LIBRARY

In [ ]:
```
import pickle
import pandas as pd
import numpy as np

from multi_factor_util import get_performance_metrics, get_data_from_dict
import matplotlib.pyplot as plt

plt.style.use('seaborn-darkgrid')
```

DATA LOADING

In [ ]:
```
data_filename = 'multifactor_data_2017_2022.bz2'
with open(data_filename, 'rb') as file:
    fundamental_price_data = pickle.load(file)
```

MARKET CAPITALISATION

In [ ]:
```
shares_data = get_data_from_dict(fundamental_price_data, 'Shares (Diluted)')
print("Shares Data:")
display(shares_data.head())

close_data = get_data_from_dict(fundamental_price_data, "Close")
print("Close Data:")
display(close_data.head())

market_cap = shares_data * close_data
print("Market Capitalization:")
display(market_cap.head())
```

Shares Data:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	2.073434e+10	1.603000e+09	658250278.0	500398000.0	908667044.0	733000000.0	432831000.0	9.880000e+09	267000000.0	257300000.0	...	797600000.0	874000000.0	1.678000e+09	1.266592e+09	2.812250e+09	250268000.0	4.089000e+09	1.057600e+09	4.996800e+09	4.271000e+09
2017-10-03	2.073434e+10	1.603000e+09	658250278.0	500398000.0	908667044.0	733000000.0	432831000.0	9.880000e+09	267000000.0	257300000.0	...	797600000.0	874000000.0	1.678000e+09	1.266592e+09	2.812250e+09	250268000.0	4.089000e+09	1.057600e+09	4.996800e+09	4.271000e+09
2017-10-04	2.073434e+10	1.603000e+09	658250278.0	500398000.0	908667044.0	733000000.0	432831000.0	9.880000e+09	267000000.0	257300000.0	...	797600000.0	874000000.0	1.678000e+09	1.266592e+09	2.812250e+09	250268000.0	4.089000e+09	1.057600e+09	4.996800e+09	4.271000e+09
2017-10-05	2.073434e+10	1.603000e+09	658250278.0	500398000.0	908667044.0	733000000.0	432831000.0	9.880000e+09	267000000.0	257300000.0	...	797600000.0	874000000.0	1.678000e+09	1.266592e+09	2.812250e+09	250268000.0	4.089000e+09	1.057600e+09	4.996800e+09	4.271000e+09
2017-10-06	2.073434e+10	1.603000e+09	658250278.0	500398000.0	908667044.0	733000000.0	432831000.0	9.880000e+09	267000000.0	257300000.0	...	797600000.0	874000000.0	1.678000e+09	1.266592e+09	2.812250e+09	250268000.0	4.089000e+09	1.057600e+09	4.996800e+09	4.271000e+09

5 rows × 100 columns

Close Data:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	36.327709	69.086456	123.357384	147.940002	52.756409	157.477875	119.987679	47.959499	178.421280	139.316406	...	101.742920	101.005196	43.475266	64.492149	101.456879	152.229996	36.936378	61.800434	46.647301	61.183491
2017-10-03	36.485950	68.559082	122.273506	148.600006	52.560257	157.528351	120.694221	47.855000	180.400482	139.335342	...	101.416298	100.102089	43.499680	64.563438	101.601212	152.509995	37.303047	61.953705	46.739811	61.280930
2017-10-04	36.249767	68.711945	123.102348	147.949997	52.517624	158.672592	122.619507	48.272499	180.577911	138.711075	...	100.427666	99.508377	43.239349	64.519562	101.331818	152.509995	37.340469	61.179173	46.218430	61.303410
2017-10-05	36.700871	68.925949	124.067749	150.250000	52.858742	157.208633	122.981590	49.042500	180.111099	138.701599	...	100.648315	98.839409	43.735603	64.815758	102.226646	152.300003	37.243191	62.082794	46.580021	61.475811
2017-10-06	36.679630	69.162910	124.095093	151.119995	53.097553	156.342072	122.857933	49.479000	180.391205	138.890808	...	100.586555	98.421326	44.077282	64.848686	102.698158	155.100006	36.962997	59.057301	46.739811	61.243454

5 rows × 100 columns

Market Capitalization:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	7.532312e+11	1.107456e+11	8.120003e+10	7.402888e+10	4.793801e+10	1.154313e+11	5.193439e+10	4.738399e+11	4.763848e+10	3.584611e+10	...	8.115015e+10	8.827854e+10	7.295150e+10	8.168523e+10	2.853221e+11	3.809830e+10	1.510329e+11	6.536014e+10	2.330872e+11	2.613147e+11
2017-10-03	7.565122e+11	1.099002e+11	8.048657e+10	7.435915e+10	4.775977e+10	1.154683e+11	5.224020e+10	4.728074e+11	4.816693e+10	3.585098e+10	...	8.088964e+10	8.748923e+10	7.299246e+10	8.177553e+10	2.857280e+11	3.816837e+10	1.525322e+11	6.552224e+10	2.335495e+11	2.617309e+11
2017-10-04	7.516151e+11	1.101452e+11	8.103216e+10	7.403388e+10	4.772103e+10	1.163070e+11	5.307352e+10	4.769323e+11	4.821430e+10	3.569036e+10	...	8.010111e+10	8.697032e+10	7.255563e+10	8.171995e+10	2.849704e+11	3.816837e+10	1.526852e+11	6.470309e+10	2.309442e+11	2.618269e+11
2017-10-05	7.609685e+11	1.104883e+11	8.166763e+10	7.518480e+10	4.803100e+10	1.152339e+11	5.323024e+10	4.845399e+11	4.808966e+10	3.568792e+10	...	8.027710e+10	8.638564e+10	7.338834e+10	8.209511e+10	2.874869e+11	3.811582e+10	1.522874e+11	6.565876e+10	2.327510e+11	2.625632e+11
2017-10-06	7.605281e+11	1.108681e+11	8.168563e+10	7.562014e+10	4.824800e+10	1.145987e+11	5.317672e+10	4.888525e+11	4.816445e+10	3.573660e+10	...	8.022784e+10	8.602024e+10	7.396168e+10	8.213682e+10	2.888129e+11	3.881657e+10	1.511417e+11	6.245900e+10	2.335495e+11	2.615708e+11

5 rows × 100 columns

REBALANCING AND GENERATING TRADING SIGNALS

In [ ]:
```
rebalancing = pd.DataFrame(index=market_cap.index)
rebalancing["is_start_of_month"] = rebalancing.index.to_series().dt.month != rebalancing.index.to_series().shift(1).dt.month
print("Rebalancing:")
display(rebalancing.head())
```

```
start_of_month_data = market_cap[market_cap.index.isin(rebalancing[rebalancing["is_start_of_month"]].index)]
print("Start of Month Data:")
display(start_of_month_data.head())

market_cap_ranks = start_of_month_data.rank(ascending=True, axis=1)
print("Market Cap Ranks:")
display(market_cap_ranks.head())

top_10_ranks = market_cap_ranks.applymap(lambda x: 1 if x <= 10 else np.nan)
print("Top 10 Ranks:")
display(top_10_ranks.head())

monthly_trading_signal = top_10_ranks.fillna(0)
print("Monthly Trading Signal:")
display(monthly_trading_signal.head())

daily_trading_signal = monthly_trading_signal.reindex(rebalancing.index)
daily_trading_signal = daily_trading_signal.ffill()
print("Daily Trading Signal:")
display(daily_trading_signal.head())
```

Rebalancing:

	is_start_of_month
2017-10-02	True
2017-10-03	False
2017-10-04	False
2017-10-05	False
2017-10-06	False

Start of Month Data:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	7.532312e+11	1.107456e+11	8.120003e+10	7.402888e+10	4.793801e+10	1.154313e+11	5.193439e+10	4.738399e+11	4.763848e+10	3.584611e+10	...	8.115015e+10	8.827854e+10	7.295150e+10	8.168523e+10	2.853221e+11	3.809830e+10	1.510329e+11	6.536014e+10	2.330872e+11	2.613147e+11
2017-11-01	8.172861e+11	1.140474e+11	8.653859e+10	8.819515e+10	5.010786e+10	1.081849e+11	5.382658e+10	5.452179e+11	5.223007e+10	3.485058e+10	...	8.237522e+10	8.584483e+10	7.437124e+10	8.344981e+10	3.005570e+11	3.569573e+10	1.481070e+11	5.717730e+10	2.361967e+11	2.684854e+11
2017-12-01	8.406693e+11	1.188343e+11	8.851103e+10	9.027738e+10	4.640362e+10	1.100296e+11	5.489694e+10	5.742009e+11	5.791599e+10	3.470420e+10	...	8.823406e+10	8.858099e+10	7.494457e+10	8.394964e+10	3.001679e+11	3.523523e+10	1.586972e+11	5.862247e+10	2.378047e+11	2.696455e+11
2018-01-02	8.424026e+11	1.216401e+11	9.290125e+10	8.936213e+10	4.387420e+10	1.091558e+11	5.426887e+10	5.897490e+11	5.565932e+10	3.193175e+10	...	9.488211e+10	9.074232e+10	7.350541e+10	8.975968e+10	3.100835e+11	4.010784e+10	1.659194e+11	6.149412e+10	2.568150e+11	2.739462e+11
2018-02-01	8.204941e+11	1.448340e+11	9.689896e+10	1.002646e+11	4.731777e+10	1.144347e+11	5.654913e+10	6.894400e+11	6.007511e+10	3.517565e+10	...	9.250621e+10	8.768994e+10	7.817178e+10	9.687545e+10	3.404393e+11	4.537476e+10	1.702231e+11	6.240485e+10	2.770387e+11	2.869620e+11

5 rows × 100 columns

Market Cap Ranks:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	100.0	74.0	61.0	54.0	31.0	76.0	33.0	95.0	30.0	4.0	...	60.0	66.0	52.0	63.0	94.0	8.0	83.0	46.0	92.0	93.0
2017-11-01	100.0	75.0	64.0	67.0	30.0	73.0	34.0	96.0	32.0	4.0	...	59.0	63.0	52.0	61.0	94.0	6.0	81.0	41.0	92.0	93.0
2017-12-01	100.0	76.0	66.0	68.0	22.0	73.0	33.0	96.0	39.0	3.0	...	65.0	67.0	50.0	61.0	94.0	4.0	84.0	40.0	92.0	93.0
2018-01-02	99.0	76.0	67.0	61.0	16.0	71.0	33.0	96.0	35.0	1.0	...	68.0	64.0	48.0	62.0	94.0	12.0	84.0	40.0	92.0	93.0
2018-02-01	98.0	79.0	66.0	67.0	22.0	70.0	33.0	97.0	37.0	4.0	...	61.0	56.0	49.0	65.0	94.0	17.0	82.0	39.0	92.0	93.0

5 rows × 100 columns

Top 10 Ranks:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1.0	...	NaN	NaN	NaN	NaN	NaN	1.0	NaN	NaN	NaN	NaN
2017-11-01	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1.0	...	NaN	NaN	NaN	NaN	NaN	1.0	NaN	NaN	NaN	NaN
2017-12-01	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1.0	...	NaN	NaN	NaN	NaN	NaN	1.0	NaN	NaN	NaN	NaN
2018-01-02	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1.0	...	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-02-01	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1.0	...	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

5 rows × 100 columns

Monthly Trading Signal:

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2017-11-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2017-12-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2018-01-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2018-02-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5 rows × 100 columns

```
Daily Trading Signal:
```

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2017-10-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2017-10-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2017-10-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2017-10-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0

5 rows × 100 columns

DAILY RETURN CALCULATION

In [ ]:
```
daily_returns = close_data.pct_change()
print("Daily Returns:")
display(daily_returns.head())

returns = daily_trading_signal.shift(1) * daily_returns
returns['Mean_Returns'] = returns.apply(lambda row: row[row != 0].mean(), axis=1)
returns.dropna(inplace=True)
print("Returns:")
display(returns.head())
```

```
Daily Returns:
```

	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UNP	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM
2017-10-02	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2017-10-03	0.004356	-0.007634	-0.008786	0.004461	-0.003718	0.000321	0.005888	-0.002179	0.011093	0.000136	...	-0.003210	-0.008941	0.000562	0.001105	0.001423	0.001839	0.009927	0.002480	0.001983	0.001593
2017-10-04	-0.006473	0.002230	0.006779	-0.004374	-0.000811	0.007264	0.015952	0.008724	0.000984	-0.004480	...	-0.009748	-0.005931	-0.005985	-0.000680	-0.002651	0.000000	0.001003	-0.012502	-0.011155	0.000367
2017-10-05	0.012444	0.003115	0.007842	0.015546	0.006495	-0.009226	0.002953	0.015951	-0.002585	-0.000068	...	0.002197	-0.006723	0.011477	0.004591	0.008831	-0.001377	-0.002605	0.014770	0.007824	0.002812
2017-10-06	-0.000579	0.003438	0.000220	0.005790	0.004518	-0.005512	-0.001005	0.008900	0.001555	0.001364	...	-0.000614	-0.004230	0.007812	0.000508	0.004612	0.018385	-0.007523	-0.048733	0.003430	-0.003780

5 rows × 100 columns

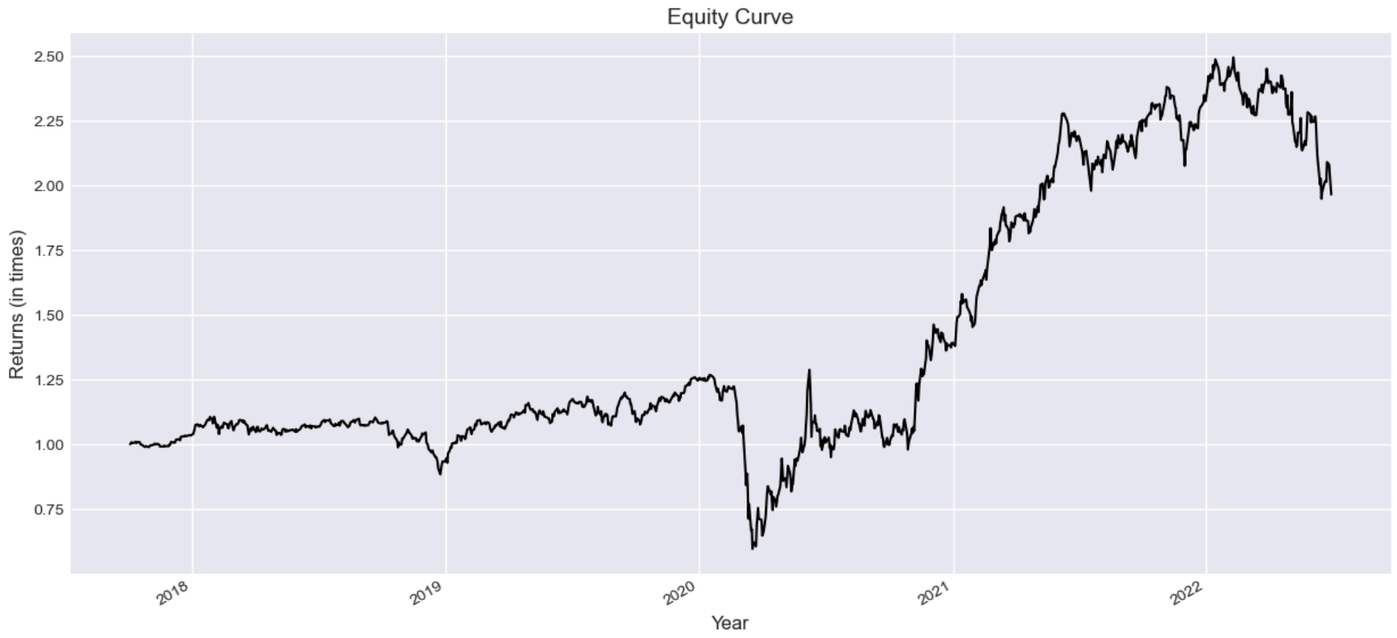
```
Returns:
```

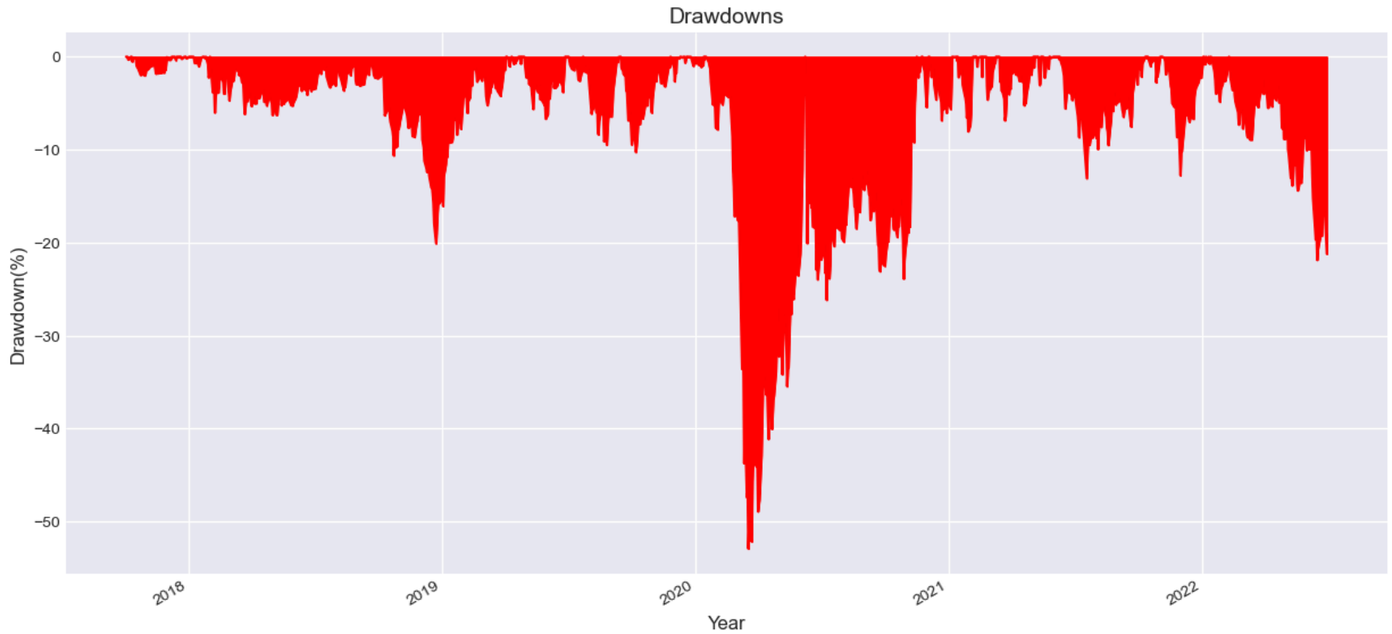
	AAPL	ABBV	ACN	ADBE	AIG	AMGN	AMT	AMZN	ELV	AON	...	UPS	USB	RTX	V	VRTX	VZ	WBA	WFC	XOM	Mean_Returns
2017-10-03	0.0	-0.0	-0.0	0.0	-0.0	0.0	0.0	-0.0	0.0	0.000136	...	-0.0	0.0	0.0	0.0	0.001839	0.0	0.0	0.0	0.0	0.000909
2017-10-04	-0.0	0.0	0.0	-0.0	-0.0	0.0	0.0	0.0	0.0	-0.004480	...	-0.0	-0.0	-0.0	-0.0	0.000000	0.0	-0.0	-0.0	0.0	0.004842
2017-10-05	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.000068	...	-0.0	0.0	0.0	0.0	-0.001377	-0.0	0.0	0.0	0.0	0.002838
2017-10-06	-0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0	0.001364	...	-0.0	0.0	0.0	0.0	0.018385	-0.0	-0.0	0.0	-0.0	-0.003247
2017-10-09	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	-0.0	0.003473	...	-0.0	-0.0	0.0	0.0	0.002901	0.0	-0.0	-0.0	0.0	0.001292

5 rows × 101 columns

PERFORMANCE ANALYSIS

In [ ]:
```
get_performance_metrics(returns)
```





	Strategy
CAGR	15.33%
Sharpe Ratio	0.61
Maximum Drawdown	-52.94%

Out[ ]:

	Strategy
CAGR	15.33%
Sharpe Ratio	0.61
Maximum Drawdown	-52.94%