-01-24	80394.36
2025-01-25	80394.36

```
2025-01-26            80394.36
2025-01-27            80394.36
2025-01-28            80394.36
2025-01-29            80394.36
2025-01-30            80394.36
2025-01-31            80394.36
2025-02-01            80394.36
2025-02-02            80394.36
2025-02-03            80394.36
2025-02-04            70404.35
2025-02-05            70404.35
2025-02-06            39883.52
2025-02-07            39883.52
2025-02-08            39883.52
2025-02-09            39883.52
2025-02-10            39883.52
2025-02-11            39883.52
2025-02-12            39883.52
2025-02-13            39883.52
2025-02-14            39883.52
2025-02-15            39883.52
2025-02-16            39883.52
2025-02-17            29866.69
2025-02-18                0.00
```

2.6 Compute Daily Performance

[14]:
```
daily_perf_df = compute_daily_performance(
    tickers=TICKERS,
    data=crypto_prices_technical_df,
    trades=trades_df,
    initial_capital=INITIAL_CAPITAL,
)

daily_perf_df
```

[14]:
```
                cash  BTC-USD_qty  BTC-USD_close  BTC-USD_position   equity  \
Date
2025-01-01 10000.00         0.00       94383.59              0.00 10000.00
2025-01-02 10000.00         0.00       96903.19              0.00 10000.00
2025-01-03 10000.00         0.00       98136.51              0.00 10000.00
2025-01-04 10000.00         0.00       98209.85              0.00 10000.00
2025-01-05     0.00         0.10       98345.33          10014.44 10014.44
…               …            …              …                 …       …
2025-07-27  9940.49         0.00      119465.52              0.00  9940.49
2025-07-28     0.00         0.08      118070.59           9844.73  9844.73
2025-07-29     0.00         0.08      117933.39           9833.29  9833.29
```

```
2025-07-30  9727.55         0.00      117830.15              0.00  9727.55
2025-07-31  9727.55         0.00      117833.75              0.00  9727.55

            BTC-USD_return  BTC-USD_cum_return  BTC-USD_drawdown  Return  \
Date
2025-01-01            0.00                0.00              0.00    0.00
2025-01-02            0.03                0.03              0.00    0.00
2025-01-03            0.01                0.04              0.00    0.00
2025-01-04            0.00                0.04              0.00    0.00
2025-01-05            0.00                0.04              0.00    0.00
…                      …                   …                 …       …
2025-07-27            0.01                0.27             -0.00    0.00
2025-07-28           -0.01                0.25             -0.02   -0.01
2025-07-29           -0.00                0.25             -0.02   -0.00
2025-07-30           -0.00                0.25             -0.02   -0.01
2025-07-31            0.00                0.25             -0.02    0.00

            Cum_Return  Drawdown
Date
2025-01-01        0.00      0.00
2025-01-02        0.00      0.00
2025-01-03        0.00      0.00
2025-01-04        0.00      0.00
2025-01-05        0.00      0.00
…                  …         …
2025-07-27       -0.01     -0.05
2025-07-28       -0.02     -0.05
2025-07-29       -0.02     -0.06
2025-07-30       -0.03     -0.07
2025-07-31       -0.03     -0.07

[212 rows x 11 columns]
```

2.7 Summary Stats

[15]:
```python
sum_stats_df = summary_stats(
    fund_list=TICKERS,
    df=daily_perf_df[['Return']],
    period="Daily",
    use_calendar_days=True,
    excel_export=False,
    pickle_export=False,
    output_confirmation=True,
)

sum_stats_df
```

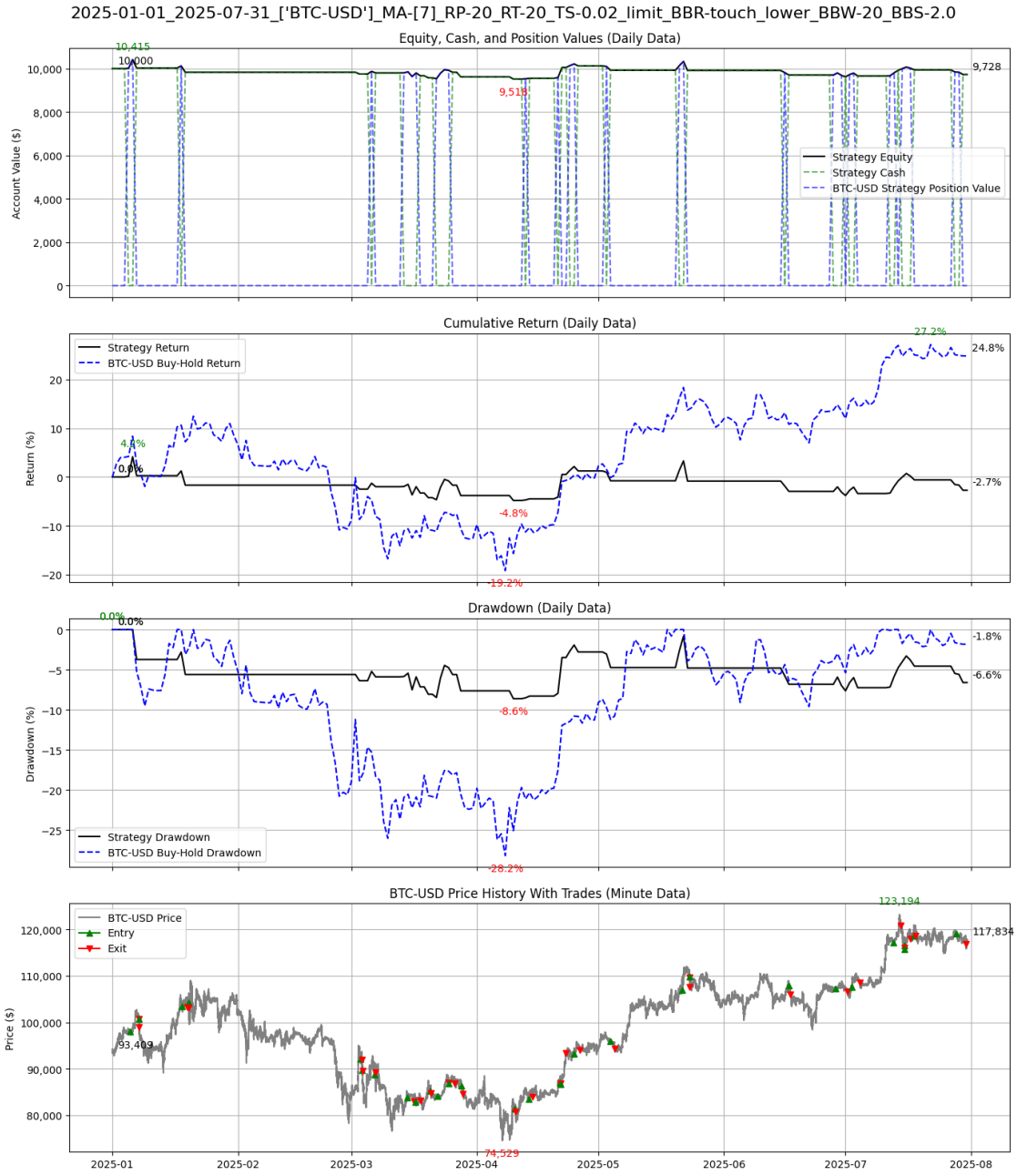
```
Summary stats complete for BTC-USD
```

[15]:
```
        Annualized Mean  Annualized Volatility  Annualized Sharpe Ratio  CAGR  \
Return            -0.04                   0.15                    -0.23 -0.05

        Daily Max Return Daily Max Return (Date)  Daily Min Return  \
Return              0.05              2025-04-22             -0.04

       Daily Min Return (Date)  Max Drawdown       Peak     Trough  \
Return              2025-05-23         -0.09 2025-01-06 2025-04-10

       Recovery Date  Days to Recover  MAR Ratio
Return           NaT              NaN      -0.54
```

2.8 Plots

[16]:
```
# Create MA_Days string for filename
if MA_DAYS == []:
    temp_ma_days = "[0]"
else:
    temp_ma_days = MA_DAYS

# Base title name
base_title_name =␣
 ↪f"{START_DATE}_{END_DATE}_{TICKERS}_MA-{temp_ma_days}_RP-{RSI_PERIOD}_RT-{RSI_THRESHOLD}_TS

# Create title name
if USE_BBANDS == True:
    bb_part = f"BBR-{BB_RULE}_BBW-{BB_WINDOW}_BBS-{BB_NUM_STD}"
    title_name = f"{base_title_name}_{bb_part}"
else:
    title_name = f"{base_title_name}"
```

[17]:
```
plot_multi_asset_equity_and_drawdown(
    tickers=TICKERS,
    daily_perf=daily_perf_df,
    trades=trades_df,
    data=crypto_prices_technical_df,
    title=title_name,
    show_plot=True,
    export_plot=False,
)
```



2.9 Analyze Trades

[18]:
```
analyze_trades(
    trades_df=trades_df,
    daily_perf_df=daily_perf_df,
    print_summary=True,
)
```

```
Trade Summary:
Total Trades: 29
Win Rate (%): 34.48%
Total Return (%): -2.72%
Average Return Per Trade: -0.08%
Max Trade Gain (%): 5.69%
Max Trade Loss (%): -2.15%
Total PnL ($): $-272.45
Average PnL Per Trade ($): $-9.39
Max Trade Gain ($): $541.25
Max Trade Loss ($): $-212.94
Max Drawdown (%): -8.61%
```

[18]:
```
(29,
 0.3448275862068966,
 np.float64(-0.02724480895281578),
 np.float64(-0.0007879214312853157),
 np.float64(0.056906459725102),
 np.float64(-0.021477397402748958),
 np.float64(-272.448089528154),
 np.float64(-9.39476170786738),
 np.float64(541.2454281653718),
 np.float64(-212.93616495016613),
 np.float64(-8.610125966080789))
```

2.10 Iterate Through Possible Parameters

[19]:
```
# See .py file for backtest iterations
```

2.11 Read Existing Results CSV, Fill NaN

[20]:
```
INITIAL_CAPITAL = 10_000
START_DATE = "2024-01-01"
END_DATE = "2024-12-31"
```

[21]:
```
# Read CSV
combined_results_df = pd.
 ↪read_csv(f"multi_asset_strategy_results_{START_DATE}_{END_DATE}.csv")
# combined_results_df = pd.
 ↪read_csv(f"multi_asset_strategy_results_{START_DATE}_{END_DATE}_{ORDER_ENTRY}.
 ↪csv")

# Fillna for any MA_DAYS that are NaN (when no MA filter is used)
combined_results_df["MA_DAYS"] = combined_results_df["MA_DAYS"].fillna(0.0)

# Deduplicate rows
combined_results_df = combined_results_df.drop_duplicates(
```

```
    subset=[
        "TICKERS",
        "MA_DAYS",
        "INITIAL_CAPITAL",
        "RSI_PERIOD",
        "RSI_THRESHOLD",
        "TRAILING_STOP_PCT",
        "Order Entry",
        "BB Rule",
        "BB Window",
        "BB Num Std",
        "Trade Taker Fee",
        "Trade Maker Fee",
    ]
)

# Export edited CSV
# combined_results_df.
 ↪to_csv(f"multi_asset_strategy_results_{START_DATE}_{END_DATE}_{ORDER_ENTRY}.
 ↪csv", index=False)
combined_results_df
```

[21]:

	TICKERS	MA_DAYS	INITIAL_CAPITAL	RSI_PERIOD	RSI_THRESHOLD	\
0	BTC-USD	0.00	10000	6	12	
1	BTC-USD	0.00	10000	6	12	
2	BTC-USD	0.00	10000	6	12	
3	BTC-USD	0.00	10000	6	12	
4	BTC-USD	0.00	10000	6	12	
…	…	…	…	…	…	
15995	BTC-USD	49.00	10000	24	30	
15996	BTC-USD	49.00	10000	24	30	
15997	BTC-USD	49.00	10000	24	30	
15998	BTC-USD	49.00	10000	24	30	
15999	BTC-USD	49.00	10000	24	30	

	TRAILING_STOP_PCT	START_DATE	END_DATE	Total Trades	Win Rate	…	\
0	0.01	2024-01-01	2024-12-31	807.00	0.27	…	
1	0.01	2024-01-01	2024-12-31	766.00	0.26	…	
2	0.01	2024-01-01	2024-12-31	970.00	0.30	…	
3	0.01	2024-01-01	2024-12-31	966.00	0.29	…	
4	0.01	2024-01-01	2024-12-31	718.00	0.29	…	
…	…	…	…	…	…	…	
15995	0.03	2024-01-01	2024-12-31	207.00	0.30	…	
15996	0.03	2024-01-01	2024-12-31	140.00	0.31	…	
15997	0.03	2024-01-01	2024-12-31	152.00	0.30	…	
15998	0.03	2024-01-01	2024-12-31	139.00	0.32	…	
15999	0.03	2024-01-01	2024-12-31	150.00	0.31	…	

```
       Runtime EMA (s)  Success-only Runtime EMA (s)  Success  Error  \
0                19.43                         19.43     True    NaN
1                18.55                         18.55     True    NaN
2                17.42                         17.42     True    NaN
3                16.45                         16.45     True    NaN
4                14.90                         14.90     True    NaN
…                …                             …         …       …
15995             3.81                          3.81     True    NaN
15996             3.67                          3.67     True    NaN
15997             3.59                          3.59     True    NaN
15998             3.48                          3.48     True    NaN
15999             3.39                          3.39     True    NaN

       Order Entry      BB Rule  BB Window  BB Num Std  Trade Taker Fee  \
0           market  touch_lower      20.00        2.00             0.00
1           market          NaN        NaN         NaN             0.00
2            limit  touch_lower      20.00        2.00             0.00
3            limit          NaN        NaN         NaN             0.00
4           market  touch_lower      20.00        2.00             0.00
…            …           …        …          …               …
15995        limit          NaN        NaN         NaN             0.00
15996       market  touch_lower      20.00        2.00             0.00
15997       market          NaN        NaN         NaN             0.00
15998        limit  touch_lower      20.00        2.00             0.00
15999        limit          NaN        NaN         NaN             0.00

       Trade Maker Fee
0                 0.00
1                 0.00
2                 0.00
3                 0.00
4                 0.00
…                 …
15995             0.00
15996             0.00
15997             0.00
15998             0.00
15999             0.00

[16000 rows x 45 columns]
```

[22]:
```
# Re-read CSV
combined_results_df = pd.
 ↪read_csv(f"multi_asset_strategy_results_{START_DATE}_{END_DATE}.csv")
```

[23]:
```
# Sort values by MAR Ratio descending
combined_results_df.sort_values(by="MAR Ratio", ascending=False, inplace=True)
```

[24]:
```
combined_results_df.columns
```

[24]:
```
Index(['TICKERS', 'MA_DAYS', 'INITIAL_CAPITAL', 'RSI_PERIOD', 'RSI_THRESHOLD',
       'TRAILING_STOP_PCT', 'START_DATE', 'END_DATE', 'Total Trades',
       'Win Rate', 'Total Return', 'Average Return Per Trade',
       'Max Trade Gain (%)', 'Max Trade Loss (%)', 'Total PnL',
       'Average PnL Per Trade', 'Max Trade Gain ($)', 'Max Trade Loss ($)',
       'Annualized Mean Return', 'Annualized Volatility',
       'Annualized Sharpe Ratio', 'CAGR', 'Daily Max Return',
       'Daily Max Return Date', 'Daily Min Return', 'Daily Min Return Date',
       'Max Drawdown', 'Peak', 'Trough', 'Recovery Date', 'Days to Recover',
       'MAR Ratio', 'Total Runtime (s)', 'Average Runtime (s)', 'Runtime (s)',
       'Runtime EMA (s)', 'Success-only Runtime EMA (s)', 'Success', 'Error',
       'Order Entry', 'BB Rule', 'BB Window', 'BB Num Std', 'Trade Taker Fee',
       'Trade Maker Fee'],
      dtype='object')
```

[25]:
```
combined_results_df[['TICKERS', 'MA_DAYS', 'RSI_PERIOD', 'RSI_THRESHOLD',
       'TRAILING_STOP_PCT', 'Total Trades',
       'Win Rate', 'Total Return', 'Average Return Per Trade',
       'Max Trade Gain (%)', 'Max Trade Loss (%)', 'Total PnL',
       'Average PnL Per Trade', 'Max Trade Gain ($)', 'Max Trade Loss ($)',
       'Max Drawdown', 'Annualized Mean Return', 'Annualized Volatility',
       'Annualized Sharpe Ratio', 'CAGR',
       'MAR Ratio', 'BB Rule', 'Trade Taker Fee', 'Trade Maker Fee']]
```

[25]:

	TICKERS	MA_DAYS	RSI_PERIOD	RSI_THRESHOLD	TRAILING_STOP_PCT	\
3862	BTC-USD	7.00	24	18	0.01	
3863	BTC-USD	7.00	24	18	0.01	
3860	BTC-USD	7.00	24	18	0.01	
3861	BTC-USD	7.00	24	18	0.01	
3442	BTC-USD	7.00	20	16	0.01	
…	…	…	…	…	…	
3815	BTC-USD	7.00	24	12	0.03	
3816	BTC-USD	7.00	24	12	0.03	
3817	BTC-USD	7.00	24	12	0.03	
3818	BTC-USD	7.00	24	12	0.03	
3819	BTC-USD	7.00	24	12	0.03	

	Total Trades	Win Rate	Total Return	Average Return Per Trade	\
3862	12.00	0.67	0.12	0.01	
3863	12.00	0.67	0.12	0.01	
3860	12.00	0.67	0.11	0.01	
3861	12.00	0.67	0.11	0.01	

```
3442         14.00      0.57          0.10                        0.01
…             …       …             …                           …
3815           NaN       NaN           NaN                         NaN
3816           NaN       NaN           NaN                         NaN
3817           NaN       NaN           NaN                         NaN
3818           NaN       NaN           NaN                         NaN
3819           NaN       NaN           NaN                         NaN

      Max Trade Gain (%)  …  Max Trade Loss ($)  Max Drawdown  \
3862                0.05  …              -83.78         -0.02
3863                0.05  …              -83.78         -0.02
3860                0.05  …              -93.48         -0.02
3861                0.05  …              -93.48         -0.02
3442                0.05  …             -119.05         -0.02
…                    …  …                   …            …
3815                 NaN  …                 NaN           NaN
3816                 NaN  …                 NaN           NaN
3817                 NaN  …                 NaN           NaN
3818                 NaN  …                 NaN           NaN
3819                 NaN  …                 NaN           NaN

      Annualized Mean Return  Annualized Volatility  Annualized Sharpe Ratio  \
3862                    0.12                   0.07                     1.78
3863                    0.12                   0.07                     1.78
3860                    0.11                   0.06                     1.65
3861                    0.11                   0.06                     1.65
3442                    0.10                   0.07                     1.44
…                       …                      …                        …
3815                     NaN                    NaN                      NaN
3816                     NaN                    NaN                      NaN
3817                     NaN                    NaN                      NaN
3818                     NaN                    NaN                      NaN
3819                     NaN                    NaN                      NaN

      CAGR  MAR Ratio      BB Rule  Trade Taker Fee  Trade Maker Fee
3862  0.12       8.11  touch_lower             0.00             0.00
3863  0.12       8.11          NaN             0.00             0.00
3860  0.11       6.81  touch_lower             0.00             0.00
3861  0.11       6.81          NaN             0.00             0.00
3442  0.10       6.54  touch_lower             0.00             0.00
…     …          …          …               …                …
3815   NaN        NaN          NaN             0.00             0.00
3816   NaN        NaN  touch_lower             0.00             0.00
3817   NaN        NaN          NaN             0.00             0.00
3818   NaN        NaN  touch_lower             0.00             0.00
3819   NaN        NaN          NaN             0.00             0.00
```

[16000 rows x 24 columns]

[26]:
```
combined_results_df = combined_results_df[(combined_results_df["Trade Taker␣
↪Fee"] > 0.0) &
                                          (combined_results_df["Trade Maker␣
↪Fee"] > 0.0) &
                                          (combined_results_df["Success"] ==␣
↪True) &
                                          (combined_results_df["MAR Ratio"] >␣
↪-10)]
combined_results_df
```

[26]:

	TICKERS	MA_DAYS	INITIAL_CAPITAL	RSI_PERIOD	RSI_THRESHOLD	\
3862	BTC-USD	7.00	10000	24	18	
3863	BTC-USD	7.00	10000	24	18	
3860	BTC-USD	7.00	10000	24	18	
3861	BTC-USD	7.00	10000	24	18	
3442	BTC-USD	7.00	10000	20	16	
…	…	…	…	…	…	
361	BTC-USD	NaN	10000	8	28	
141	BTC-USD	NaN	10000	6	26	
381	BTC-USD	NaN	10000	8	30	
161	BTC-USD	NaN	10000	6	28	
181	BTC-USD	NaN	10000	6	30	

	TRAILING_STOP_PCT	START_DATE	END_DATE	Total Trades	Win Rate	…	\
3862	0.01	2024-01-01	2024-12-31	12.00	0.67	…	
3863	0.01	2024-01-01	2024-12-31	12.00	0.67	…	
3860	0.01	2024-01-01	2024-12-31	12.00	0.67	…	
3861	0.01	2024-01-01	2024-12-31	12.00	0.67	…	
3442	0.01	2024-01-01	2024-12-31	14.00	0.57	…	
…	…	…	…	…	…	…	
361	0.01	2024-01-01	2024-12-31	769.00	0.24	…	
141	0.01	2024-01-01	2024-12-31	776.00	0.24	…	
381	0.01	2024-01-01	2024-12-31	768.00	0.24	…	
161	0.01	2024-01-01	2024-12-31	769.00	0.24	…	
181	0.01	2024-01-01	2024-12-31	769.00	0.24	…	

	Runtime EMA (s)	Success-only Runtime EMA (s)	Success	Error	\
3862	2.39	2.39	True	NaN	
3863	2.39	2.39	True	NaN	
3860	2.32	2.33	True	NaN	
3861	2.31	2.31	True	NaN	
3442	2.51	2.51	True	NaN	
…	…	…	…	…	
361	15.89	15.89	True	NaN	
141	14.09	14.09	True	NaN	

```
381             18.36                         18.36     True    NaN
161             16.43                         16.43     True    NaN
181             20.65                         20.65     True    NaN

      Order Entry      BB Rule  BB Window  BB Num Std  Trade Taker Fee  \
3862        limit  touch_lower      20.00        2.00             0.00
3863        limit          NaN        NaN         NaN             0.00
3860       market  touch_lower      20.00        2.00             0.00
3861       market          NaN        NaN         NaN             0.00
3442        limit  touch_lower      20.00        2.00             0.00
…             …          …        …          …                …
361        market          NaN        NaN         NaN             0.00
141        market          NaN        NaN         NaN             0.00
381        market          NaN        NaN         NaN             0.00
161        market          NaN        NaN         NaN             0.00
181        market          NaN        NaN         NaN             0.00

      Trade Maker Fee
3862             0.00
3863             0.00
3860             0.00
3861             0.00
3442             0.00
…                …
361              0.00
141              0.00
381              0.00
161              0.00
181              0.00

[15928 rows x 45 columns]
```

[27]:
```python
def plot_iteration_results(
    results_df: pd.DataFrame,
) -> None:

    combined_results_df = results_df.copy()

    # Create histogram of results for MAR Ratio
    plt.figure(figsize=(12, 6))
    plt.hist(combined_results_df['MAR Ratio'], bins=200, density=True, alpha=0.
 ↪6, color='g')
    plt.title('Distribution of MAR Ratio')
    plt.xlabel('MAR Ratio')
    plt.ylabel('Frequency')
    plt.grid()
    plt.show()
```

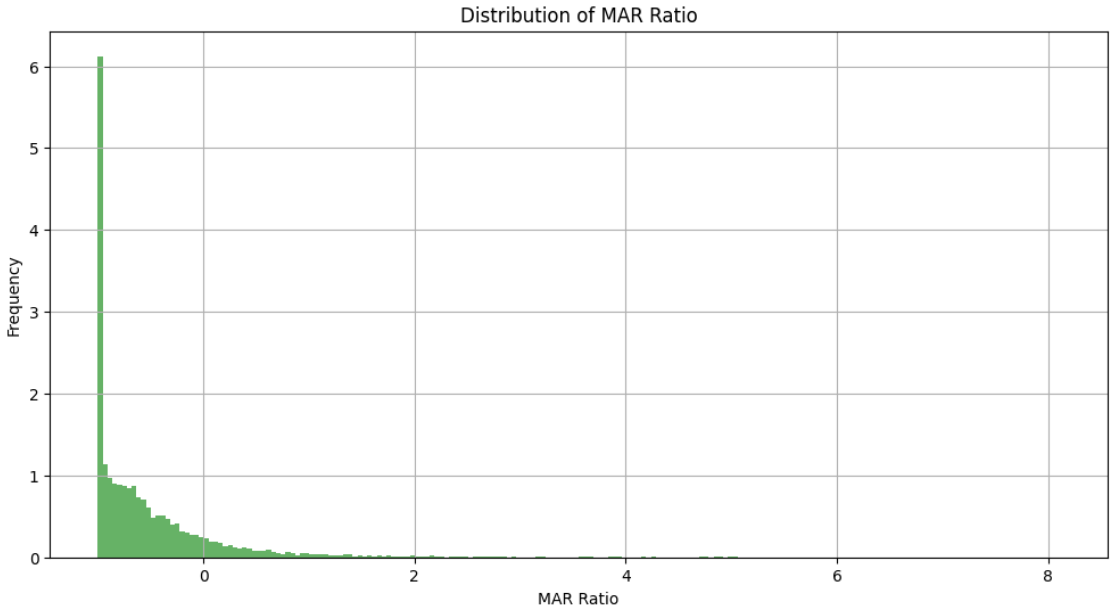
```
    # Create histogram of results for MA Days
    plt.figure(figsize=(12, 6))
    plt.hist(combined_results_df['MA_DAYS'], bins=200, density=True, alpha=0.6,␣
↪color='g')
    plt.title('Distribution of MA Days')
    plt.xlabel('MA Days')
    plt.ylabel('Frequency')
    plt.grid()
    plt.show()

    # Create histogram of results for RSI period
    plt.figure(figsize=(12, 6))
    plt.hist(combined_results_df['RSI_PERIOD'], bins=200, density=True, alpha=0.
↪6, color='g')
    plt.title('Distribution of RSI Period')
    plt.xlabel('RSI Period')
    plt.ylabel('Frequency')
    plt.grid()
    plt.show()

    # Create histogram of results for RSI threshold
    plt.figure(figsize=(12, 6))
    plt.hist(combined_results_df['RSI_THRESHOLD'], bins=200, density=True,␣
↪alpha=0.6, color='g')
    plt.title('Distribution of RSI Threshold')
    plt.xlabel('RSI Threshold')
    plt.ylabel('Frequency')
    plt.grid()
    plt.show()

    # Create histogram of results for trailing stop percentage
    plt.figure(figsize=(12, 6))
    plt.hist(combined_results_df['TRAILING_STOP_PCT'], bins=200, density=True,␣
↪alpha=0.6, color='g')
    plt.title('Distribution of Trailing Stop Percentage')
    plt.xlabel('Trailing Stop Percentage')
    plt.ylabel('Frequency')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs MA_DAYS
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['MA_DAYS'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. MA_DAYS')
    plt.xlabel('MA_DAYS')
```

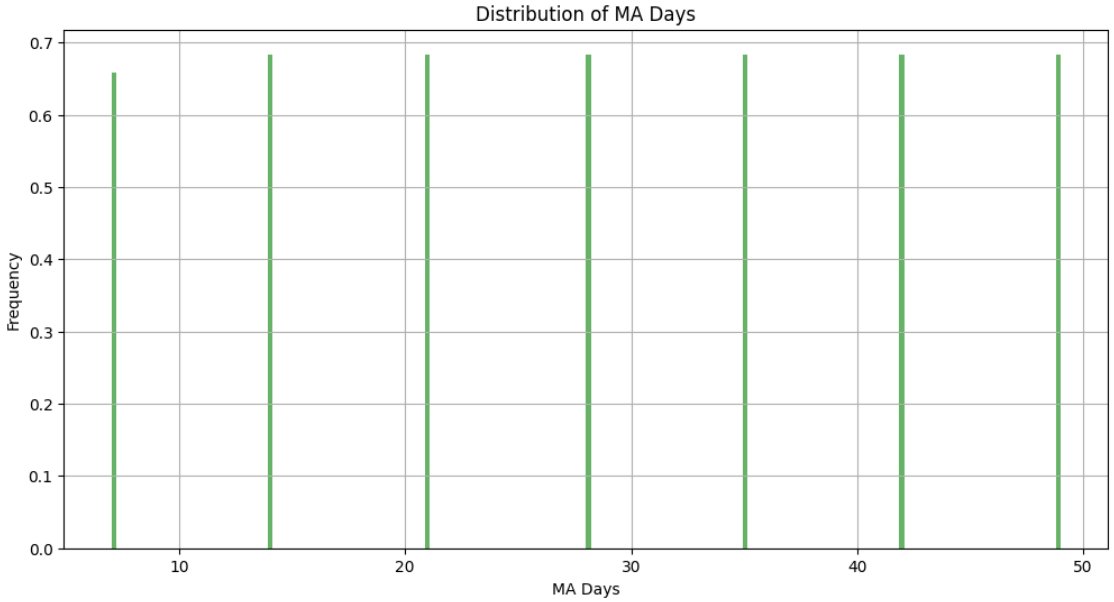
```
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs RSI_PERIOD
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['RSI_PERIOD'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. RSI_PERIOD')
    plt.xlabel('RSI_PERIOD')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR ratio vs RSI_THRESHOLD
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['RSI_THRESHOLD'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. RSI_THRESHOLD')
    plt.xlabel('RSI_THRESHOLD')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs TRAILING_STOP
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['TRAILING_STOP_PCT'],␣
↪combined_results_df['MAR Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. TRAILING_STOP')
    plt.xlabel('TRAILING_STOP')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs Total Return
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['Total Return'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Total Return')
    plt.xlabel('Total Return')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs Win Rate
    plt.figure(figsize=(12, 6))
```

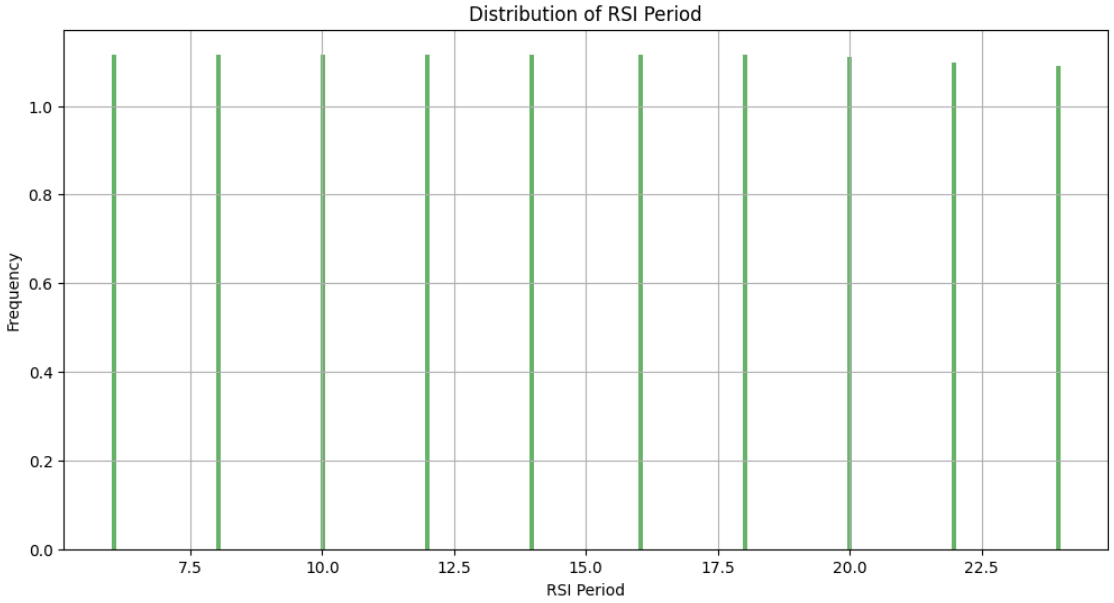
```
    plt.scatter(combined_results_df['Win Rate'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Win Rate')
    plt.xlabel('Win Rate')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs Max Drawdown
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['Max Drawdown'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Max Drawdown')
    plt.xlabel('Max Drawdown')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs Total Trades
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['Total Trades'], combined_results_df['MAR␣
↪Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Total Trades')
    plt.xlabel('Total Trades')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs CAGR
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['CAGR'], combined_results_df['MAR Ratio'],␣
↪alpha=0.6)
    plt.title('MAR Ratio vs. CAGR')
    plt.xlabel('CAGR')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs Annualized Mean Return
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['Annualized Mean Return'],␣
↪combined_results_df['MAR Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Annualized Mean Return')
    plt.xlabel('Annualized Mean Return')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()
```

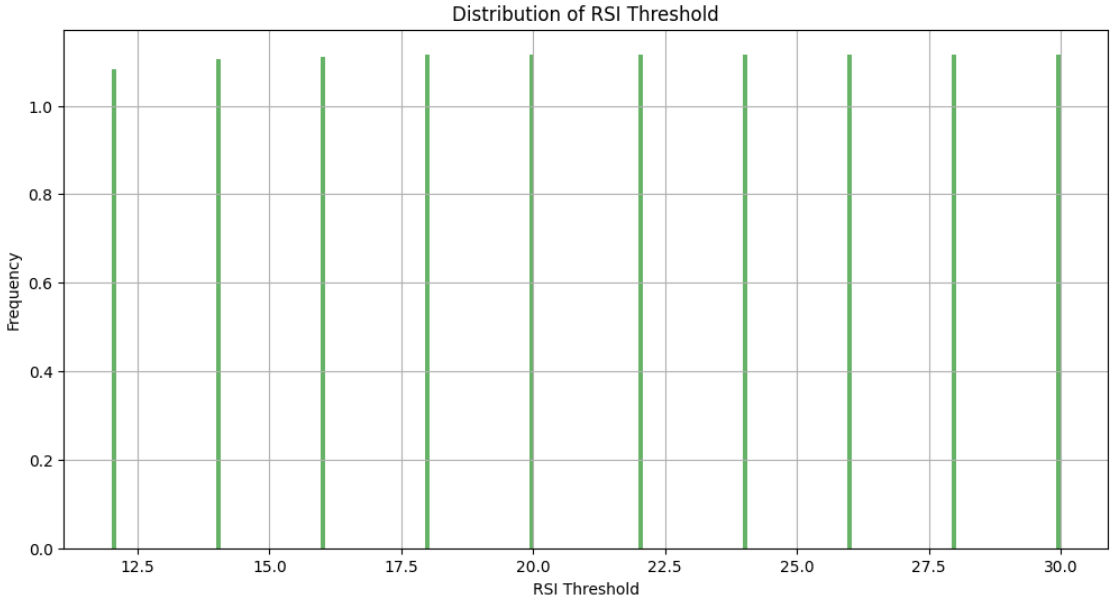
```
    # Plot MAR Ratio vs Annualized Volatility
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['Annualized Volatility'],␣
↪combined_results_df['MAR Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Annualized Volatility')
    plt.xlabel('Annualized Volatility')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    # Plot MAR Ratio vs Annualized Sharpe Ratio
    plt.figure(figsize=(12, 6))
    plt.scatter(combined_results_df['Annualized Sharpe Ratio'],␣
↪combined_results_df['MAR Ratio'], alpha=0.6)
    plt.title('MAR Ratio vs. Annualized Sharpe Ratio')
    plt.xlabel('Annualized Sharpe Ratio')
    plt.ylabel('MAR Ratio')
    plt.grid()
    plt.show()

    return None
```

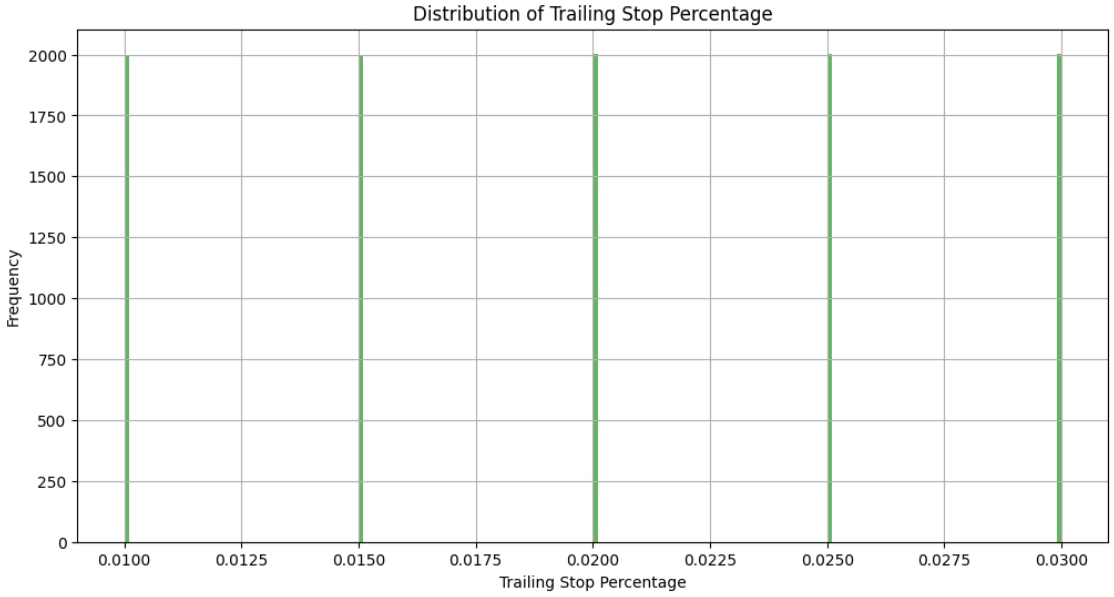
[28]:
```
plot_iteration_results(
    results_df=combined_results_df,
)
```

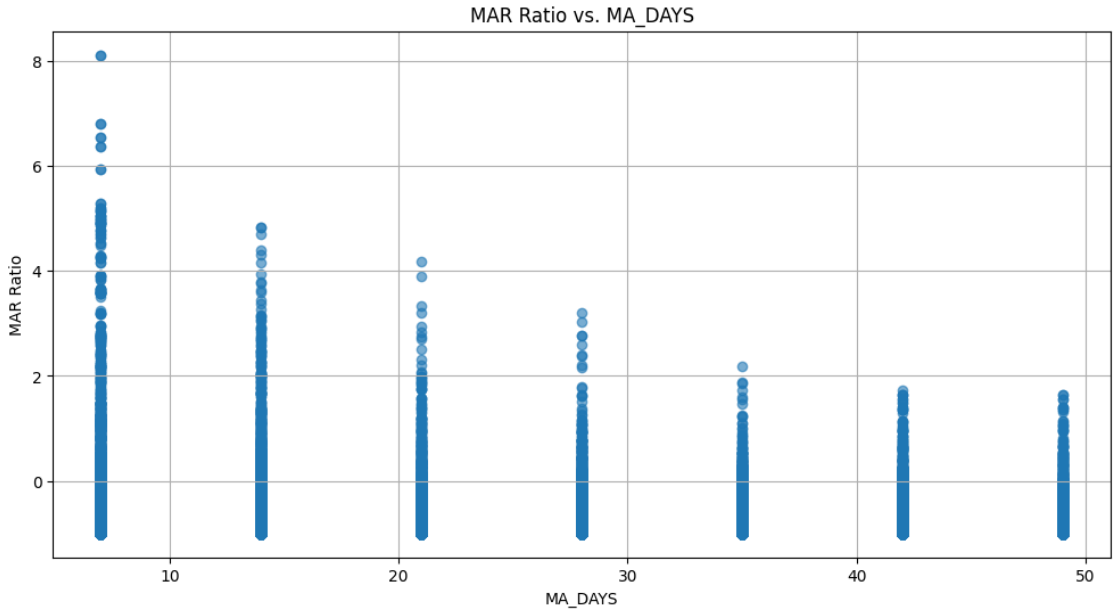


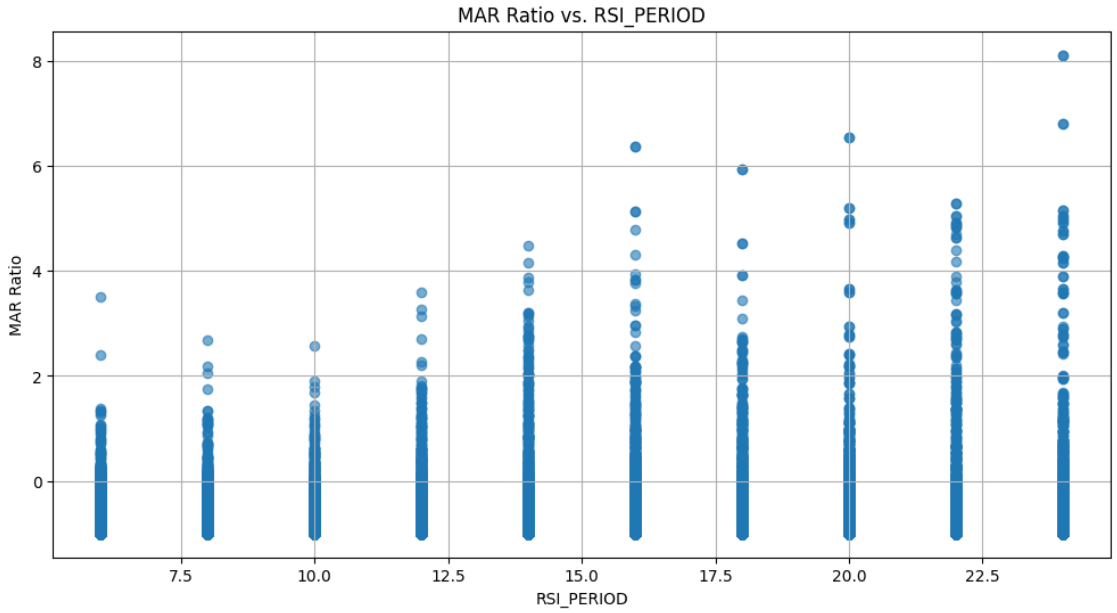

Distribution of MA Days
Frequency
MA Days
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
10
20
30
40
50

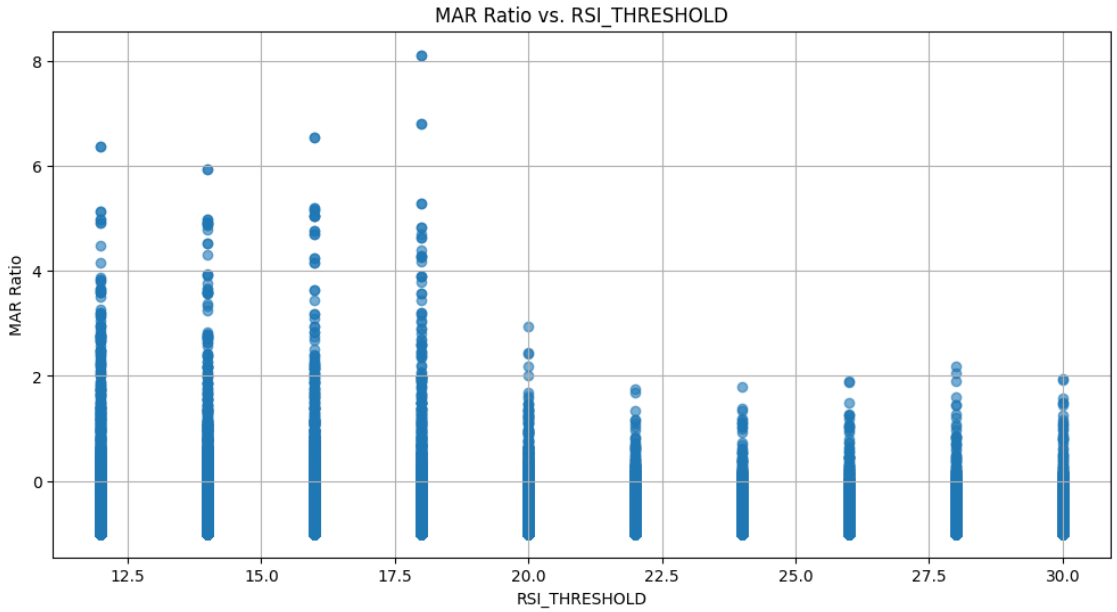

Distribution of RSI Period
Frequency
RSI Period
0.0
0.2
0.4
0.6
0.8
1.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5

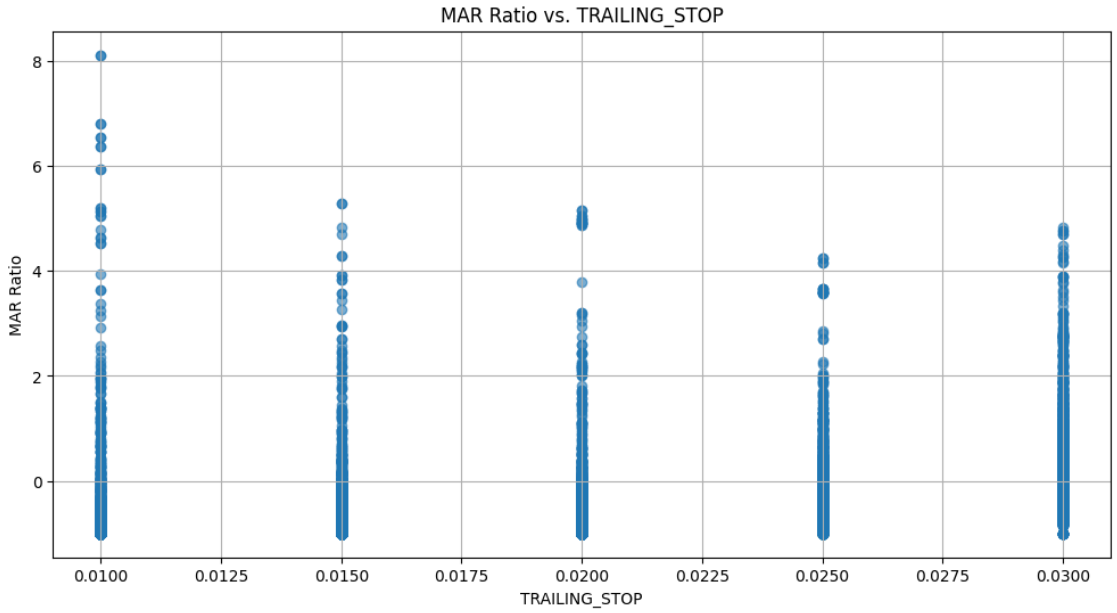

Distribution of RSI Threshold
Frequency
RSI Threshold
0.0
0.2
0.4
0.6
0.8
1.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

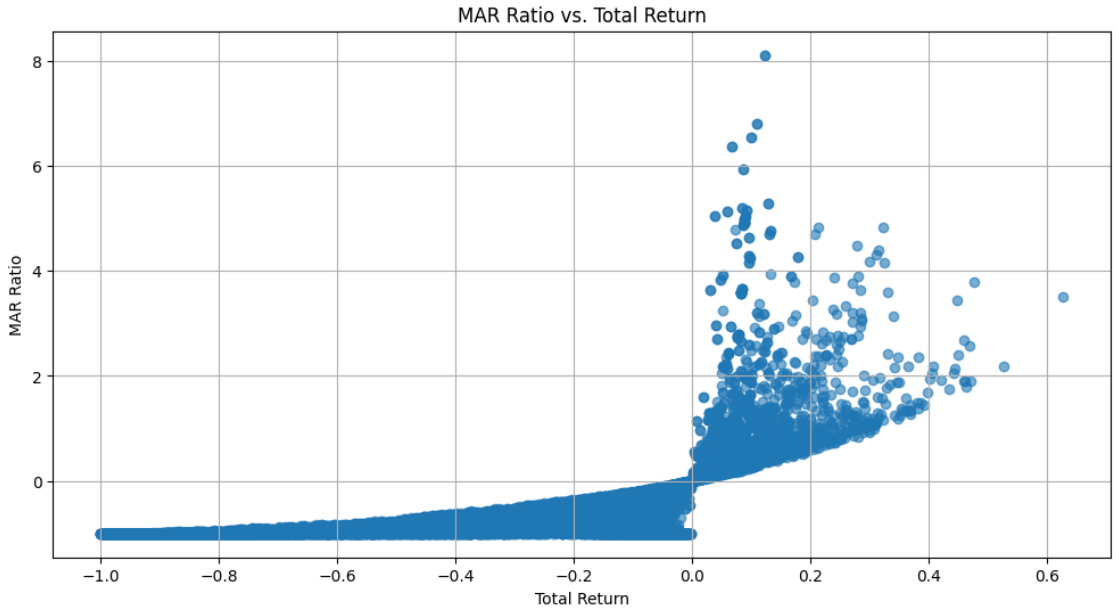

Distribution of Trailing Stop Percentage
Frequency
Trailing Stop Percentage
0
250
500
750
1000
1250
1500
1750
2000
0.0100
0.0125
0.0150
0.0175
0.0200
0.0225
0.0250
0.0275
0.0300

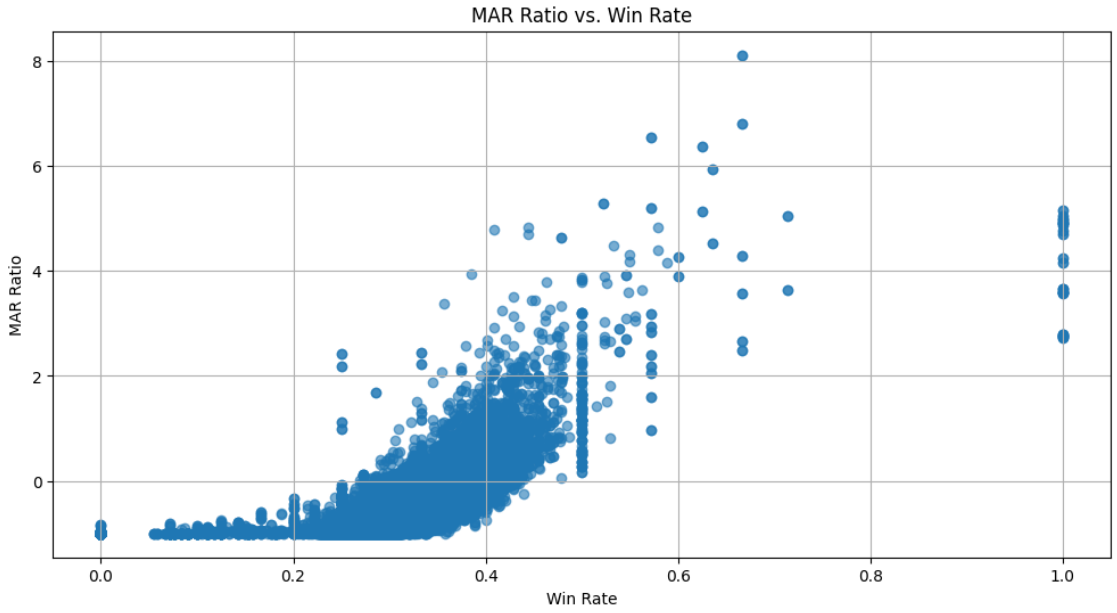

MAR Ratio vs. MA_DAYS
MAR Ratio
MA_DAYS
8
6
4
2
0
10
20
30
40
50

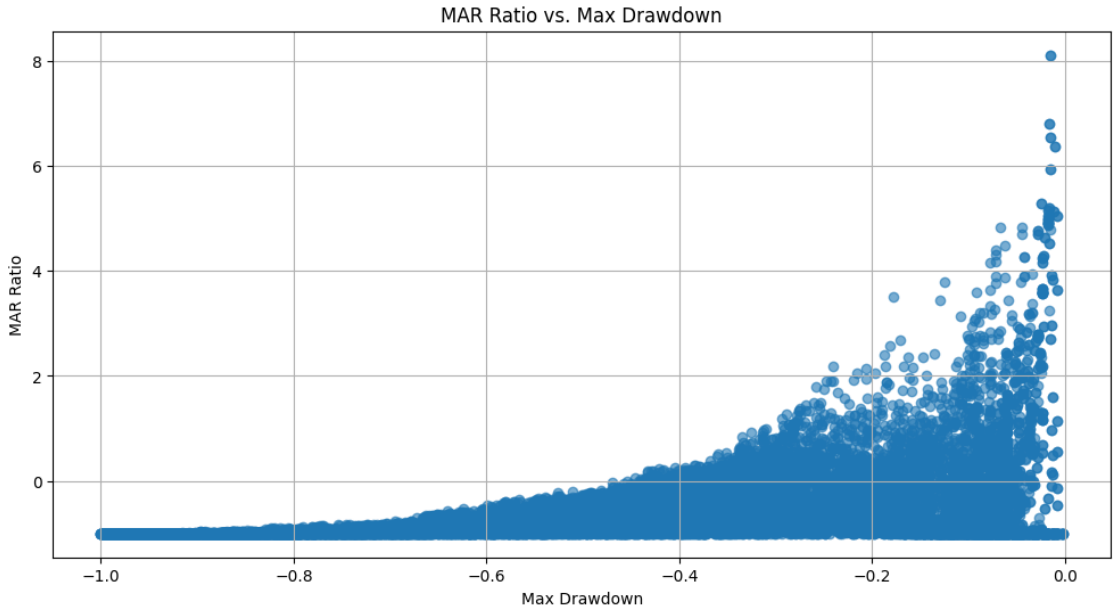

MAR Ratio vs. RSI_PERIOD
MAR Ratio
RSI_PERIOD
8
6
4
2
0
7.5
10.0
12.5
15.0
17.5
20.0
22.5

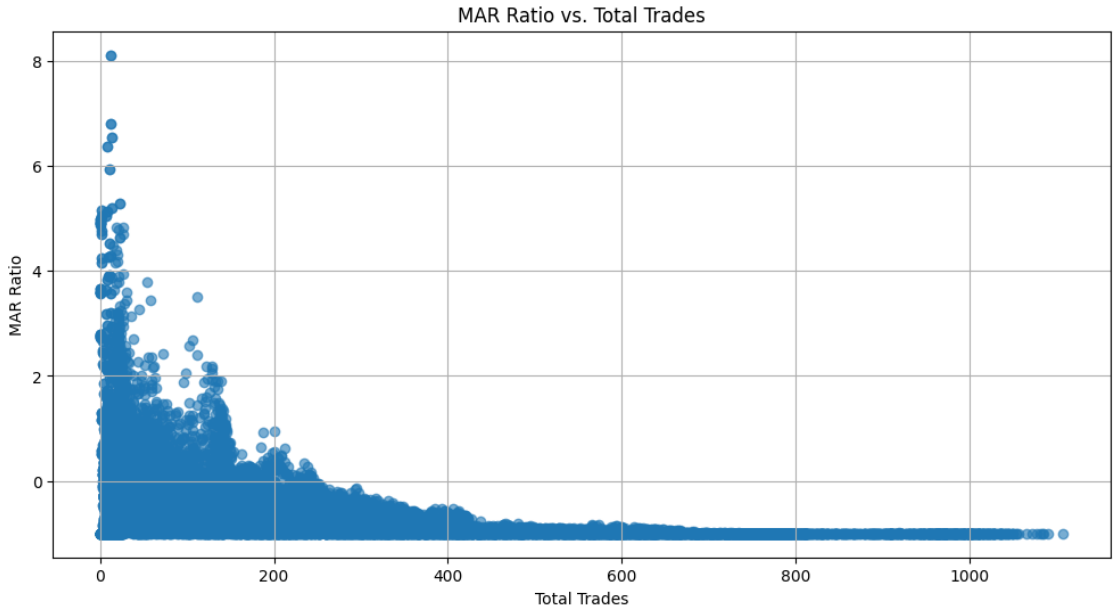

MAR Ratio vs. RSI_THRESHOLD
MAR Ratio
RSI_THRESHOLD
8
6
4
2
0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

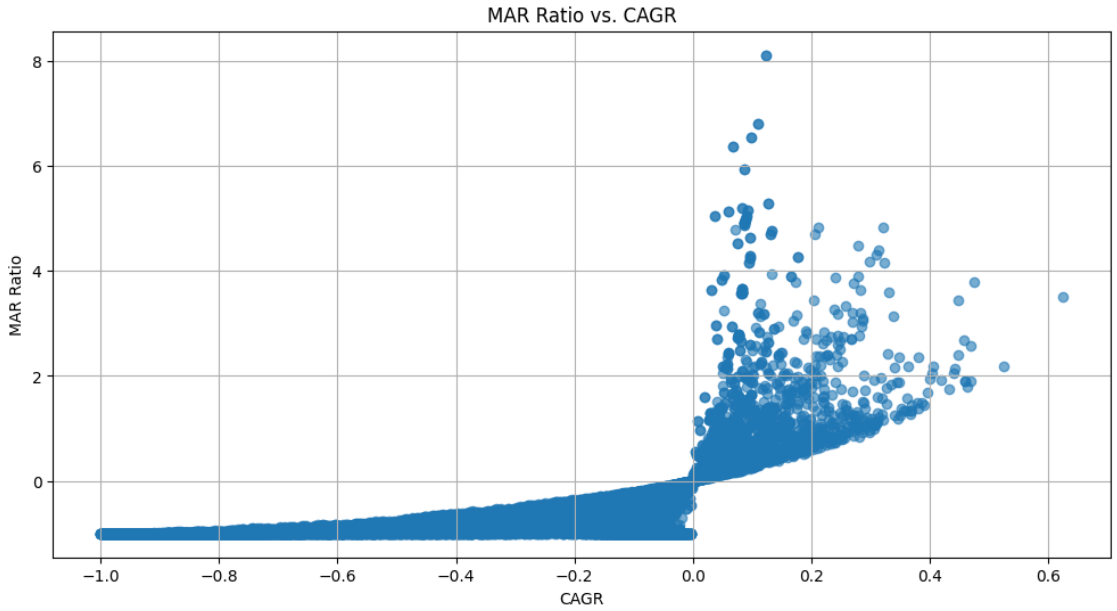

MAR Ratio vs. TRAILING_STOP
MAR Ratio
TRAILING_STOP
8
6
4
2
0
0.0100
0.0125
0.0150
0.0175
0.0200
0.0225
0.0250
0.0275
0.0300

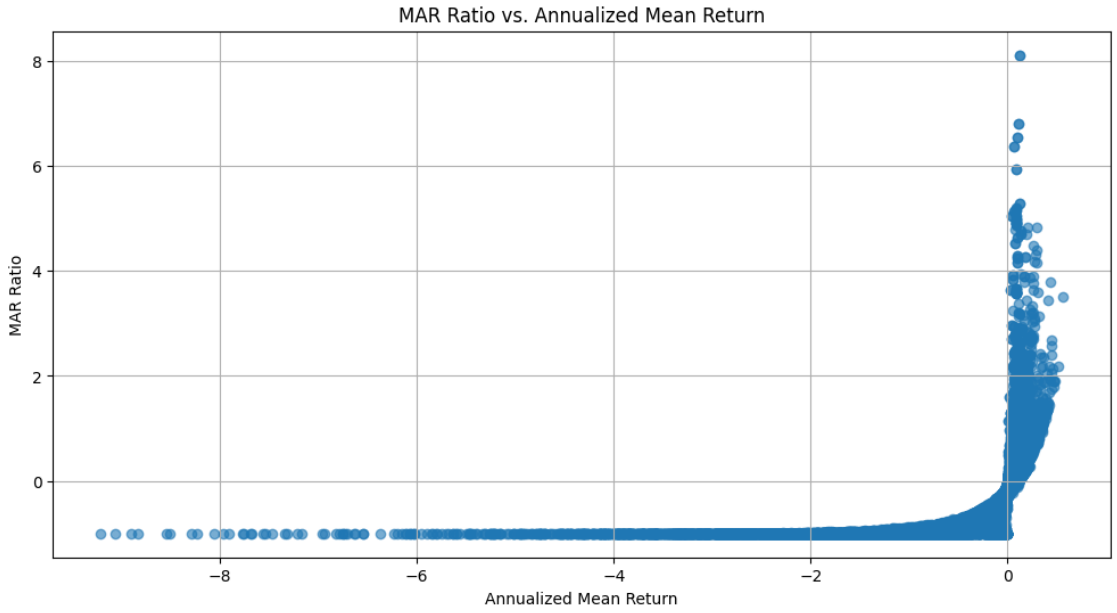

MAR Ratio vs. Total Return
MAR Ratio
Total Return
8
6
4
2
0
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6

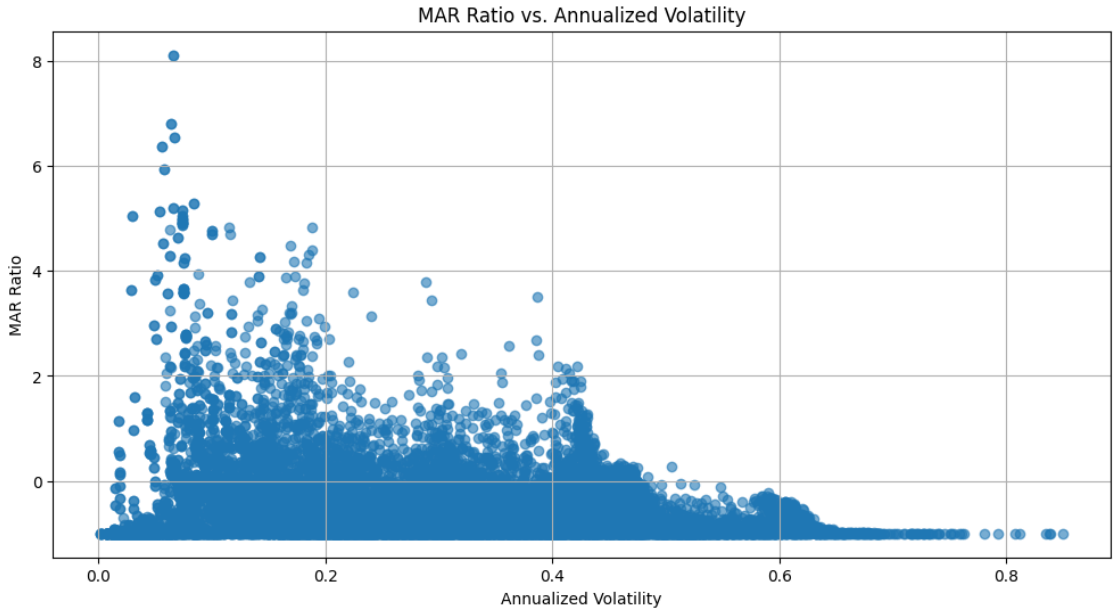

MAR Ratio vs. Win Rate
MAR Ratio
Win Rate
8
6
4
2
0
0.0
0.2
0.4
0.6
0.8
1.0

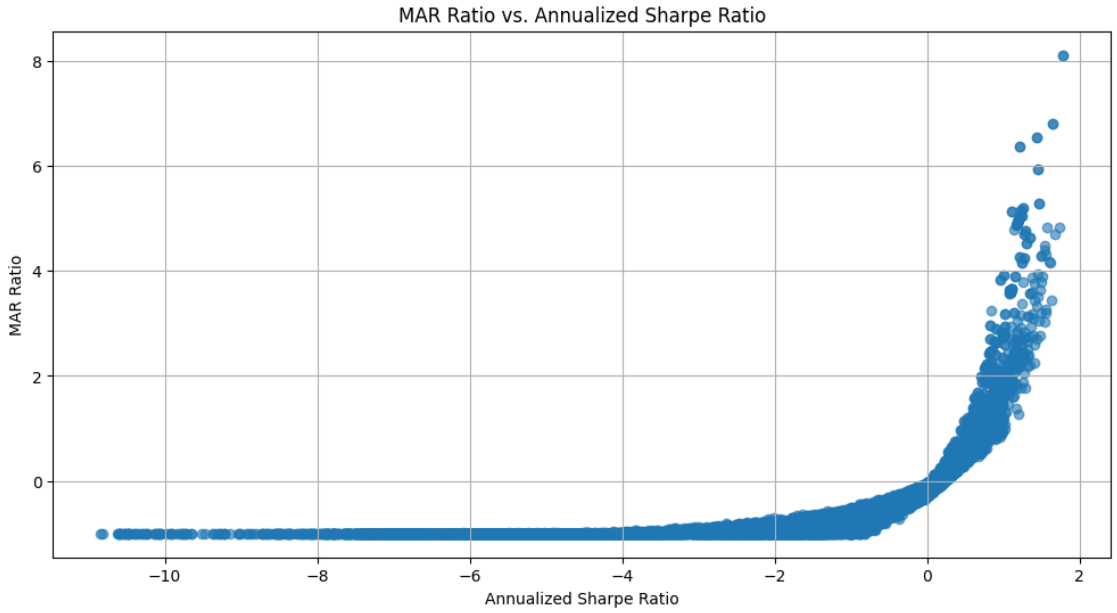

MAR Ratio vs. Max Drawdown
MAR Ratio
Max Drawdown
8
6
4
2
0
−1.0
−0.8
−0.6
−0.4
−0.2
0.0


MAR Ratio vs. Total Trades
MAR Ratio
Total Trades
8
6
4
2
0
0
200
400
600
800
1000


MAR Ratio vs. CAGR
MAR Ratio
CAGR
8
6
4
2
0
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6


MAR Ratio vs. Annualized Mean Return
MAR Ratio
Annualized Mean Return
8
6
4
2
0
−8
−6
−4
−2
0





[29]:
```
import math
import pandas as pd
from typing import Iterable, Mapping, Optional, Tuple

def filter_top_percent(
    df: pd.DataFrame,
```

```
    cols: Iterable[str],
    top_pct: float,
    how: str = "all",  # "all" = rows must be in top pct for every column;␣
 ↪"any" = for at least one
    ascending: Optional[Mapping[str, bool]] = None,  # True = smaller is better;
 ↪ False = larger is better
    coerce_numeric: bool = True,  # coerce non-numeric to NaN for the listed␣
 ↪columns
) -> Tuple[pd.DataFrame, pd.Series]:
    """
    Filter rows to the top X% for a set of columns.

    Parameters
    ----------
    df : pd.DataFrame
        Source data.
    cols : Iterable[str]
        Columns to evaluate.
    top_pct : float
        Percentage (e.g., 10 or 0.10 for top 10%).
    how : {"all", "any"}, default "all"
        "all": keep rows that are in the top X% for *every* column␣
 ↪(intersection).
        "any": keep rows that are in the top X% for *at least one* column␣
 ↪(union).
    ascending : dict[str, bool] | None
        Per-column direction. For each col: True => smaller is better (use␣
 ↪lower tail),
        False => larger is better (use upper tail). If None, defaults to False␣
 ↪for all.
        Example: {"Max Drawdown": True, "MAR Ratio": False}
    coerce_numeric : bool
        If True, tries to convert the specified cols to numeric.

    Returns
    -------
    filtered_df : pd.DataFrame
        Rows meeting the criterion.
    thresholds : pd.Series
        Threshold value used for each column (the cutoff included in the keep).
    """
    if 0 < top_pct <= 1:
        frac = top_pct
    elif 1 < top_pct <= 100:
        frac = top_pct / 100.0
    else:
```

```
        raise ValueError("top_pct must be in (0,1] or (1,100].")

    cols = list(cols)
    if coerce_numeric:
        for c in cols:
            if c in df.columns:
                df[c] = pd.to_numeric(df[c], errors="coerce")

    if ascending is None:
        ascending = {c: False for c in cols}  # larger is better by default
    else:
        # Any unspecified column defaults to larger-is-better
        ascending = {**{c: False for c in cols}, **ascending}

    n = len(df)
    # Use quantile cutoff; include ties on the boundary
    thresholds = {}
    masks = {}

    for c in cols:
        if c not in df.columns:
            raise KeyError(f"Column '{c}' not found in DataFrame.")

        # If smaller is better, top X% = bottom X% (lower tail). Else upper␣
↪tail.
        q = frac if ascending[c] else (1 - frac)
        # Guard against all-NaN columns
        if df[c].notna().any():
            cutoff = df[c].quantile(q)
        else:
            cutoff = float("nan")
        thresholds[c] = cutoff

        if ascending[c]:
            # keep values <= cutoff (lower tail)
            masks[c] = df[c] <= cutoff
        else:
            # keep values >= cutoff (upper tail)
            masks[c] = df[c] >= cutoff

    thresholds = pd.Series(thresholds)

    if how == "all":
        keep_mask = pd.concat(masks, axis=1).all(axis=1)
    elif how == "any":
        keep_mask = pd.concat(masks, axis=1).any(axis=1)
    else:
```

```
        raise ValueError("how must be 'all' or 'any'.")

    filtered_df = df[keep_mask].copy()
    return filtered_df, thresholds
```

[30]:
```
top25_mix, thresh_mix = filter_top_percent(
    df=combined_results_df,
    cols=["MAR Ratio"],
    top_pct=25,
    how="all",
    ascending={}  # Set True for lowest value
)
```

[31]:
```
top10_mar, thresh_mix = filter_top_percent(
    df=combined_results_df,
    cols=["MAR Ratio", "CAGR", "Total Return"],
    top_pct=10,
    how="all",
    ascending={}  # Set True for lowest value
)
```

[32]:
```
top10_mar = top10_mar.sort_values(by=["Total Return"], ascending=False)
top10_mar
```

[32]:

	TICKERS	MA_DAYS	INITIAL_CAPITAL	RSI_PERIOD	RSI_THRESHOLD	\
2018	BTC-USD	7.00	10000	6	12	
2298	BTC-USD	7.00	10000	8	20	
1678	BTC-USD	NaN	10000	22	18	
2778	BTC-USD	7.00	10000	12	28	
2478	BTC-USD	7.00	10000	10	18	
…	…	…	…	…	…	
3432	BTC-USD	7.00	10000	20	14	
3433	BTC-USD	7.00	10000	20	14	
7222	BTC-USD	21.00	10000	18	14	
12614	BTC-USD	42.00	10000	12	12	
2807	BTC-USD	7.00	10000	14	12	

	TRAILING_STOP_PCT	START_DATE	END_DATE	Total Trades	Win Rate	…	\
2018	0.03	2024-01-01	2024-12-31	112.00	0.43	…	
2298	0.03	2024-01-01	2024-12-31	129.00	0.43	…	
1678	0.03	2024-01-01	2024-12-31	54.00	0.46	…	
2778	0.03	2024-01-01	2024-12-31	132.00	0.43	…	
2478	0.03	2024-01-01	2024-12-31	102.00	0.40	…	
…	…	…	…	…	…	…	
3432	0.03	2024-01-01	2024-12-31	4.00	0.25	…	
3433	0.03	2024-01-01	2024-12-31	4.00	0.25	…	
7222	0.01	2024-01-01	2024-12-31	17.00	0.41	…	

```
12614               0.03  2024-01-01  2024-12-31         45.00      0.33  …
2807                0.01  2024-01-01  2024-12-31         17.00      0.47  …

       Runtime EMA (s)  Success-only Runtime EMA (s)  Success  Error  \
2018              3.31                          3.31     True    NaN
2298              3.65                          3.65     True    NaN
1678              2.49                          2.49     True    NaN
2778              3.76                          3.76     True    NaN
2478              3.17                          3.17     True    NaN
…                 …                             …        …       …
3432              2.44                          2.44     True    NaN
3433              2.43                          2.43     True    NaN
7222              2.17                          2.17     True    NaN
12614             2.59                          2.59     True    NaN
2807              2.50                          2.50     True    NaN

       Order Entry      BB Rule  BB Window  BB Num Std  Trade Taker Fee  \
2018         limit  touch_lower      20.00        2.00             0.00
2298         limit  touch_lower      20.00        2.00             0.00
1678         limit  touch_lower      20.00        2.00             0.00
2778         limit  touch_lower      20.00        2.00             0.00
2478         limit  touch_lower      20.00        2.00             0.00
…            …          …        …          …               …
3432        market  touch_lower      20.00        2.00             0.00
3433        market          NaN        NaN         NaN             0.00
7222         limit  touch_lower      20.00        2.00             0.00
12614        limit  touch_lower      20.00        2.00             0.00
2807         limit          NaN        NaN         NaN             0.00

       Trade Maker Fee
2018              0.00
2298              0.00
1678              0.00
2778              0.00
2478              0.00
…                 …
3432              0.00
3433              0.00
7222              0.00
12614             0.00
2807              0.00

[1395 rows x 45 columns]
```

[33]:
```
top10_mar[['TICKERS', 'MA_DAYS', 'RSI_PERIOD', 'RSI_THRESHOLD',
       'TRAILING_STOP_PCT', 'Total Trades',
       'Win Rate', 'Total Return', 'Average Return Per Trade',
```

```
        'Max Trade Gain (%)', 'Max Trade Loss (%)', 'Total PnL',
        'Average PnL Per Trade', 'Max Trade Gain ($)', 'Max Trade Loss ($)',
        'Max Drawdown', 'Annualized Mean Return', 'Annualized Volatility',
        'Annualized Sharpe Ratio', 'CAGR',
        'MAR Ratio', 'BB Rule']]
```

[33]:

	TICKERS	MA_DAYS	RSI_PERIOD	RSI_THRESHOLD	TRAILING_STOP_PCT	\
2018	BTC-USD	7.00	6	12	0.03	
2298	BTC-USD	7.00	8	20	0.03	
1678	BTC-USD	NaN	22	18	0.03	
2778	BTC-USD	7.00	12	28	0.03	
2478	BTC-USD	7.00	10	18	0.03	
…	…	…	…	…	…	
3432	BTC-USD	7.00	20	14	0.03	
3433	BTC-USD	7.00	20	14	0.03	
7222	BTC-USD	21.00	18	14	0.01	
12614	BTC-USD	42.00	12	12	0.03	
2807	BTC-USD	7.00	14	12	0.01	

	Total Trades	Win Rate	Total Return	Average Return Per Trade	\
2018	112.00	0.43	0.63	0.01	
2298	129.00	0.43	0.53	0.00	
1678	54.00	0.46	0.48	0.01	
2778	132.00	0.43	0.47	0.00	
2478	102.00	0.40	0.47	0.00	
…	…	…	…	…	
3432	4.00	0.25	0.04	0.01	
3433	4.00	0.25	0.04	0.01	
7222	17.00	0.41	0.04	0.00	
12614	45.00	0.33	0.04	0.00	
2807	17.00	0.47	0.03	0.00	

	Max Trade Gain (%)	…	Average PnL Per Trade	Max Trade Gain ($)	\
2018	0.20	…	61.06	2560.50	
2298	0.20	…	45.30	2516.12	
1678	0.14	…	88.31	1494.60	
2778	0.20	…	39.71	2384.95	
2478	0.20	…	46.13	2441.05	
…	…	…	…	…	
3432	0.08	…	88.59	794.78	
3433	0.08	…	88.59	794.78	
7222	0.05	…	20.77	453.05	
12614	0.09	…	7.79	888.31	
2807	0.04	…	20.54	414.40	

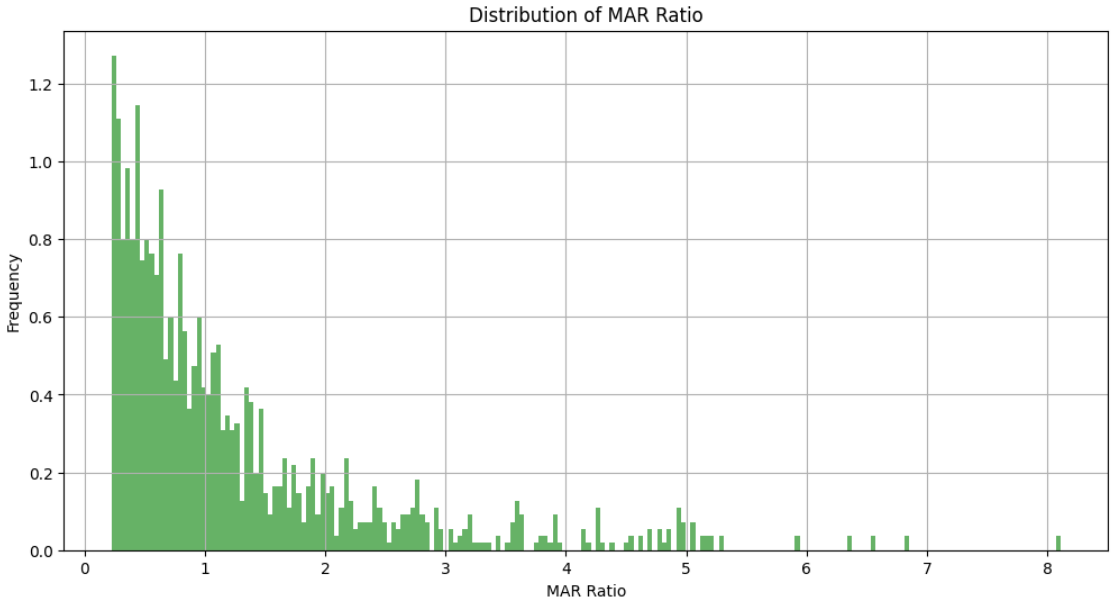
	Max Trade Loss ($)	Max Drawdown	Annualized Mean Return	\
2018	-561.85	-0.18	0.56	

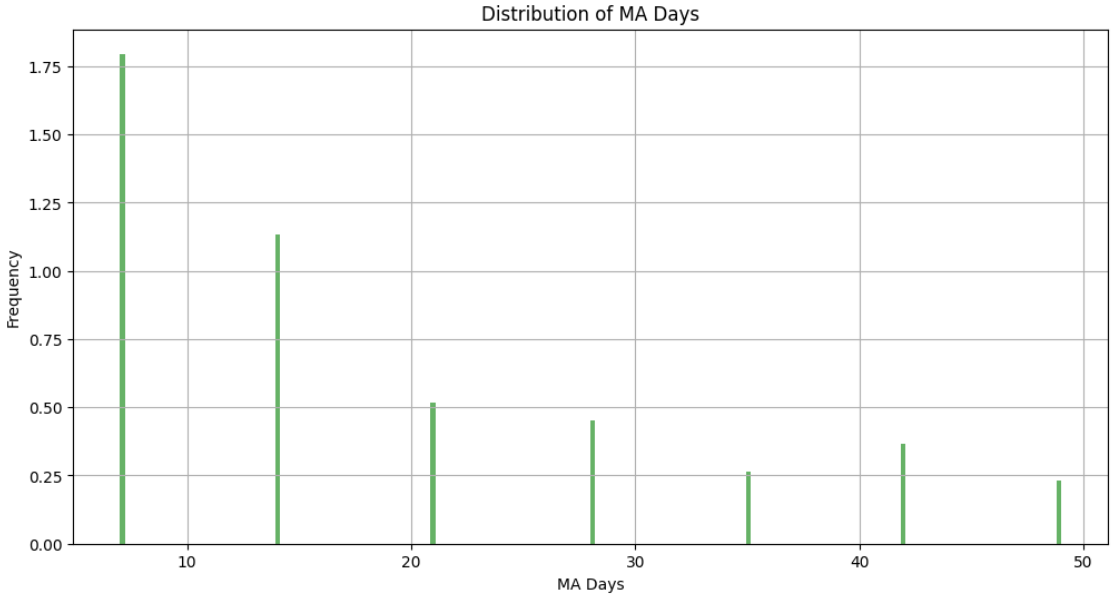
```
2298              -564.09        -0.24                    0.51
1678              -473.36        -0.13                    0.43
2778              -522.34        -0.25                    0.47
2478              -504.15        -0.18                    0.45
…                   …          …                        …
3432              -235.02        -0.04                    0.04
3433              -235.02        -0.04                    0.04
7222              -130.56        -0.04                    0.04
12614             -299.13        -0.15                    0.05
2807              -161.43        -0.03                    0.04

       Annualized Volatility  Annualized Sharpe Ratio  CAGR  MAR Ratio  \
2018                    0.39                     1.45  0.63       3.51
2298                    0.42                     1.21  0.53       2.19
1678                    0.29                     1.49  0.48       3.79
2778                    0.43                     1.11  0.47       1.90
2478                    0.36                     1.24  0.47       2.58
…                       …                        …     …          …
3432                    0.08                     0.47  0.04       0.98
3433                    0.08                     0.47  0.04       0.98
7222                    0.06                     0.57  0.04       0.94
12614                   0.19                     0.27  0.03       0.23
2807                    0.06                     0.58  0.03       1.22

           BB Rule
2018   touch_lower
2298   touch_lower
1678   touch_lower
2778   touch_lower
2478   touch_lower
…              …
3432   touch_lower
3433           NaN
7222   touch_lower
12614  touch_lower
2807           NaN

[1395 rows x 22 columns]
```

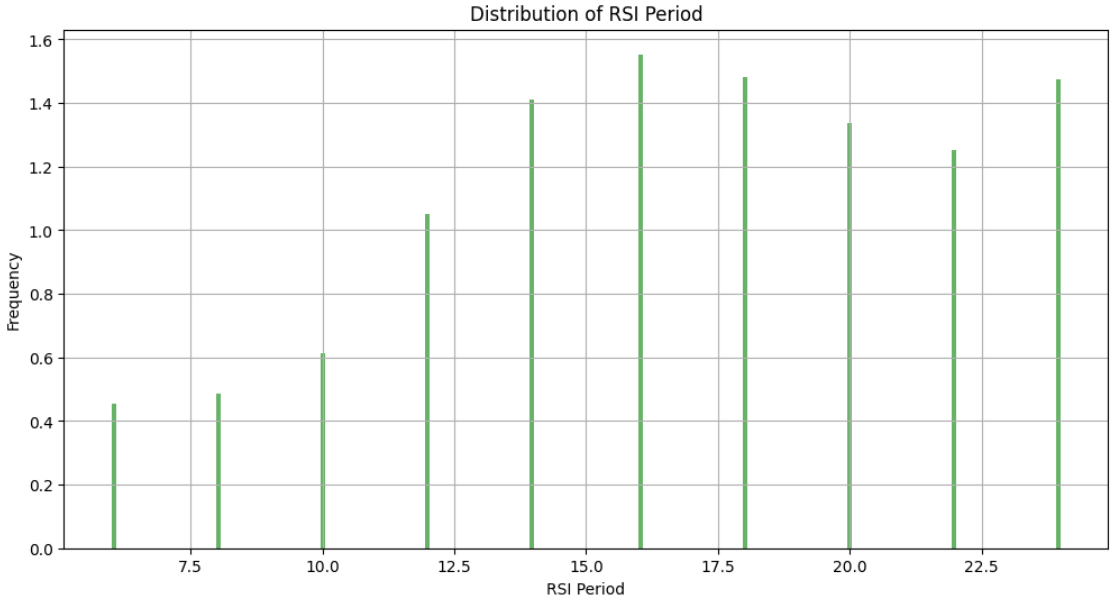
[34]:
```
thresh_mix
```

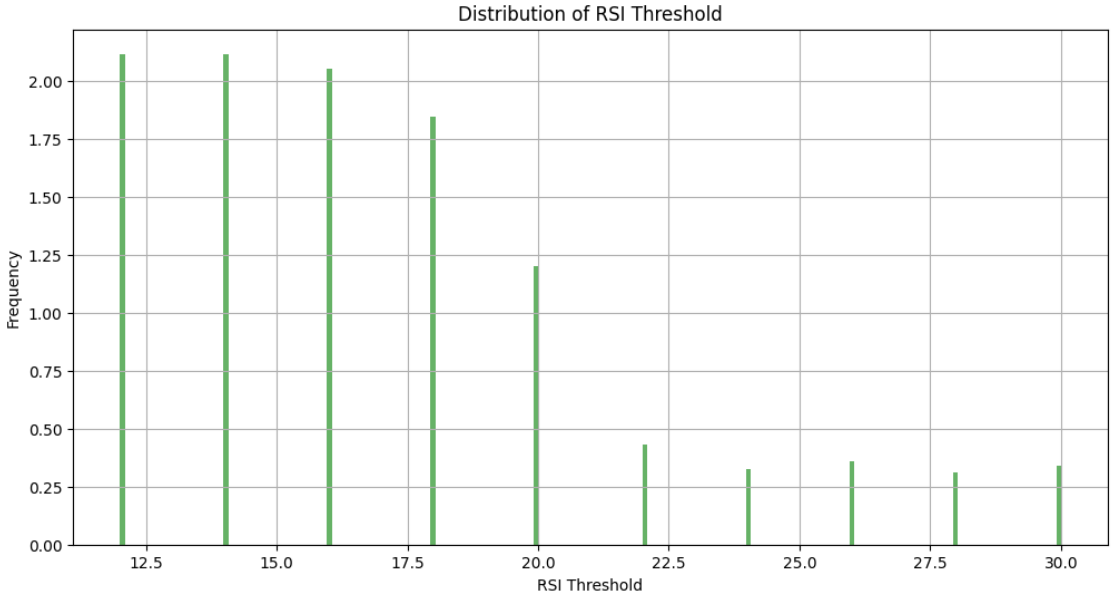
[34]:
```
MAR Ratio      0.22
CAGR           0.03
Total Return   0.03
dtype: float64
```

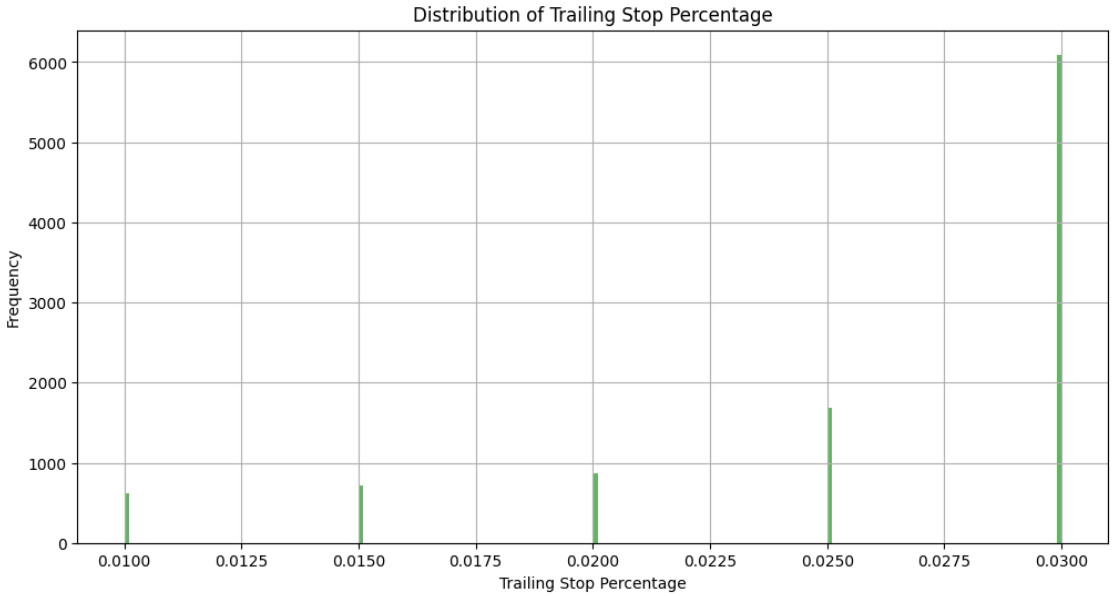
[35]:
```
plot_iteration_results(
    results_df=top10_mar,
)
```

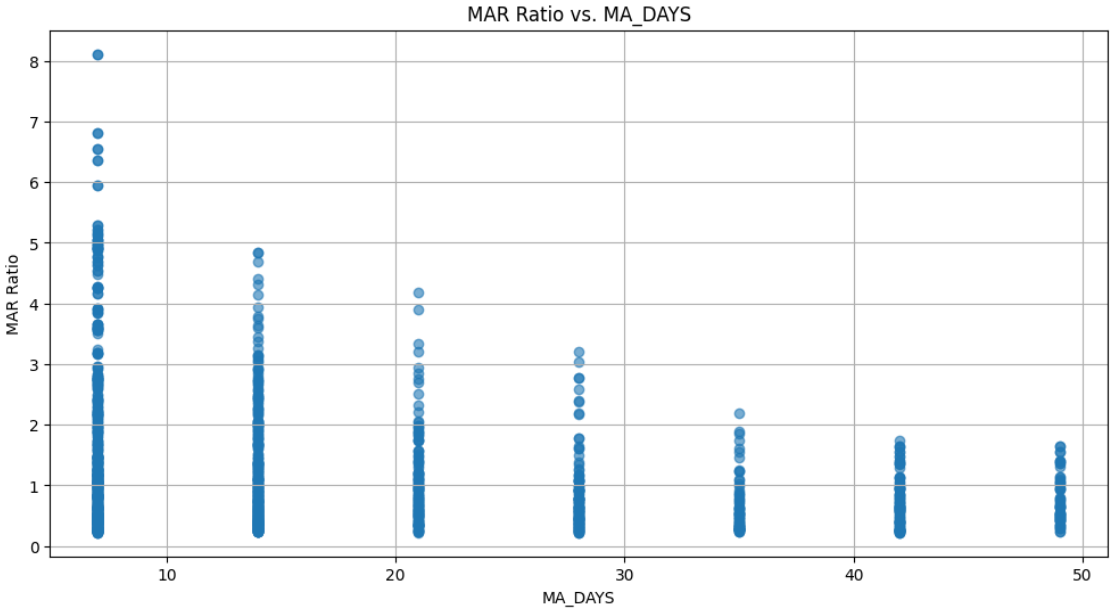


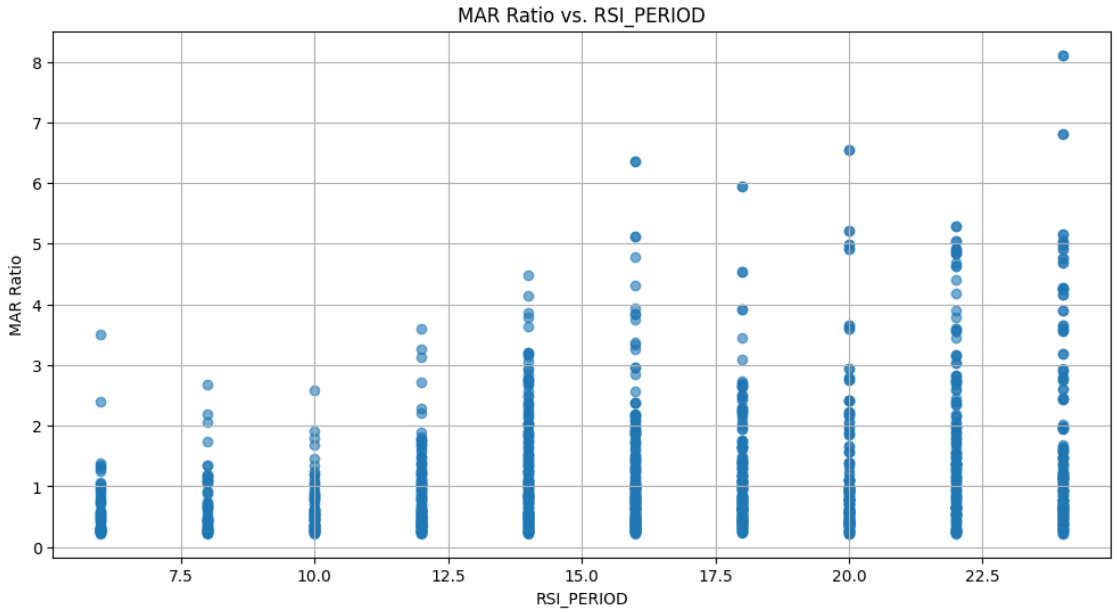


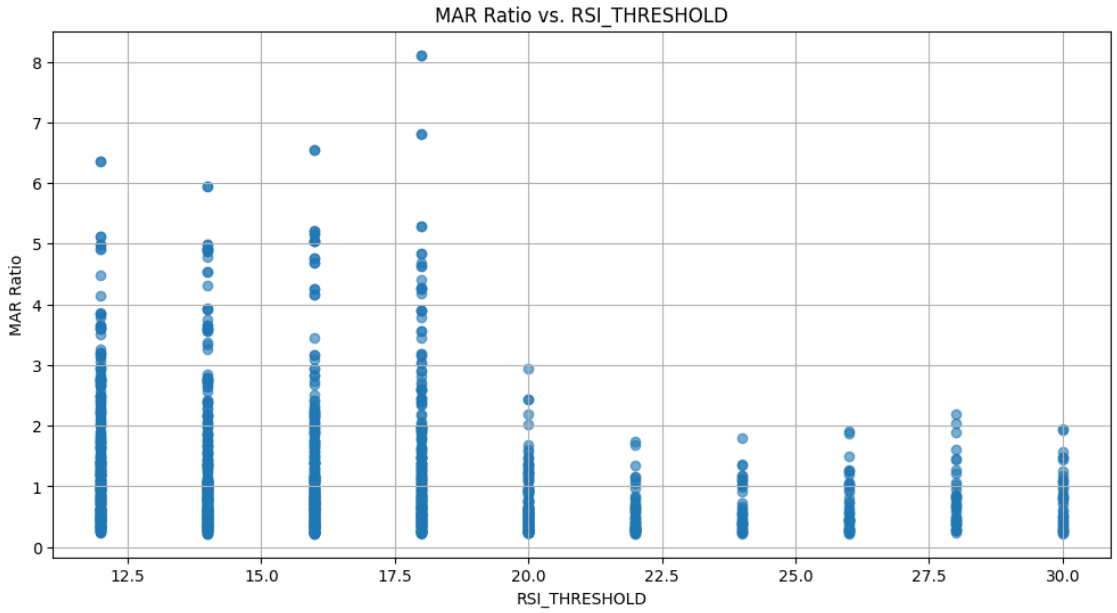

Distribution of RSI Period
Frequency
RSI Period
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
7.5
10.0
12.5
15.0
17.5
20.0
22.5

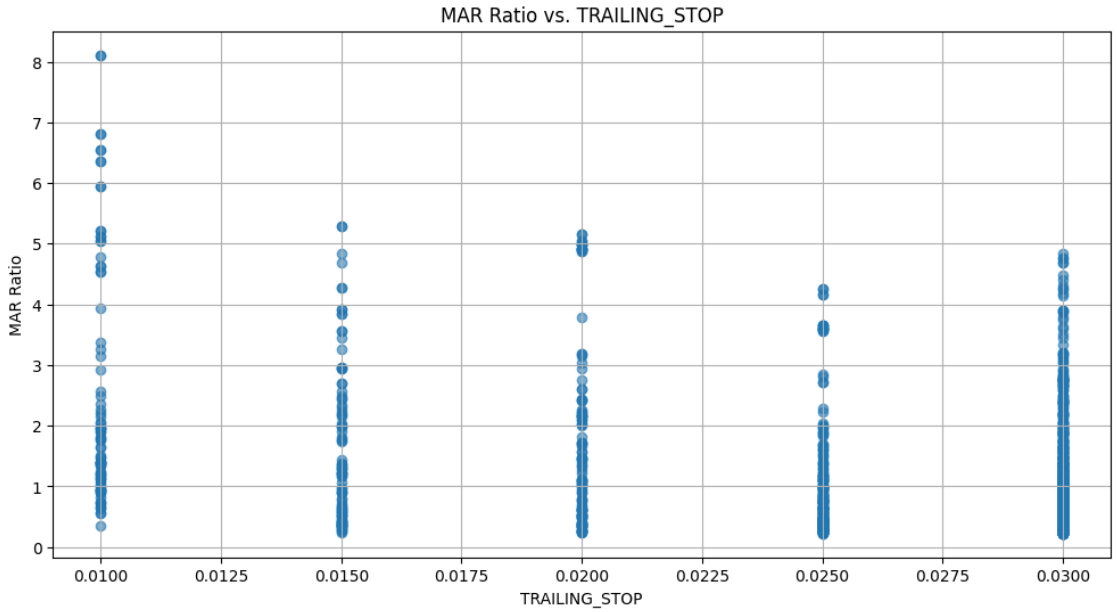

Distribution of RSI Threshold
Frequency
RSI Threshold
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

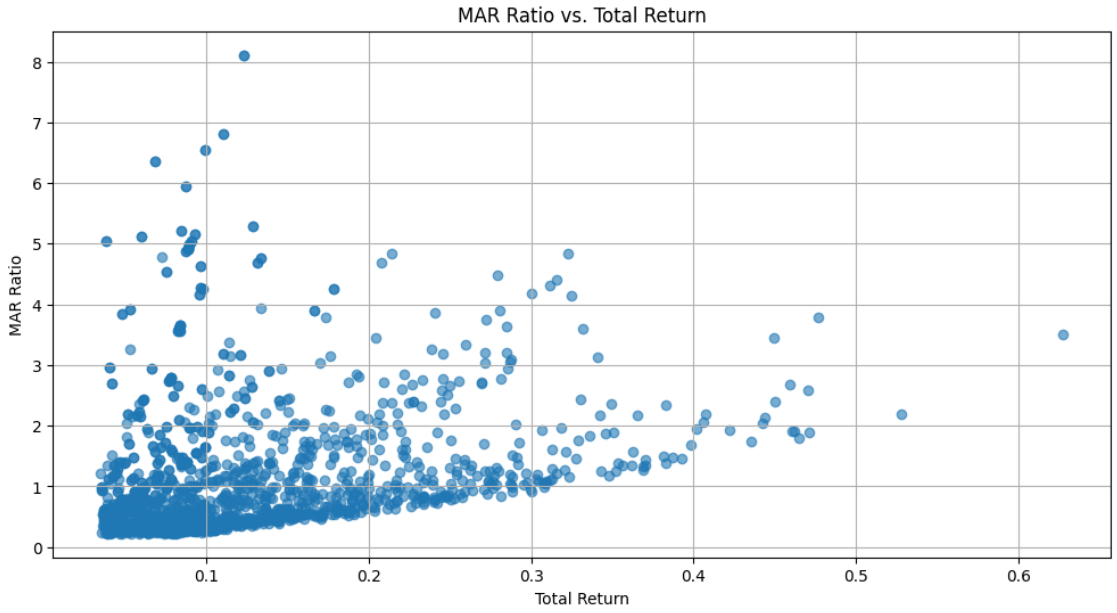

Distribution of Trailing Stop Percentage
Frequency
Trailing Stop Percentage
0
1000
2000
3000
4000
5000
6000
0.0100
0.0125
0.0150
0.0175
0.0200
0.0225
0.0250
0.0275
0.0300

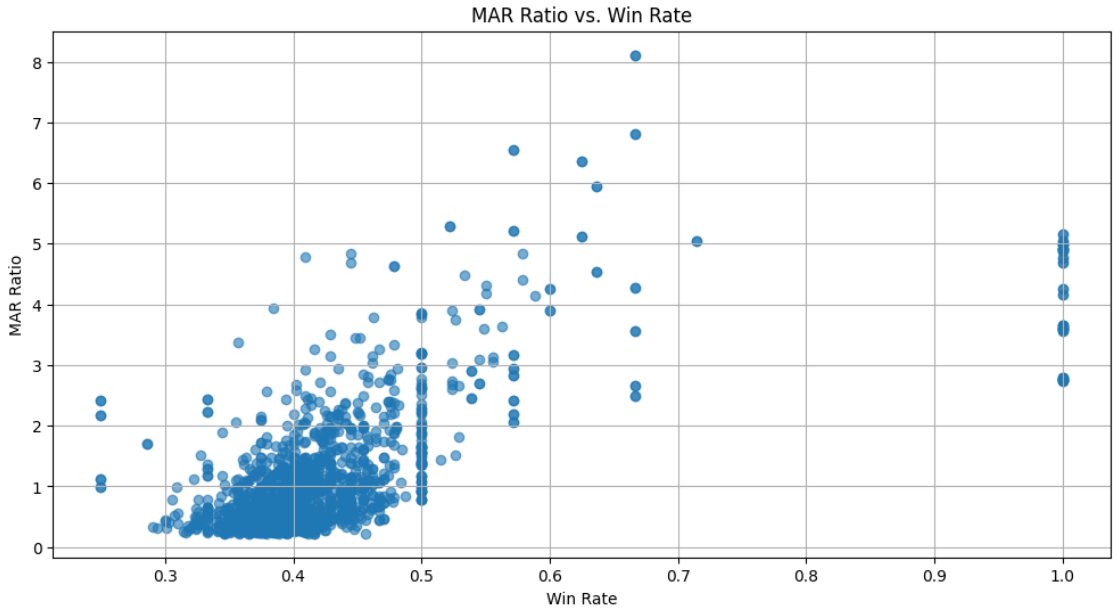

MAR Ratio vs. MA_DAYS
MAR Ratio
MA_DAYS
0
1
2
3
4
5
6
7
8
10
20
30
40
50

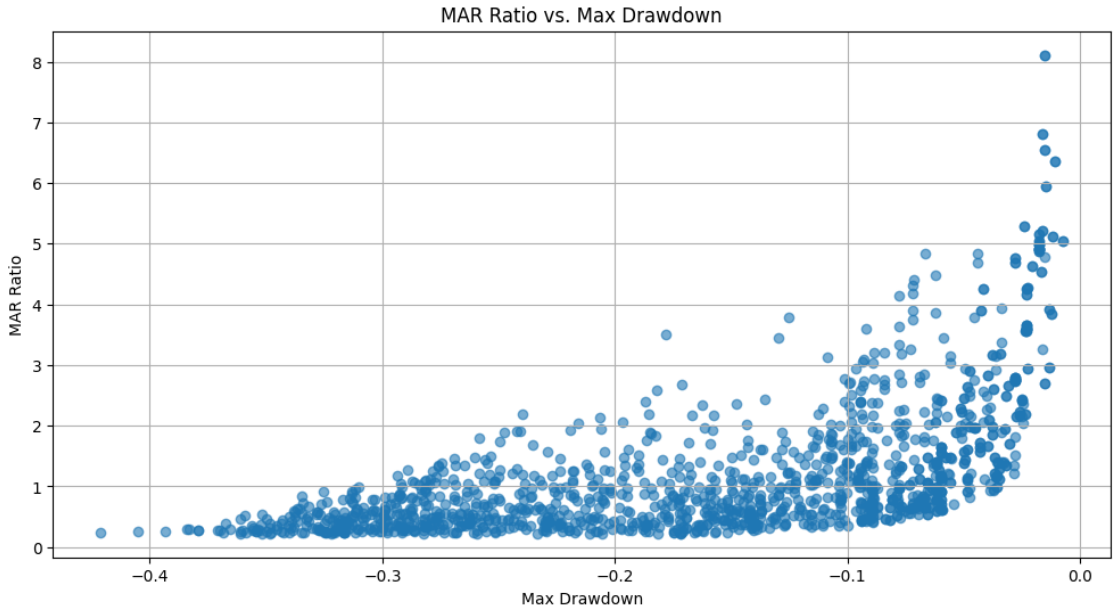

MAR Ratio vs. RSI_PERIOD
MAR Ratio
RSI_PERIOD
0
1
2
3
4
5
6
7
8
7.5
10.0
12.5
15.0
17.5
20.0
22.5

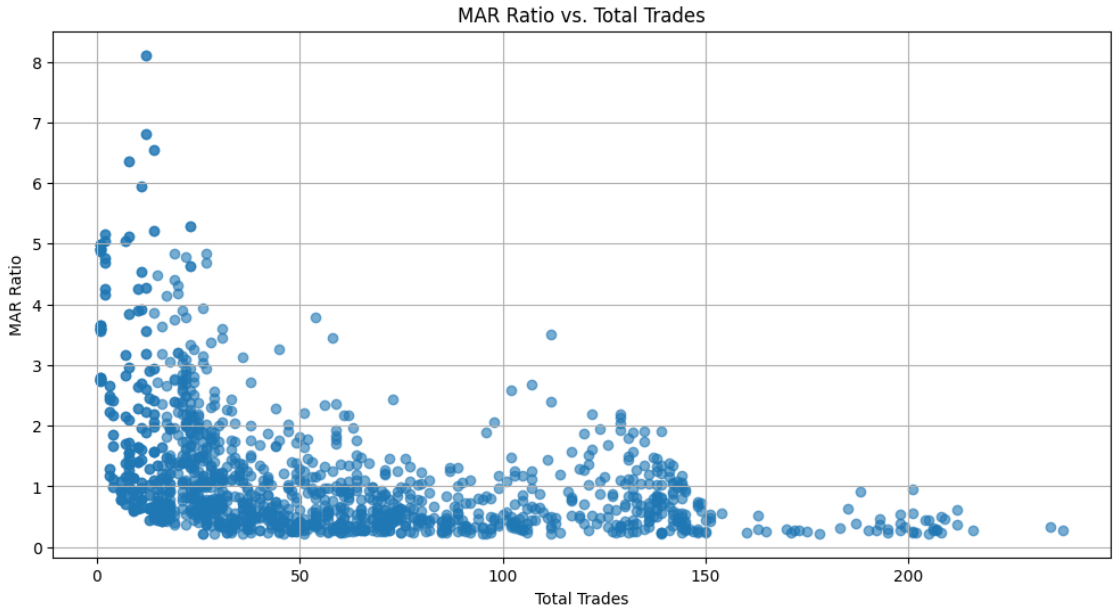

MAR Ratio vs. RSI_THRESHOLD
MAR Ratio
RSI_THRESHOLD
0
1
2
3
4
5
6
7
8
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

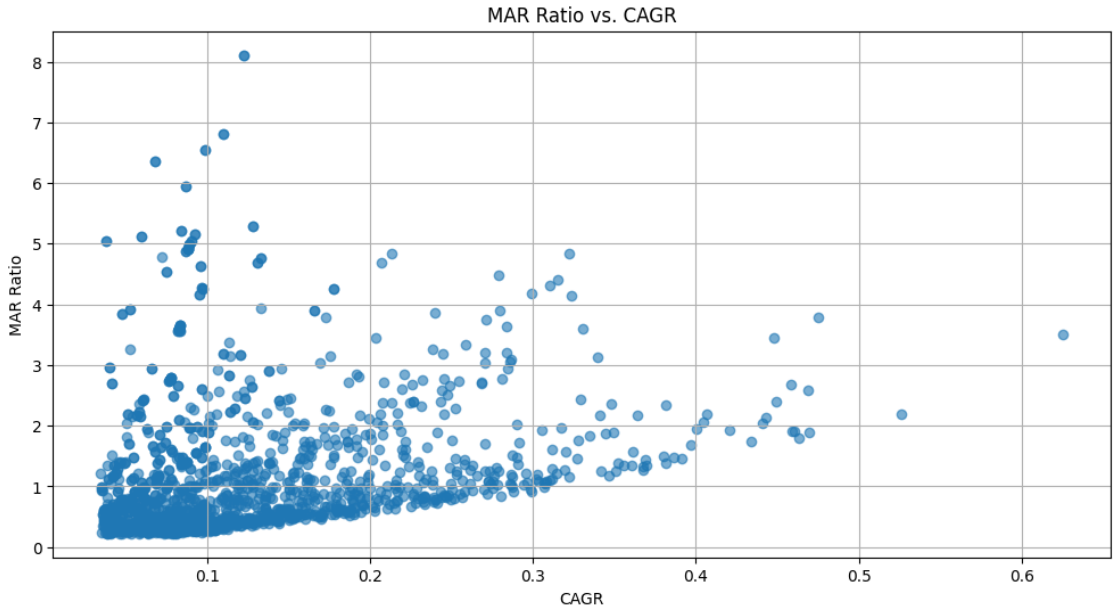

MAR Ratio vs. TRAILING_STOP
MAR Ratio
TRAILING_STOP
0
1
2
3
4
5
6
7
8
0.0100
0.0125
0.0150
0.0175
0.0200
0.0225
0.0250
0.0275
0.0300

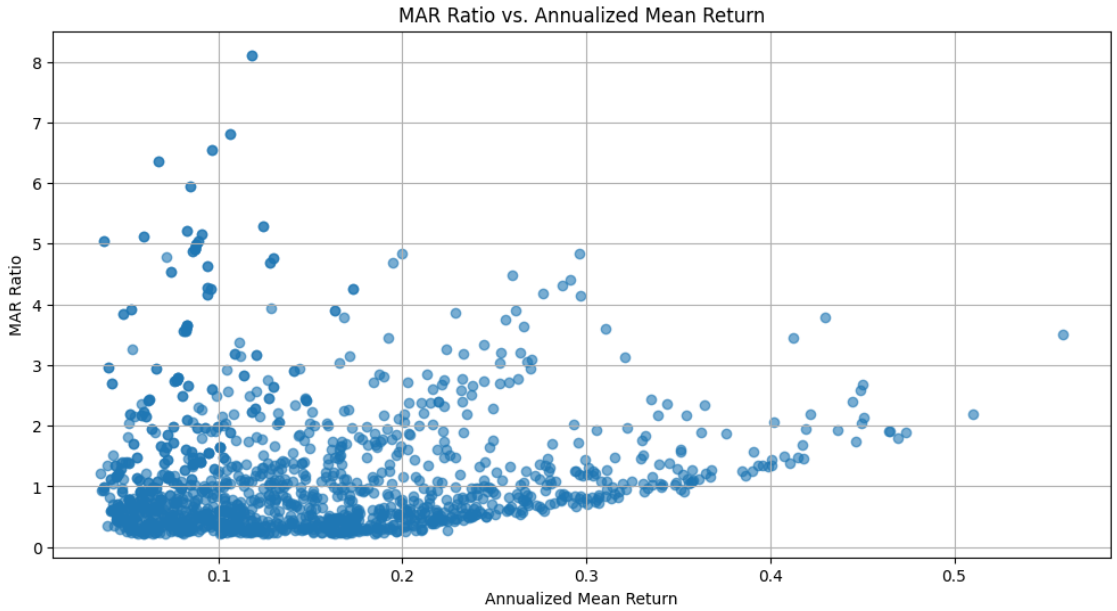

MAR Ratio vs. Total Return
MAR Ratio
Total Return
0
1
2
3
4
5
6
7
8
0.1
0.2
0.3
0.4
0.5
0.6

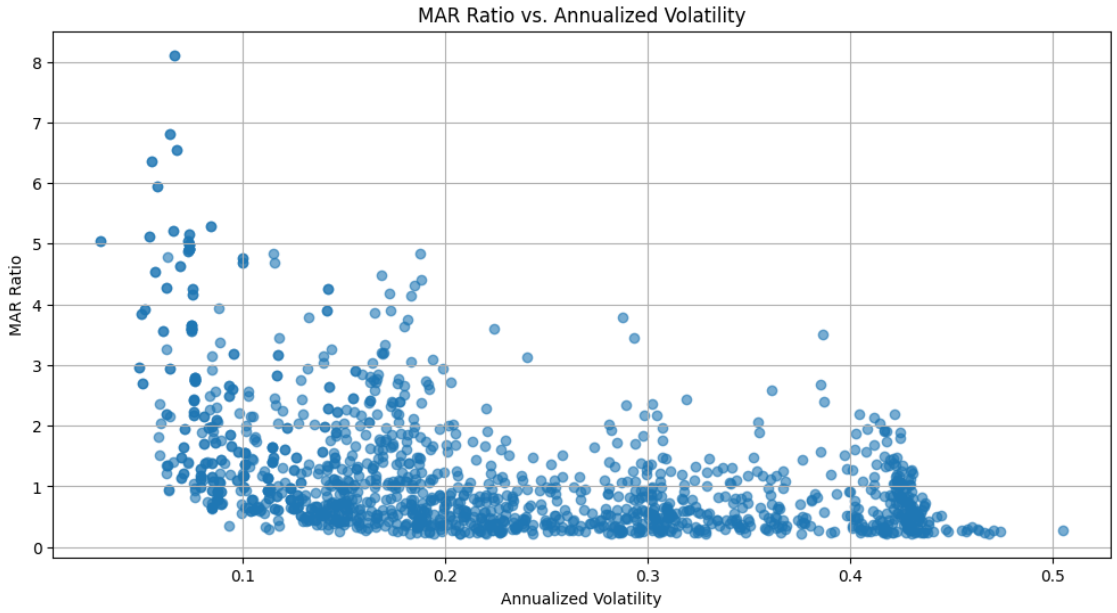

MAR Ratio vs. Win Rate
MAR Ratio
Win Rate
0
1
2
3
4
5
6
7
8
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

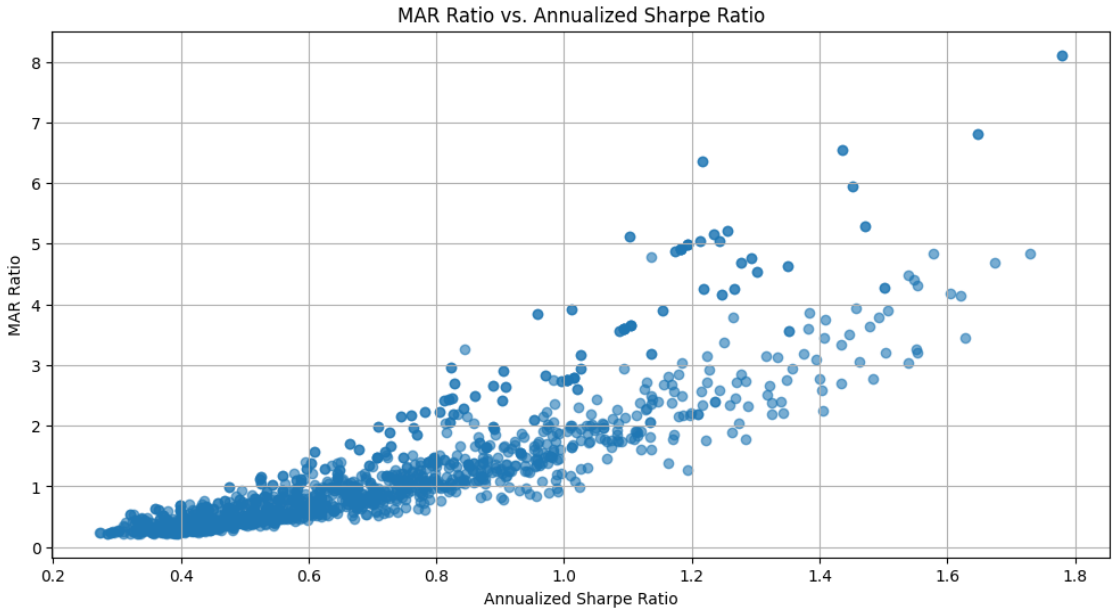

MAR Ratio vs. Max Drawdown
MAR Ratio
Max Drawdown
0
1
2
3
4
5
6
7
8
−0.4
−0.3
−0.2
−0.1
0.0


MAR Ratio vs. Total Trades
MAR Ratio
Total Trades
0
1
2
3
4
5
6
7
8
0
50
100
150
200


MAR Ratio vs. CAGR
MAR Ratio
CAGR
0
1
2
3
4
5
6
7
8
0.1
0.2
0.3
0.4
0.5
0.6


MAR Ratio vs. Annualized Mean Return
MAR Ratio
Annualized Mean Return
0
1
2
3
4
5
6
7
8
0.1
0.2
0.3
0.4
0.5


MAR Ratio vs. Annualized Volatility
MAR Ratio
Annualized Volatility
0
1
2
3
4
5
6
7
8
0.1
0.2
0.3
0.4
0.5



2.12 Delete existing ZIP files

[36]:
```
# import os
# from pathlib import Path
# from glob import escape
# from typing import Iterable, Tuple, List

# ParamSet = Tuple[list, int, int]  # (ma_days, rsi_period, rsi_threshold)

# def delete_zip_variants_batch(
#     base_dir: Path,
#     param_sets: Iterable[ParamSet],
#     dry_run: bool = False,
# ) -> List[Path]:
#     """
#     Delete all zip file variants whose filenames contain
#     ..._{ma_days}_{rsi_period}_{rsi_threshold}_... .zip

#     - Matches recursively under `base_dir`.
#     - Escapes '[' and ']' in ma_days so glob works.
#     - If dry_run=True, only prints what would be deleted.

#     Returns a list of deleted (or would-delete if dry_run) Paths.
#     """
#     deleted: List[Path] = []
```

```
#     for ma_days, rsi_period, rsi_threshold in param_sets:
#         # replicate naming exactly as your exporter: str(list) e.g. "[7, 14]"
#         ma_days_str = str(ma_days)
#         # escape for glob ([], etc.)
#         ma_days_glob = escape(ma_days_str)

#         pattern = f"*_{ma_days_glob}_{rsi_period}_{rsi_threshold}_*.zip"

#         for zip_file in base_dir.rglob(pattern):
#             if dry_run:
#                 print(f"[DRY-RUN] Would delete: {zip_file}")
#             else:
#                 try:
#                     os.remove(zip_file)
#                     print(f"Deleted: {zip_file}")
#                 except OSError as e:
#                     print(f"Failed to delete {zip_file}: {e}")
#                     continue
#             deleted.append(zip_file)

#     if not deleted:
#         print("No matching zip files found for the provided parameter sets.")

#     return deleted
```

[37]:
```
# from pathlib import Path
# from itertools import product
# from typing import Iterable, List, Tuple

# # Reuse the existing function you already have:
# # delete_zip_variants_batch(base_dir: Path, param_sets: Iterable[Tuple[list,␣
 ↪int, int]], dry_run: bool = False)

# def build_param_sets(
#     ma_days_options: Iterable[list],
#     rsi_period_options: Iterable[int],
#     rsi_threshold_options: Iterable[int],
# ) -> List[Tuple[list, int, int]]:
#     """
#     Cartesian product of the provided options:
#     returns [(ma_days, rsi_period, rsi_threshold), ...]
#     """
#     return [(md, rp, rt) for md, rp, rt in product(ma_days_options,␣
 ↪rsi_period_options, rsi_threshold_options)]
```

[38]:
```
# # Base directory that contains year subfolders with ZIPs
# base = Path(current_directory) / "Iterations"
```

```
# # Provide every value you want included; the helper will generate all combos.
# ma_days_options = [[], [7], [14], [21], [28], [35], [42]]

# # rsi_period_options = [6, 8, 10, 12, 14, 16, 18, 20, 22, 24]
# rsi_period_options = [5, 7, 9, 11, 13, 15, 17, 19]

# rsi_threshold_options = [15, 17, 19, 21, 23, 25, 27, 29, 35]
# # rsi_threshold_options = [15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26,␣
 ↪27, 28, 29, 30]

# param_sets = build_param_sets(
#     ma_days_options=ma_days_options,
#     rsi_period_options=rsi_period_options,
#     rsi_threshold_options=rsi_threshold_options,
# )

# # Preview first
# delete_zip_variants_batch(base, param_sets, dry_run=False)
```

2.13 Rename ZIP Files

[39]:
```
# import os
# import re

# # Directory where your zip files live
# zip_dir = Path(current_directory) / "Iterations" / "2021"

# # Regex pattern - order part is optional
# pattern = re.compile(
#     r"^(?P<start>\d{4}-\d{2}-\d{2})_"
#     r"(?P<end>\d{4}-\d{2}-\d{2})_"
#     r"(?P<tickers>\[.*?\])_"
#     r"(?P<ma>\[.*?\])_"
#     r"(?P<rp>\d+)_"
#     r"(?P<rt>\d+)_"
#     r"(?P<ts>[\d.]+)"
#     r"(?:_(?P<order>.+))?"   # optional order
#     r"\.zip$"
# )

# for fname in os.listdir(zip_dir):
#     if not fname.endswith(".zip"):
#         continue

#     match = pattern.match(fname)
#     if not match:
```

```
#         print(f"Skipping {fname} (does not match pattern)")
#         continue

#     # Extract fields
#     start = match.group("start")
#     end = match.group("end")
#     tickers = match.group("tickers")
#     ma = match.group("ma")
#     rp = match.group("rp")
#     rt = match.group("rt")
#     ts = match.group("ts")
#     order = match.group("order") or "market"  # default if missing

#     # Replace [] with [0]
#     if ma == "[]":
#         ma = "[0]"

#     # Force ts to 3 decimal places
#     ts = f"{float(ts):.3f}"

#     # Build new filename
#     new_fname =␣
 ↪f"{start}_{end}_{tickers}_MA-{ma}_RP-{rp}_RT-{rt}_TS-{ts}_{order}.zip"

#     # Paths
#     old_path = os.path.join(zip_dir, fname)
#     new_path = os.path.join(zip_dir, new_fname)

#     # Skip if already exists
#     if os.path.exists(new_path):
#         print(f"Skipping {fname} -> {new_fname} (already exists)")
#         continue

#     # Rename file
#     os.rename(old_path, new_path)
#     print(f"Renamed: {fname} -> {new_fname}")
```

[40]:
```
# import os
# import re

# # Directory where your zip files live
# zip_dir = Path(current_directory) / "Iterations" / "2021"

# # Regex to capture the TS portion in the already-renamed format
# pattern = re.compile(
#     r"^(?P<prefix>.*_TS-)(?P<ts>[\d.]+)(?P<suffix>_.+\.zip)$"
# )
```

```
# for fname in os.listdir(zip_dir):
#     if not fname.endswith(".zip"):
#         continue

#     match = pattern.match(fname)
#     if not match:
#         print(f"Skipping {fname} (does not match TS pattern)")
#         continue

#     prefix = match.group("prefix")
#     ts = match.group("ts")
#     suffix = match.group("suffix")

#     # Reformat TS to 3 decimal places
#     ts_new = f"{float(ts):.3f}"

#     new_fname = f"{prefix}{ts_new}{suffix}"

#     old_path = os.path.join(zip_dir, fname)
#     new_path = os.path.join(zip_dir, new_fname)

#     # Skip if already exists
#     if os.path.exists(new_path):
#         print(f"Skipping {fname} -> {new_fname} (already exists)")
#         continue

#     os.rename(old_path, new_path)
#     print(f"Renamed: {fname} -> {new_fname}")
```

[ ]:
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[ ]:
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[41]:
```
# # Copy this <!-- INSERT_01_VIX_DF_Info_HERE --> to index_temp.md
# export_track_md_deps(dep_file=dep_file, md_filename="01_VIX_DF_Info.md",␣
 ↪content=df_info_markdown(vix))
```

[42]:
```
# # Copy this <!-- INSERT_01_VIX_Stats_HERE --> to index_temp.md
# export_track_md_deps(dep_file=dep_file, md_filename="01_VIX_Stats.md",␣
 ↪content=vix_stats.to_markdown(floatfmt=".2f"))
```