QF621 Quantitative Trading Strategies

Systematic Trading Strategies on Insider Transactions

Group 5:

Bryan Seah

Fernando Oktavianes

Jiang Jin

Miti Nopnirapath

Stephen Kusrianto

Wang Li

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Economic Intuition and Objective

Insiders have a clear informational advantage as compared to public about their company.

- **Timely information**: Insiders have access to information before it becomes public (e.g., earnings results prior to quarterly reporting).
- **Non-public information:** Insiders may have privileged knowledge that may never be publicly disclosed information (e.g., negative negotiations with key suppliers).

Given that insiders must self-report when buying or selling securities (and related derivatives) of their company. Our team can utilise and explore these self-reports to develop our trading strategies and gain an advantage from the information they provide.

Assumptions

- Derivative transactions had no signal (derivative data was excluded from the analysis)
- Constant signal magnitude between small to large cap companies
- Underlying stocks are continually listed between 2006 to 2023
- Long insiders have material non-public information that generate alphas

Data Sourcing

U.S. SECURITIES AND EXCHANGE COMMISSION

Insiders must report their market activities using Form 3, 4 and 5. These information are available on SEC EDGAR database. https://www.sec.gov/dera/data/form-345

- Form 3: When an entity becomes insider, they must fill this form to disclose their ownership of the company's securities within 10 days of transaction date.
- Form 4: Individual insiders must file within 2 business days following transactions.
- Form 5: Corporate or individual insiders who own more than 10% of the company's equity securities, are required to file no later than 45 days after the company's fiscal year ends.

Data Sourcing

- Download 2006 Q1 - 2023 Q1 zip files from SEC EDGAR database
- Write parser function to convert and link data values from 8 TSV files into the dataframe
- Scheduled automation possible for our strategy implementation by utilizing the daily filings instead of historical data

The dataset covers **22k+ unique securities** totalling 7.9M rows. Therefore we need to limit our universe for research purposes.

Data Preprocessing

- Filtering RSU (Restricted Stock Units) and other compensation filings
- Left-right pocket filings (internal movement insiders with multiple Identifier IDs)
- Multiple, bite-sized filings in one day by the same insiders
- Extract S&P & R1000 Constituents Information from Wikipedia (BeautifulSoup)
- Co-Location matching between Underlying Company HQs and Insiders

Backtester - YFCrossSectionalBT

```python
class YFCrossSectionalBT:
    def __init__(self, universe, start_date=None, end_date=None):
        try:
            input_type = universe[0]
        except KeyError:
            input_type = universe.iloc[0]

        if isinstance(input_type, str):
            self.yf_data = yf.download([s.replace('.', '-') for s in universe], start=start_date, end=end_date)
            self.adj_open = (self.yf_data['Adj Close']/self.yf_data['Close'])*self.yf_data['Open']
        elif isinstance(input_type, pd.Series):
            self.adj_open = universe.copy()

        # benchmark is sp500
        bm = yf.download('^GSPC', start=start_date, end=end_date).reindex(self.adj_open.index)
        self.bm = (bm['Adj Close']/bm['Close']) * bm['Open']
```

The backtester class is based on data readily available from yfinance.

On instantiation, it calculates adj open price based on the universe it was given, and also fetch data for sp500.

Backtester - YFCrossSectionalBT

```
def backtest(self, signal, delay, holding_period):
    # Forward return (-1 shift) which is further shifted for each delayed trades day
    shifted_returns = self.adj_open.pct_change().shift(-1-delay)
    # From earliest signal day to latest + holding period
    shifted_returns = shifted_returns.loc[signal.index.min(): signal.index.max() + pd.Timedelta(holding_period, 'd')]

    #weightings are rolling mean of signal/holding period.
    weightings = (signal.reindex(shifted_returns.index)/holding_period).rolling(holding_period, min_periods=1).sum()

    #returns are then calculated as sum of weights * shifted returns per period
    #cumulative products of this series + 1 results in the total return index
    #we also shift day back to convert the value back to base return, i.e. returns earned on
    #trade closing on the end of holding period.
    cumulative_returns = ((weightings*shifted_returns).sum(1)+1).cumprod().shift(1+delay).dropna()

    # summing the weightings by each rows results in deployed capital per period.
    deployed_capital = weightings.sum(1).reindex(cumulative_returns.index)

    # We use the benchmark multiplied by deployed capital for a fair comparison
    equal_exposure_bm = (deployed_capital*(self.bm.pct_change())+1).cumprod().fillna(1).reindex(cumulative_returns.index)

    # also, turnover of both buy and sell.
    turnover = weightings.diff().abs().sum(1).reindex(cumulative_returns.index)

    return BTResults(cumulative_returns, equal_exposure_bm, turnover, deployed_capital)
```

Backtester

$$\text{Portfolio Returns}_i = R_i = \sum_{s}^{\text{all stocks}} w_{i,s} r_{i+\Delta,s}$$

$$\text{Capital Deployed}_t = C_t = \sum_{s}^{\text{all stocks}} w_{t,s}$$

Where w is weights of the stock s, t is the time period, r is the forward return (price at time t / price at time t+1) at time t, and delta is the delay (in this case, we are trading next day open, so delay = 1).

$$\text{Benchmark Returns}_t = B_t = C_t b_t$$

$$\text{Turnover}_t = T_t = \sum_{s} |w_{t,s} - w_{t-1,s}|$$

B is the benchmark return at time t

Backtester - Results Class

```python
class BTResults:
    """Results container with calculation for each ratio
    Assumes a daily returns.
    """
    def __init__(self, total_return_series, benchmark, turnover, deployed_capital):
        self.total_return_series = total_return_series
        self.benchmark = benchmark
        self.turnover = turnover
        self.deployed_capital = deployed_capital
```

Given a total return series, a benchmark, turnover, and deployed capital, we can calculate a wide range of metrics.

Trading Strategies

- Strategy 1: Naïve Buy and Hold
- Strategy 2: Insider - Company Relationship
- Strategy 3: Insider Trade Size
- Strategy 4: Insider Holding Ratio
- Strategy 5: Signal Magnitude by Unique Insiders
- Strategy 6: Signal Magnitude by Co-Location
- Strategy 7: Winning Insiders Strategy

Trading Strategies

Method 1: Train-test split (13 years - 5 years)

Method 2: Annual rebalancing

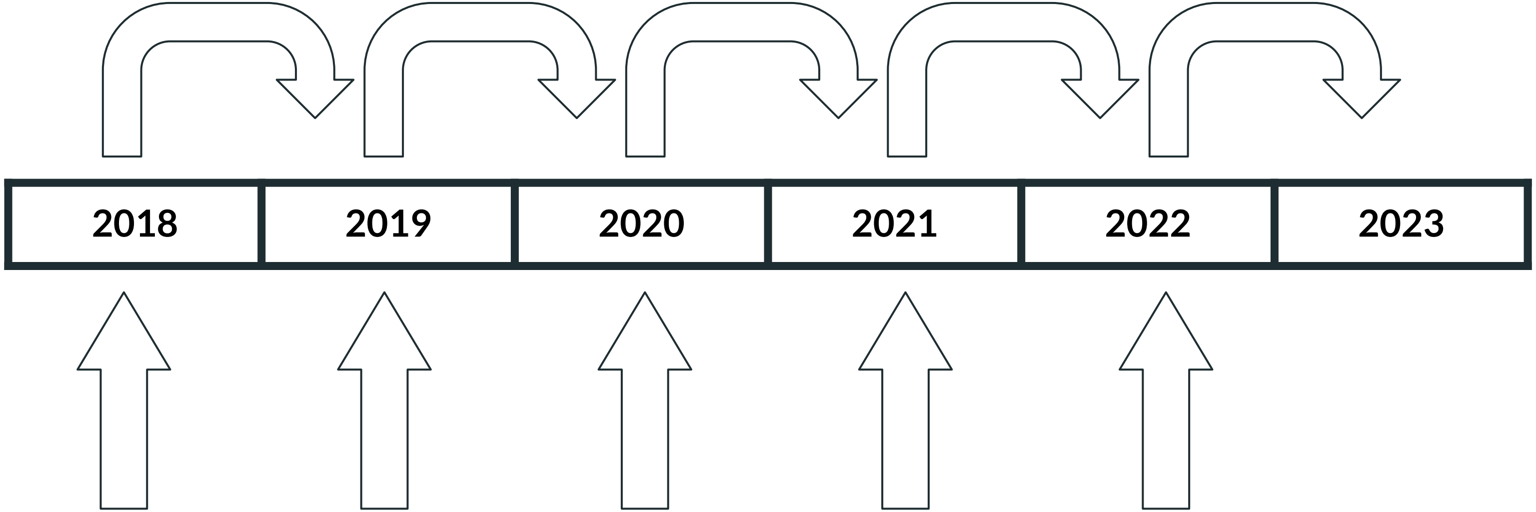
Illustration for method 1:

		0	1	2	3	4	5	6	7	8	9
FILLINGDATE	ISSUERTRADINGSYMBOL										
2010-01-04	ACN	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	ADP	0.015513	0.013129	0.012652	0.011222	0.015751	0.008600	0.015990	0.013129	0.007646	0.022903
	AKAM	0.277034	0.266507	0.266986	0.266986	0.262679	0.251675	0.245933	0.286124	0.273206	0.302392
	AME	0.353169	0.354578	0.358099	0.384507	0.392606	0.364084	0.367958	0.368310	0.353521	0.361972
	BSX	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000

```
{2006: 57,
 2007: 26,
 2008: 2,
 2009: 62,
 2010: 59,
 2011: 54,
 2012: 53,
 2013: 58,
 2014: 58,
 2015: 57,
 2016: 58,
 2017: 58,
 2018: 57}
```

```
(58, 4)
```

Illustration for method 2:



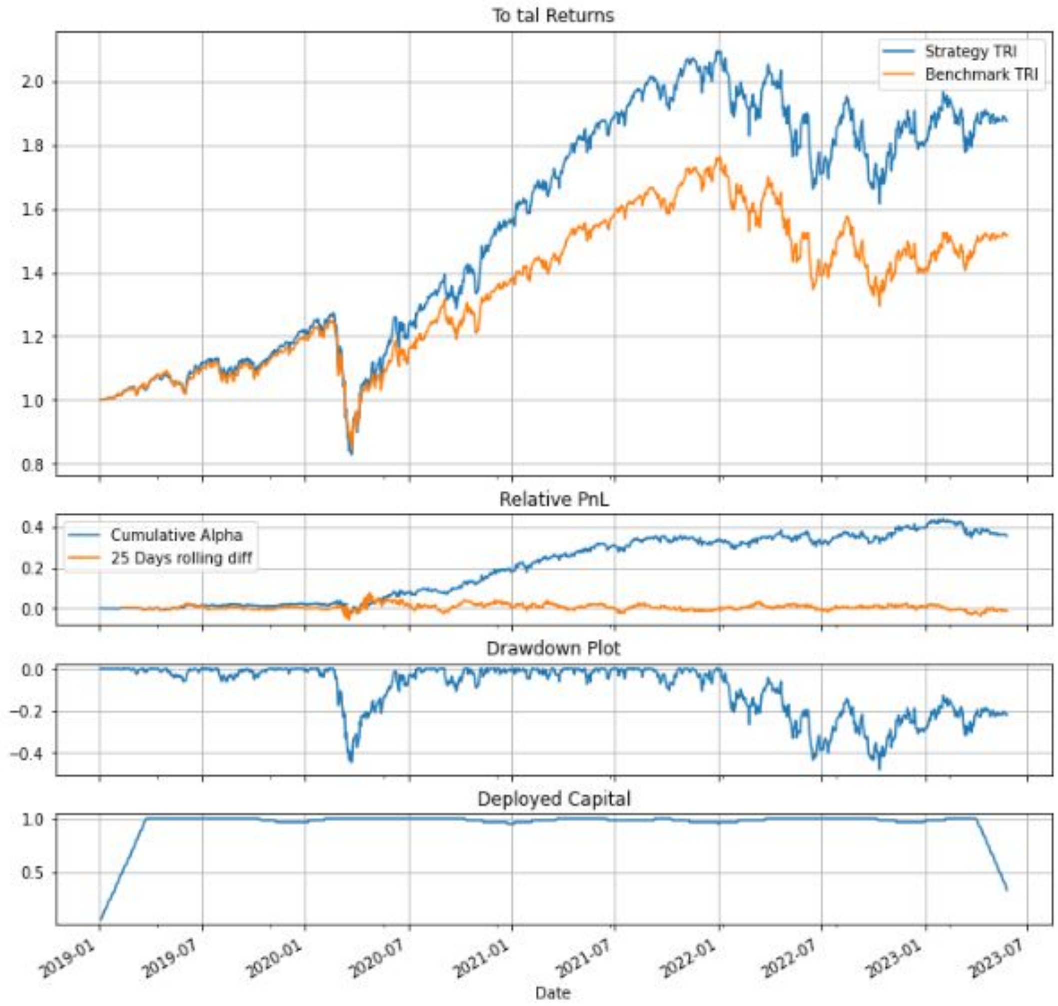
Identify optimal holding period and use it for next year trading

Strategy 1: Naïve Buy and Hold

Strategy 1

Method 1:

	Strategy	Benchmark
Expected Period Return	0.000658	0.000442
Ann. Sharpe	0.783612	0.619882
Ann. Sortino	1.084677	0.852706
Calmer	0.321475	0.213628
Max DD.	-0.478678	-0.466525
CAGR	0.153883	0.099663
Avg. Daily Turnover	0.029707	NaN



Strategy 1

Method 2:

	Strategy	Benchmark
Expected Period Return	0.000599	0.000268
Ann. Sharpe	1.183100	0.807555
Ann. Sortino	1.755187	1.191635
Calmer	1.673977	1.097161
Max DD.	-0.153240	-0.152535
CAGR	0.153411	0.070377
Avg. Daily Turnover	0.095350	NaN

		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.214187	1.865688	NaN	0.108712	1.363855	0.000426	-0.079709
	Strategy	1.271209	1.905506	0.026058	0.147663	1.357037	0.000574	-0.108813
2008	Benchmark	-0.084351	-0.112606	NaN	-0.023627	-0.178201	-0.000051	-0.132587
	Strategy	0.435473	0.614947	0.062949	0.056596	0.425787	0.000265	-0.132922
2009	Benchmark	-1.171006	-1.541353	NaN	-0.402451	-0.818897	-0.001756	-0.491455
	Strategy	-0.293968	-0.416214	0.813143	-0.212707	-0.483030	-0.000522	-0.440359
2010	Benchmark	1.541111	2.407248	NaN	0.320131	2.419918	0.001179	-0.132290
	Strategy	1.952072	3.147020	0.024124	0.477888	3.217221	0.001645	-0.148541
2011	Benchmark	0.955953	1.352962	NaN	0.137046	0.810161	0.000553	-0.169158
	Strategy	1.462071	2.157047	0.024833	0.256666	1.801933	0.000964	-0.142439
2012	Benchmark	0.197518	0.268541	NaN	0.019355	0.093939	0.000165	-0.206039
	Strategy	0.312654	0.429091	0.028923	0.044873	0.180391	0.000268	-0.248752
2013	Benchmark	0.909324	1.380951	NaN	0.103813	0.980825	0.000420	-0.105843
	Strategy	1.364854	2.095210	0.029048	0.176500	1.690164	0.000678	-0.104428
2014	Benchmark	1.827331	2.640639	NaN	0.180863	2.969360	0.000680	-0.060910
	Strategy	2.577422	3.858649	0.026127	0.290249	5.085460	0.001035	-0.057074
2015	Benchmark	1.141889	1.627925	NaN	0.111761	1.315968	0.000441	-0.084927
	Strategy	1.499784	2.220660	0.026199	0.185831	1.761550	0.000707	-0.105493
2016	Benchmark	-0.349441	-0.478703	NaN	-0.055281	-0.442429	-0.000187	-0.124948
	Strategy	-0.034237	-0.044865	0.026629	-0.018111	-0.126820	-0.000022	-0.142810
2017	Benchmark	1.781590	2.631680	NaN	0.164771	2.937388	0.000623	-0.056094
	Strategy	2.046504	3.107744	0.026082	0.229628	3.707466	0.000846	-0.061937
2018	Benchmark	2.217178	3.021048	NaN	0.154933	2.394617	0.000582	-0.064701
	Strategy	2.686646	3.779988	0.026228	0.226639	3.261974	0.000825	-0.069479
2019	Benchmark	-0.019863	-0.026796	NaN	-0.012095	-0.059627	-0.000011	-0.202836
	Strategy	0.445918	0.619823	0.026962	0.057382	0.291435	0.000266	-0.196895
2020	Benchmark	1.982059	2.866338	NaN	0.209310	2.789236	0.000778	-0.075042
	Strategy	1.972787	2.876215	0.035834	0.232259	3.554701	0.000856	-0.065339
2021	Benchmark	0.973149	1.361176	NaN	0.206974	0.762036	0.000845	-0.271607
	Strategy	1.322386	1.894867	0.026213	0.380476	1.355948	0.001432	-0.280597
2022	Benchmark	1.500807	2.184572	NaN	0.170643	2.096299	0.000650	-0.081402
	Strategy	1.469700	2.113596	0.044559	0.187085	1.925473	0.000712	-0.097163
2023	Benchmark	-0.888999	-1.191521	NaN	-0.198459	-0.782707	-0.000777	-0.253555
	Strategy	-0.378575	-0.521104	0.347036	-0.110935	-0.549085	-0.000356	-0.202036

Strategy 2: Insider-Company Relationship

Director

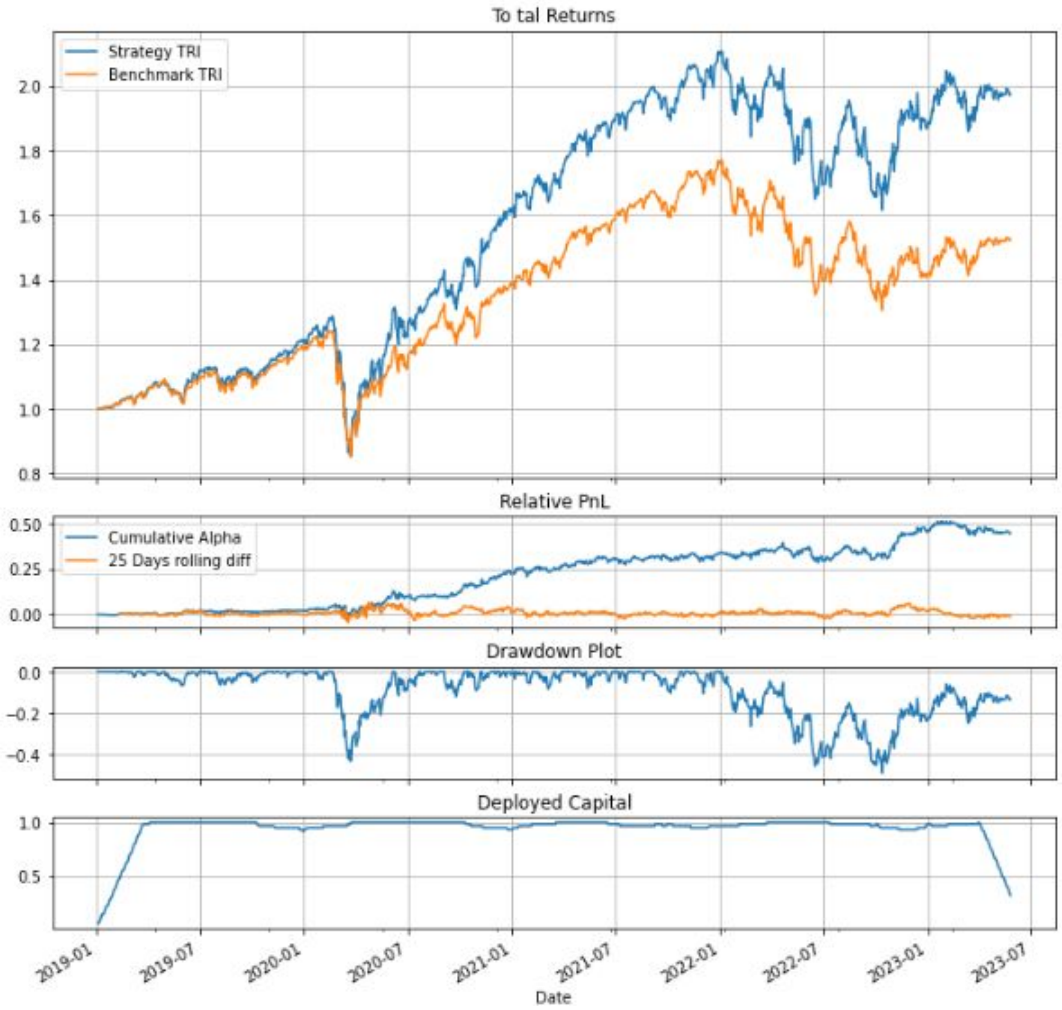
Ten Percent Owner

Strategy 2

Method 1:

Director

	Strategy	Benchmark
Expected Period Return	0.000708	0.000445
Ann. Sharpe	0.825495	0.631313
Ann. Sortino	1.155440	0.869892
Calmer	0.340882	0.217317
Max DD.	-0.491363	-0.464105
CAGR	0.167497	0.100858
Avg. Daily Turnover	0.032070	NaN



Strategy 2

Method 2:

Director

	Strategy	Benchmark
Expected Period Return	0.000616	0.000278
Ann. Sharpe	1.190304	0.806827
Ann. Sortino	1.763584	1.186555
Calmer	1.704210	1.071819
Max DD.	-0.159825	-0.151403
CAGR	0.159218	0.071552
Avg. Daily Turnover	0.050850	NaN

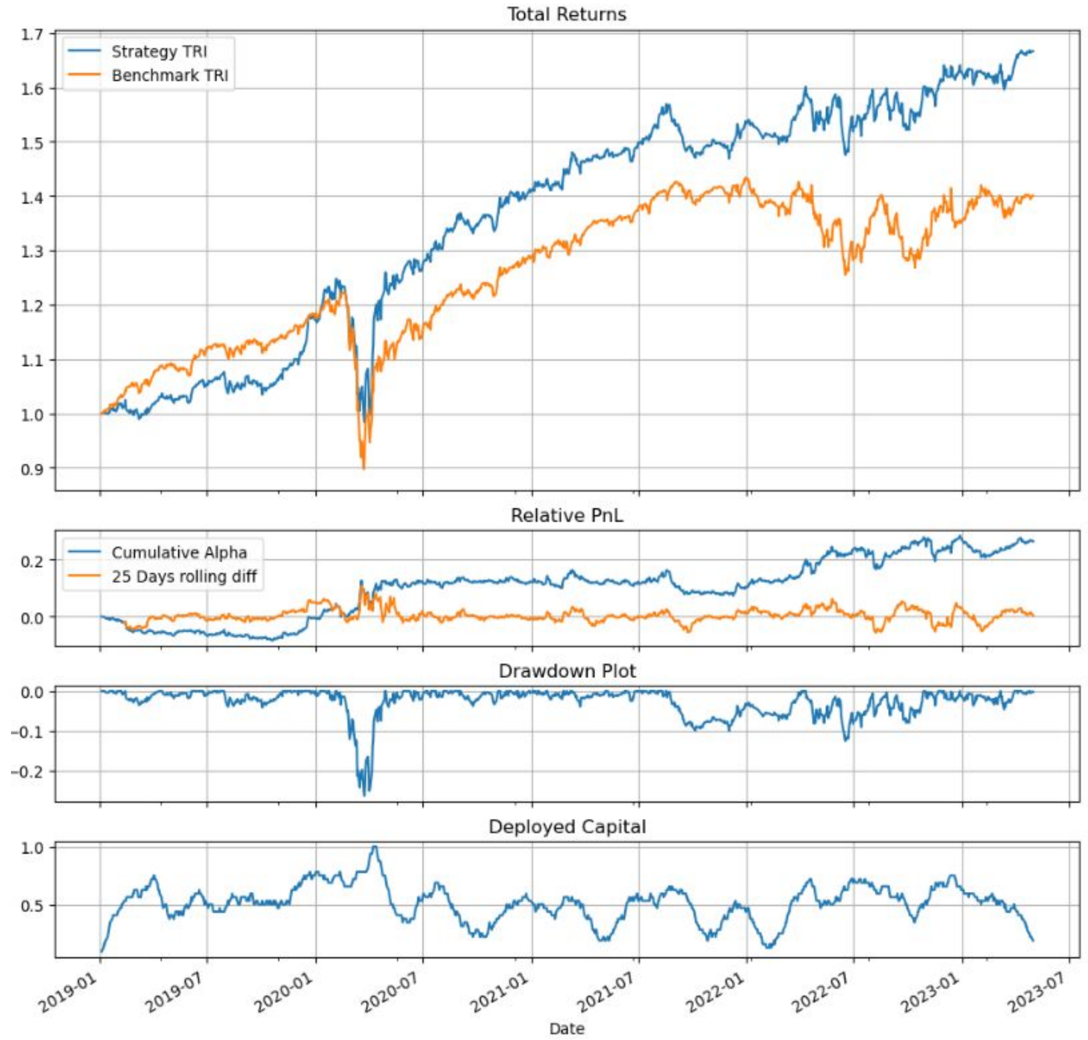
		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.225895	1.885527	NaN	0.108981	1.391669	0.000427	-0.078310
	Strategy	1.430127	2.155102	0.028307	0.166386	1.638267	0.000637	-0.101562
2008	Benchmark	-0.079602	-0.106505	NaN	-0.022588	-0.172497	-0.000047	-0.130949
	Strategy	0.579689	0.834824	0.074237	0.081628	0.524791	0.000359	-0.155544
2009	Benchmark	-1.078765	-1.454513	NaN	-0.360158	-0.736570	-0.001525	-0.488967
	Strategy	-0.451134	-0.638803	0.025785	-0.234747	-0.477410	-0.000733	-0.491709
2010	Benchmark	1.539833	2.407664	NaN	0.316780	2.394583	0.001168	-0.132290
	Strategy	1.948287	3.167328	0.024600	0.510733	3.369222	0.001743	-0.151588
2011	Benchmark	0.955953	1.352962	NaN	0.137046	0.810161	0.000553	-0.169158
	Strategy	1.342482	1.941484	0.025388	0.235959	1.592865	0.000899	-0.148135
2012	Benchmark	0.198018	0.269241	NaN	0.019465	0.094861	0.000165	-0.205197
	Strategy	0.318685	0.438016	0.030253	0.046771	0.181517	0.000280	-0.257665
2013	Benchmark	0.898533	1.363757	NaN	0.102317	0.968549	0.000415	-0.105639
	Strategy	1.312273	2.005300	0.029449	0.170418	1.776658	0.000658	-0.095920
2014	Benchmark	1.822680	2.632319	NaN	0.179938	2.956414	0.000677	-0.060864
	Strategy	2.518704	3.767736	0.028050	0.295598	5.208539	0.001054	-0.056753
2015	Benchmark	1.130873	1.611310	NaN	0.110377	1.301528	0.000436	-0.084806
	Strategy	1.437894	2.100266	0.027552	0.186306	1.785335	0.000711	-0.104353
2016	Benchmark	-0.344007	-0.471322	NaN	-0.054239	-0.436357	-0.000183	-0.124299
	Strategy	0.018353	0.024054	0.028078	-0.010942	-0.070871	0.000012	-0.154396
2017	Benchmark	1.774494	2.620641	NaN	0.163958	2.922902	0.000620	-0.056094
	Strategy	1.924714	2.883564	0.026902	0.212694	3.063863	0.000790	-0.069420
2018	Benchmark	2.232393	3.044323	NaN	0.155112	2.441829	0.000582	-0.063523
	Strategy	2.991475	4.255175	0.028880	0.265931	3.905339	0.000952	-0.068094
2019	Benchmark	-0.041581	-0.056040	NaN	-0.014869	-0.074289	-0.000023	-0.200152
	Strategy	0.483356	0.672055	0.028089	0.067486	0.332065	0.000311	-0.203230
2020	Benchmark	1.891968	2.729035	NaN	0.194276	2.614103	0.000727	-0.074318
	Strategy	1.872928	2.749512	0.029427	0.226834	3.385707	0.000839	-0.066998
2021	Benchmark	0.968614	1.354455	NaN	0.205484	0.756550	0.000839	-0.271607
	Strategy	1.289318	1.858466	0.027588	0.382525	1.368972	0.001449	-0.279425
2022	Benchmark	1.426679	2.073497	NaN	0.156488	1.751117	0.000601	-0.089365
	Strategy	1.371920	1.981590	0.033522	0.171807	1.710965	0.000661	-0.100415
2023	Benchmark	-0.805915	-1.084915	NaN	-0.181987	-0.763629	-0.000698	-0.238319
	Strategy	-0.153895	-0.214737	0.368339	-0.068681	-0.324246	-0.000151	-0.211818

Strategy 2

Method 1:

Ten Percent Owner

	Strategy	Benchmark
Expected Period Return	0.000500	0.000343
Ann. Sharpe	1.025215	0.671416
Ann. Sortino	1.452726	0.916046
Calmer	0.475743	0.248963
Max DD.	-0.263866	-0.325988
CAGR	0.125532	0.081159
Avg. Daily Turnover	0.030063	NaN



Strategy 2

Method 2:

Ten Percent Owner

	Strategy	Benchmark
Expected Period Return	0.000382	0.000287
Ann. Sharpe	1.210151	1.112438
Ann. Sortino	1.815786	1.680399
Calmer	1.712394	1.843496
Max DD.	-0.124283	-0.107334
CAGR	0.092071	0.074188
Avg. Daily Turnover	0.069700	NaN

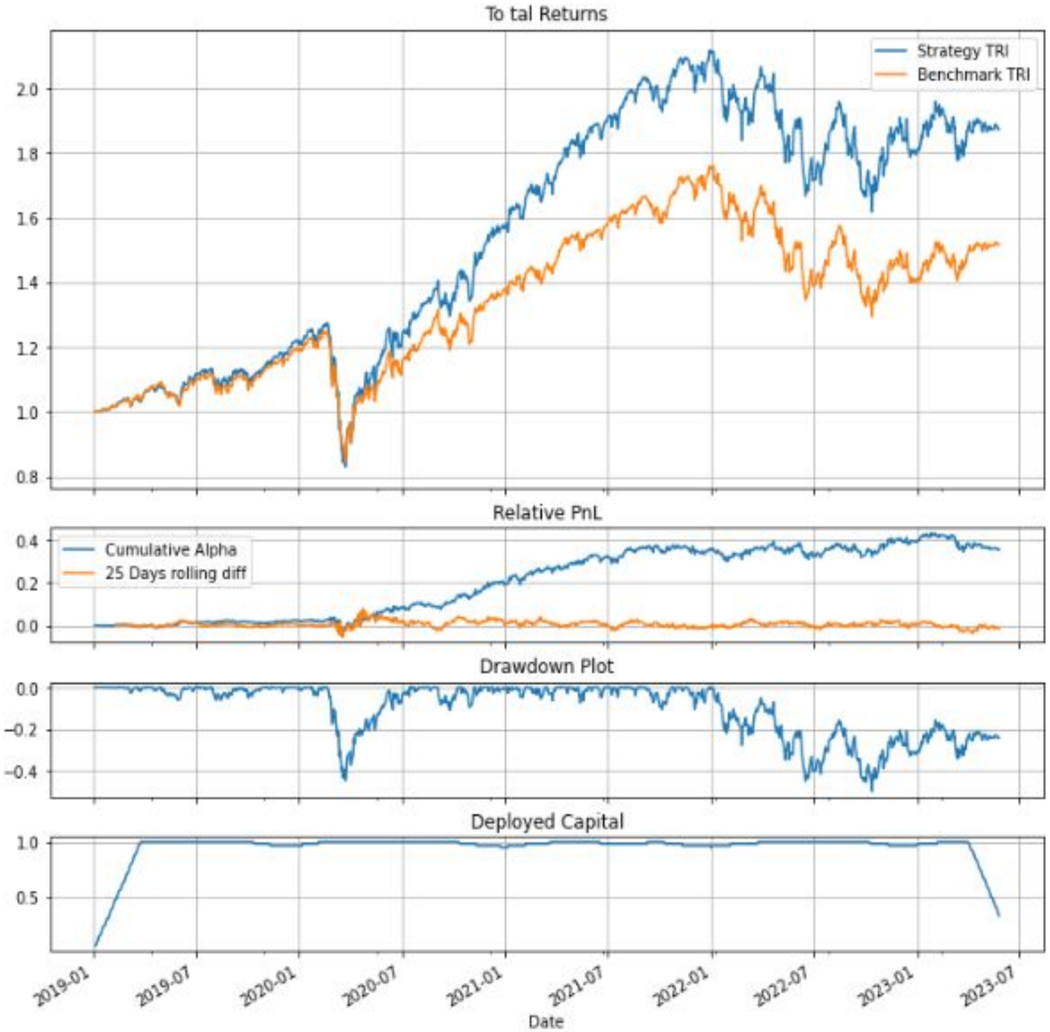
		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.192660	1.759359	NaN	0.091674	1.111920	0.000360	-0.082446
	Strategy	0.894529	1.331328	0.018199	0.071596	0.813374	0.000288	-0.088023
2008	Benchmark	0.702056	1.023263	NaN	0.080150	0.929045	0.000341	-0.086272
	Strategy	0.425448	0.639107	0.232158	0.045221	0.512630	0.000218	-0.088214
2009	Benchmark	-1.002121	-1.301801	NaN	-0.308248	-0.623772	-0.001265	-0.494168
	Strategy	-0.495374	-0.639620	0.531333	-0.439580	-0.591426	-0.001315	-0.743255
2010	Benchmark	1.668201	2.698383	NaN	0.282382	2.142762	0.001038	-0.131784
	Strategy	1.373124	2.213710	0.018152	0.309399	1.284736	0.001164	-0.240827
2011	Benchmark	1.685016	2.510953	NaN	0.171822	2.070670	0.000650	-0.082979
	Strategy	1.415191	2.096260	0.017028	0.162696	1.797258	0.000625	-0.090525
2012	Benchmark	0.549879	0.762354	NaN	0.059811	0.491529	0.000257	-0.121684
	Strategy	0.866870	1.235441	0.018379	0.094574	1.176023	0.000386	-0.080418
2013	Benchmark	1.356760	2.151697	NaN	0.103061	1.693709	0.000402	-0.060849
	Strategy	2.048096	3.265224	0.016885	0.156707	2.228374	0.000589	-0.070324
2014	Benchmark	2.547624	3.824399	NaN	0.132212	4.849326	0.000499	-0.027264
	Strategy	1.980699	2.894405	0.015335	0.126036	3.720572	0.000478	-0.033875
2015	Benchmark	1.211845	1.844324	NaN	0.104066	1.202575	0.000408	-0.086536
	Strategy	1.295611	1.903013	0.019153	0.120571	1.657014	0.000469	-0.072764
2016	Benchmark	-0.074886	-0.096945	NaN	-0.008935	-0.136716	-0.000024	-0.065356
	Strategy	0.301509	0.432100	0.029851	0.026323	0.378123	0.000120	-0.069616
2017	Benchmark	1.662659	2.464250	NaN	0.094410	3.042510	0.000366	-0.031030
	Strategy	0.992173	1.436372	0.023614	0.075815	1.609080	0.000302	-0.047117
2018	Benchmark	3.341648	5.035652	NaN	0.152851	7.518384	0.000570	-0.020330
	Strategy	3.247403	4.737858	0.034084	0.210963	6.033138	0.000771	-0.034967
2019	Benchmark	-0.045796	-0.066276	NaN	-0.010779	-0.079626	-0.000020	-0.135368
	Strategy	1.096620	1.692139	0.104510	0.121461	1.019572	0.000483	-0.119130
2020	Benchmark	2.383905	3.520207	NaN	0.149140	5.650617	0.000562	-0.026394
	Strategy	2.253094	3.434171	0.021537	0.167591	4.318615	0.000628	-0.038807
2021	Benchmark	0.778314	1.080795	NaN	0.130681	0.603992	0.000552	-0.216362
	Strategy	0.955175	1.410398	0.014330	0.159727	1.079628	0.000648	-0.147947
2022	Benchmark	0.981072	1.394227	NaN	0.050209	0.998533	0.000200	-0.050282
	Strategy	1.046013	1.550079	0.012004	0.053929	0.840396	0.000215	-0.064171
2023	Benchmark	-0.027397	-0.038057	NaN	-0.013307	-0.126033	-0.000015	-0.105581
	Strategy	0.876380	1.236377	0.058341	0.102180	1.233587	0.000417	-0.082832

Strategy 3: Insider Trade Size

Strategy 3

Method 1:

	Strategy	Benchmark
Expected Period Return	0.000658	0.000442
Ann. Sharpe	0.781236	0.619882
Ann. Sortino	1.079461	0.852706
Calmer	0.308387	0.213628
Max DD.	-0.498469	-0.466525
CAGR	0.153721	0.099663
Avg. Daily Turnover	0.029785	NaN



Strategy 3

Method 2:

	Strategy	Benchmark
Expected Period Return	0.000619	0.000301
Ann. Sharpe	1.257068	0.872857
Ann. Sortino	1.876099	1.294874
Calmer	1.841342	1.284126
Max DD.	-0.152329	-0.152228
CAGR	0.163609	0.079887
Avg. Daily Turnover	0.155367	NaN

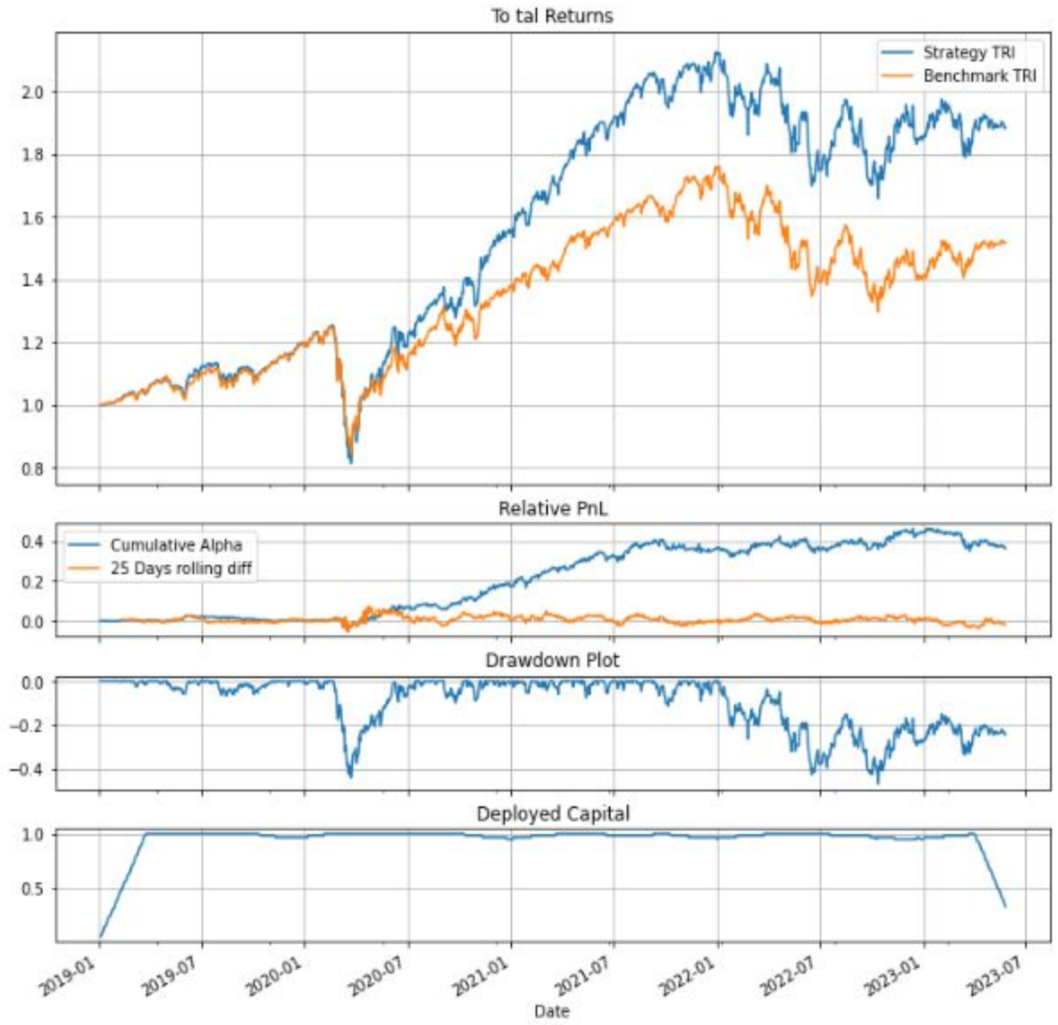
		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.214187	1.865688	NaN	0.108712	1.363855	0.000426	-0.079709
	Strategy	1.204921	1.794934	0.026709	0.139841	1.229937	0.000547	-0.113698
2008	Benchmark	-0.192750	-0.255830	NaN	-0.039451	-0.270000	-0.000115	-0.146114
	Strategy	0.315934	0.444968	0.042511	0.037996	0.256563	0.000198	-0.148098
2009	Benchmark	-1.171006	-1.541353	NaN	-0.402451	-0.818897	-0.001756	-0.491455
	Strategy	-0.534444	-0.748688	0.821080	-0.283609	-0.653633	-0.000924	-0.433897
2010	Benchmark	1.541111	2.407248	NaN	0.320131	2.419918	0.001179	-0.132290
	Strategy	1.858196	2.962285	0.024501	0.416680	2.872770	0.001465	-0.145045
2011	Benchmark	0.969026	1.372094	NaN	0.139614	0.823424	0.000562	-0.169553
	Strategy	1.520512	2.249226	0.026807	0.266323	1.928314	0.000994	-0.138112
2012	Benchmark	0.186351	0.253243	NaN	0.016945	0.082322	0.000156	-0.205844
	Strategy	0.306436	0.420278	0.030607	0.043225	0.175192	0.000260	-0.246729
2013	Benchmark	0.909324	1.380951	NaN	0.103813	0.980825	0.000420	-0.105843
	Strategy	1.352697	2.082488	0.029473	0.172656	1.691873	0.000665	-0.102050
2014	Benchmark	1.827331	2.640639	NaN	0.180863	2.969360	0.000680	-0.060910
	Strategy	2.550250	3.811941	0.026346	0.285841	5.009052	0.001022	-0.057065
2015	Benchmark	1.141889	1.627925	NaN	0.111761	1.315968	0.000441	-0.084927
	Strategy	1.496116	2.214585	0.026330	0.185890	1.764933	0.000707	-0.105324
2016	Benchmark	0.006157	0.008690	NaN	-0.015870	-0.125701	0.000003	-0.126249
	Strategy	0.420531	0.565826	0.248889	0.057376	0.450379	0.000277	-0.127396
2017	Benchmark	1.781590	2.631680	NaN	0.164771	2.937388	0.000623	-0.056094
	Strategy	1.960388	2.964625	0.026119	0.218438	3.447699	0.000809	-0.063358
2018	Benchmark	2.217178	3.021048	NaN	0.154933	2.394617	0.000582	-0.064701
	Strategy	2.682857	3.766062	0.026398	0.229548	3.286068	0.000835	-0.069855
2019	Benchmark	-0.019863	-0.026796	NaN	-0.012095	-0.059627	-0.000011	-0.202836
	Strategy	0.433895	0.602444	0.027023	0.056068	0.282230	0.000263	-0.198661
2020	Benchmark	1.960177	2.833110	NaN	0.206147	2.753801	0.000768	-0.074859
	Strategy	1.911783	2.780512	0.032621	0.224495	3.509415	0.000831	-0.063969
2021	Benchmark	0.973149	1.361176	NaN	0.206974	0.762036	0.000845	-0.271607
	Strategy	1.342217	1.919798	0.026271	0.386143	1.378320	0.001447	-0.280155
2022	Benchmark	2.383712	3.624859	NaN	0.311744	5.083564	0.001093	-0.061324
	Strategy	2.991732	4.668796	0.851912	0.470137	5.280512	0.001543	-0.089032
2023	Benchmark	-0.888999	-1.191521	NaN	-0.198459	-0.782707	-0.000777	-0.253555
	Strategy	-0.443861	-0.606398	0.347642	-0.125698	-0.606807	-0.000423	-0.207146

Strategy 4: Insider Percentage Holding

Strategy 4

Method 1:

	Strategy	Benchmark
Expected Period Return	0.000659	0.000441
Ann. Sharpe	0.796574	0.621219
Ann. Sortino	1.106218	0.853995
Calmer	0.331759	0.214535
Max DD.	-0.467005	-0.464302
CAGR	0.154933	0.099609
Avg. Daily Turnover	0.031153	NaN



Strategy 4

Method 2:

	Strategy	Benchmark
Expected Period Return	0.000635	0.000301
Ann. Sharpe	1.258607	0.867504
Ann. Sortino	1.879655	1.283189
Calmer	1.869284	1.266626
Max DD.	-0.150968	-0.151370
CAGR	0.166284	0.078883
Avg. Daily Turnover	0.226256	NaN

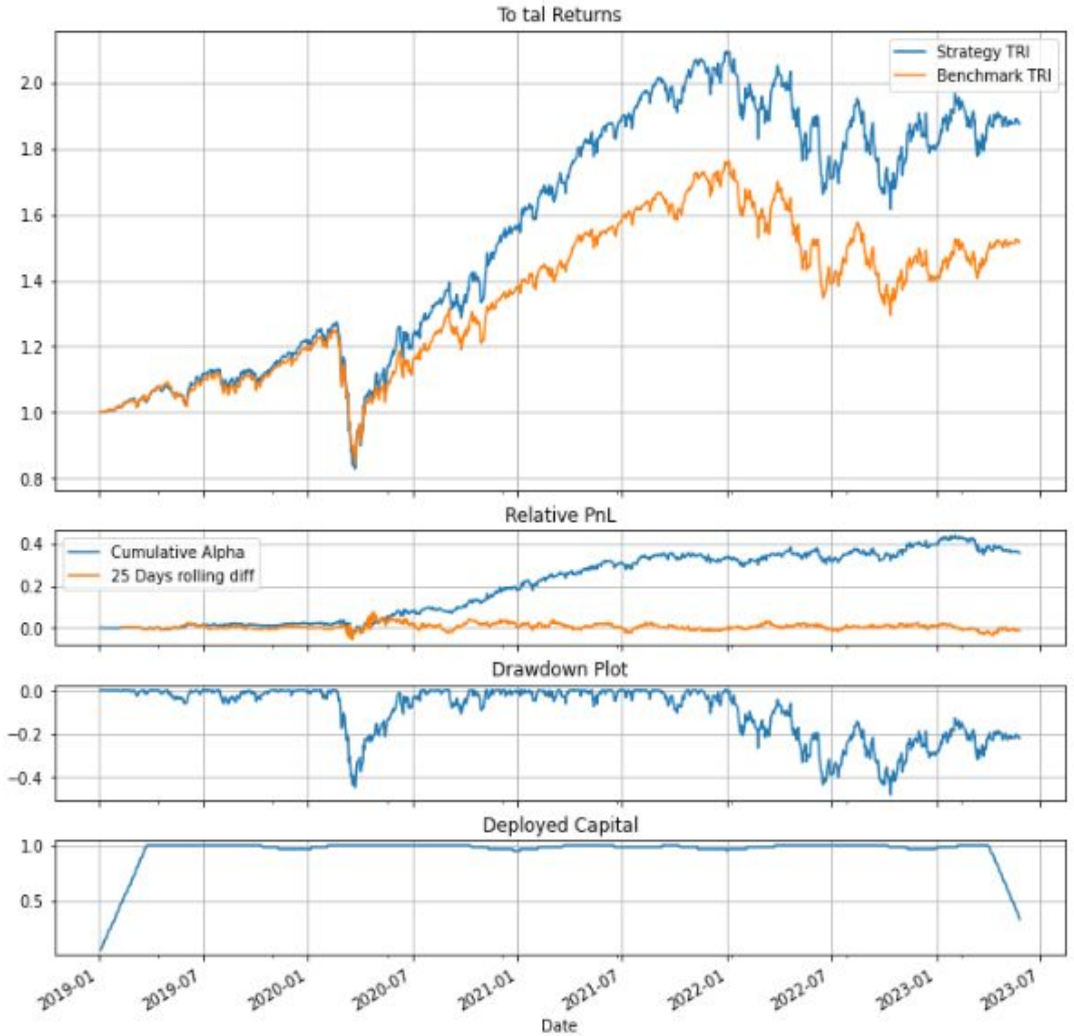
		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.214187	1.865688	NaN	0.108712	1.363855	0.000426	-0.079709
	Strategy	1.235278	1.832932	0.027600	0.137866	1.319813	0.000538	-0.104459
2008	Benchmark	-0.182965	-0.242805	NaN	-0.038029	-0.258720	-0.000110	-0.146990
	Strategy	0.307222	0.433148	0.042521	0.036423	0.219724	0.000189	-0.165769
2009	Benchmark	-1.043992	-1.413513	NaN	-0.384015	-0.816454	-0.001617	-0.470345
	Strategy	-0.385801	-0.549107	1.748481	-0.258970	-0.661283	-0.000703	-0.391618
2010	Benchmark	1.541111	2.407248	NaN	0.320131	2.419918	0.001179	-0.132290
	Strategy	1.968612	3.200328	0.025130	0.471956	3.325658	0.001624	-0.141914
2011	Benchmark	0.955953	1.352962	NaN	0.137046	0.810161	0.000553	-0.169158
	Strategy	1.579094	2.373470	0.026573	0.278177	2.001104	0.001031	-0.139012
2012	Benchmark	0.204909	0.278734	NaN	0.020951	0.101645	0.000170	-0.206122
	Strategy	0.300579	0.412220	0.027352	0.041764	0.165076	0.000253	-0.252999
2013	Benchmark	0.951958	1.447414	NaN	0.110007	1.036459	0.000443	-0.106138
	Strategy	1.331409	2.044312	0.032296	0.173423	1.614978	0.000668	-0.107384
2014	Benchmark	1.827331	2.640639	NaN	0.180863	2.969360	0.000680	-0.060910
	Strategy	2.519107	3.771030	0.026842	0.281383	4.765166	0.001008	-0.059050
2015	Benchmark	1.141889	1.627925	NaN	0.111761	1.315968	0.000441	-0.084927
	Strategy	1.419267	2.085593	0.027112	0.171710	1.563413	0.000658	-0.109830
2016	Benchmark	-0.079364	-0.111587	NaN	-0.026272	-0.208050	-0.000045	-0.126277
	Strategy	0.505142	0.678974	0.203668	0.070078	0.557618	0.000322	-0.125674
2017	Benchmark	1.781590	2.631680	NaN	0.164771	2.937388	0.000623	-0.056094
	Strategy	2.006498	3.079264	0.027372	0.219914	3.519047	0.000813	-0.062492
2018	Benchmark	2.217178	3.021048	NaN	0.154933	2.394617	0.000582	-0.064701
	Strategy	2.650456	3.731233	0.027261	0.221961	3.252996	0.000810	-0.068233
2019	Benchmark	-0.019863	-0.026796	NaN	-0.012095	-0.059627	-0.000011	-0.202836
	Strategy	0.410142	0.570011	0.027863	0.052387	0.267234	0.000249	-0.196035
2020	Benchmark	1.930455	2.788682	NaN	0.201052	2.695167	0.000750	-0.074597
	Strategy	1.785231	2.585419	0.030850	0.202806	2.922694	0.000759	-0.069390
2021	Benchmark	0.973149	1.361176	NaN	0.206974	0.762036	0.000845	-0.271607
	Strategy	1.373375	1.994960	0.027429	0.397571	1.411765	0.001480	-0.281612
2022	Benchmark	2.300012	3.481627	NaN	0.298323	4.893562	0.001052	-0.060962
	Strategy	2.835574	4.319151	0.600242	0.453818	6.111584	0.001519	-0.074255
2023	Benchmark	-0.965971	-1.295916	NaN	-0.214096	-0.824650	-0.000849	-0.259620
	Strategy	-0.444864	-0.608794	0.917755	-0.125434	-0.578767	-0.000420	-0.216725

Strategy 5: Signal Magnitude by Unique Insiders

Strategy 5

Method 1:

	Strategy	Benchmark
Expected Period Return	0.000658	0.000442
Ann. Sharpe	0.783612	0.619882
Ann. Sortino	1.084677	0.852706
Calmer	0.321475	0.213628
Max DD.	-0.478678	-0.466525
CAGR	0.153883	0.099663
Avg. Daily Turnover	0.029707	NaN



Strategy 5

Method 2:

	Strategy	Benchmark
Expected Period Return	0.000599	0.000268
Ann. Sharpe	1.183100	0.807555
Ann. Sortino	1.755187	1.191635
Calmer	1.673977	1.097161
Max DD.	-0.153240	-0.152535
CAGR	0.153411	0.070377
Avg. Daily Turnover	0.095350	NaN

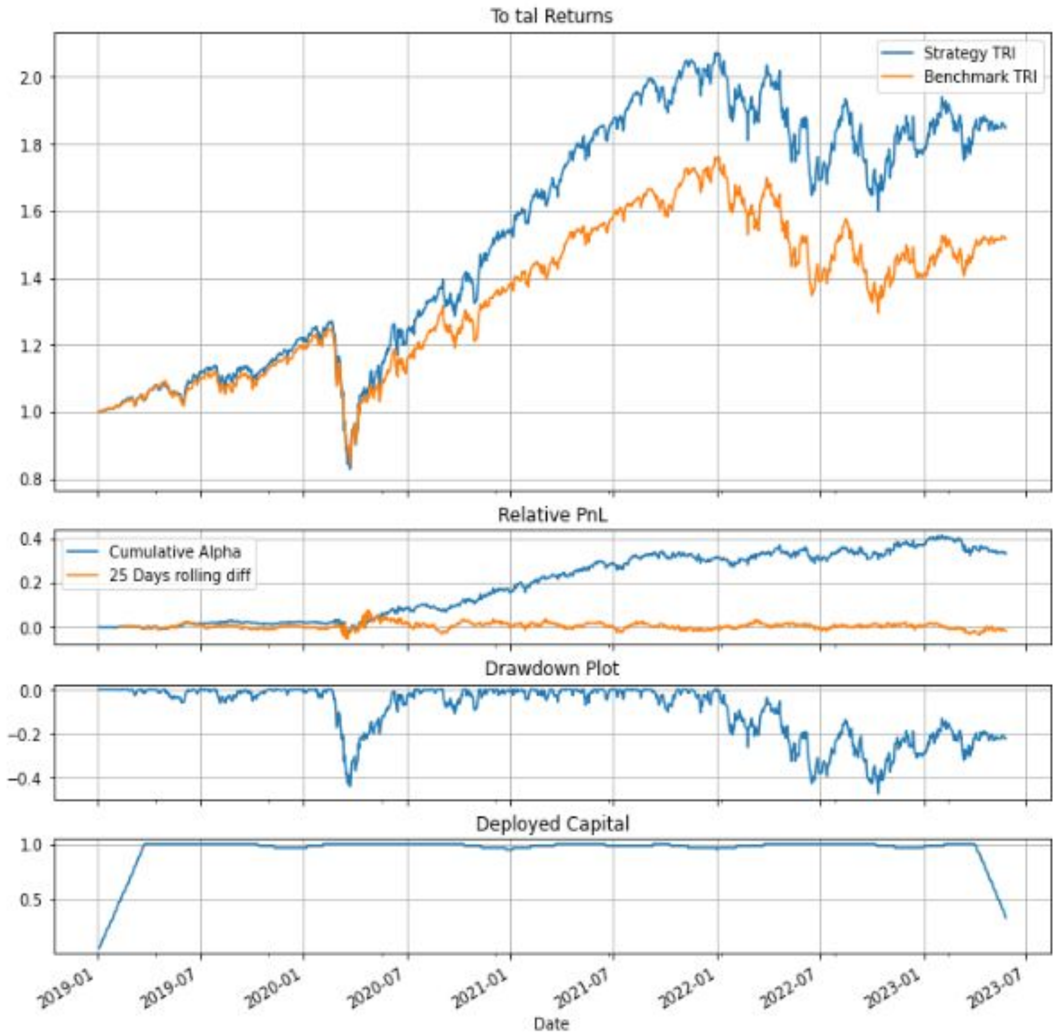
		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.214187	1.865688	NaN	0.108712	1.363855	0.000426	-0.079709
	Strategy	1.271209	1.905506	0.026058	0.147663	1.357037	0.000574	-0.108813
2008	Benchmark	-0.084351	-0.112606	NaN	-0.023627	-0.178201	-0.000051	-0.132587
	Strategy	0.435473	0.614947	0.062949	0.056596	0.425787	0.000265	-0.132922
2009	Benchmark	-1.171006	-1.541353	NaN	-0.402451	-0.818897	-0.001756	-0.491455
	Strategy	-0.293968	-0.416214	0.813143	-0.212707	-0.483030	-0.000522	-0.440359
2010	Benchmark	1.541111	2.407248	NaN	0.320131	2.419918	0.001179	-0.132290
	Strategy	1.952072	3.147020	0.024124	0.477888	3.217221	0.001645	-0.148541
2011	Benchmark	0.955953	1.352962	NaN	0.137046	0.810161	0.000553	-0.169158
	Strategy	1.462071	2.157047	0.024833	0.256666	1.801933	0.000964	-0.142439
2012	Benchmark	0.197518	0.268541	NaN	0.019355	0.093939	0.000165	-0.206039
	Strategy	0.312654	0.429091	0.028923	0.044873	0.180391	0.000268	-0.248752
2013	Benchmark	0.909324	1.380951	NaN	0.103813	0.980825	0.000420	-0.105843
	Strategy	1.364854	2.095210	0.029048	0.176500	1.690164	0.000678	-0.104428
2014	Benchmark	1.827331	2.640639	NaN	0.180863	2.969360	0.000680	-0.060910
	Strategy	2.577422	3.858649	0.026127	0.290249	5.085460	0.001035	-0.057074
2015	Benchmark	1.141889	1.627925	NaN	0.111761	1.315968	0.000441	-0.084927
	Strategy	1.499784	2.220660	0.026199	0.185831	1.761550	0.000707	-0.105493
2016	Benchmark	-0.349441	-0.478703	NaN	-0.055281	-0.442429	-0.000187	-0.124948
	Strategy	-0.034237	-0.044865	0.026629	-0.018111	-0.126820	-0.000022	-0.142810
2017	Benchmark	1.781590	2.631680	NaN	0.164771	2.937388	0.000623	-0.056094
	Strategy	2.046504	3.107744	0.026082	0.229628	3.707466	0.000846	-0.061937
2018	Benchmark	2.217178	3.021048	NaN	0.154933	2.394617	0.000582	-0.064701
	Strategy	2.686646	3.779988	0.026228	0.226639	3.261974	0.000825	-0.069479
2019	Benchmark	-0.019863	-0.026796	NaN	-0.012095	-0.059627	-0.000011	-0.202836
	Strategy	0.445918	0.619823	0.026962	0.057382	0.291435	0.000266	-0.196895
2020	Benchmark	1.982059	2.866338	NaN	0.209310	2.789236	0.000778	-0.075042
	Strategy	1.972787	2.876215	0.035834	0.232259	3.554701	0.000856	-0.065339
2021	Benchmark	0.973149	1.361176	NaN	0.206974	0.762036	0.000845	-0.271607
	Strategy	1.322386	1.894867	0.026213	0.380476	1.355948	0.001432	-0.280597
2022	Benchmark	1.500807	2.184572	NaN	0.170643	2.096299	0.000650	-0.081402
	Strategy	1.469700	2.113596	0.044559	0.187085	1.925473	0.000712	-0.097163
2023	Benchmark	-0.888999	-1.191521	NaN	-0.198459	-0.782707	-0.000777	-0.253555
	Strategy	-0.378575	-0.521104	0.347036	-0.110935	-0.549085	-0.000356	-0.202036

Strategy 6: Signal Magnitude by Co-Location

Strategy 6

Method 1:

	Strategy	Benchmark
Expected Period Return	0.000644	0.000442
Ann. Sharpe	0.771142	0.619882
Ann. Sortino	1.066811	0.852706
Calmer	0.317223	0.213628
Max DD.	-0.473185	-0.466525
CAGR	0.150105	0.099663
Avg. Daily Turnover	0.029733	NaN



Strategy 6

Method 2:

	Strategy	Benchmark
Expected Period Return	0.000632	0.000280
Ann. Sharpe	1.251305	0.831870
Ann. Sortino	1.867011	1.231129
Calmer	1.879270	1.209802
Max DD.	-0.151519	-0.151155
CAGR	0.163493	0.074056
Avg. Daily Turnover	0.101821	NaN

		Ann. Sharpe	Ann. Sortino	Avg. Daily Turnover	CAGR	Calmer	Expected Period Return	Max DD.
2007	Benchmark	1.214187	1.865688	NaN	0.108712	1.363855	0.000426	-0.079709
	Strategy	1.253060	1.890890	0.025881	0.146559	1.332864	0.000570	-0.109958
2008	Benchmark	-0.096422	-0.128759	NaN	-0.025366	-0.194287	-0.000058	-0.130557
	Strategy	0.473907	0.671724	0.068354	0.062367	0.497092	0.000286	-0.125463
2009	Benchmark	-1.171006	-1.541353	NaN	-0.402451	-0.818897	-0.001756	-0.491455
	Strategy	-0.253111	-0.357650	0.814054	-0.196255	-0.425530	-0.000444	-0.461202
2010	Benchmark	1.541111	2.407248	NaN	0.320131	2.419918	0.001179	-0.132290
	Strategy	1.941813	3.124744	0.024072	0.475256	3.390020	0.001638	-0.140193
2011	Benchmark	0.955953	1.352962	NaN	0.137046	0.810161	0.000553	-0.169158
	Strategy	1.504575	2.230756	0.024681	0.267989	1.949466	0.001001	-0.137468
2012	Benchmark	0.197518	0.268541	NaN	0.019355	0.093939	0.000165	-0.206039
	Strategy	0.260895	0.357438	0.028912	0.033199	0.131691	0.000222	-0.252097
2013	Benchmark	0.913439	1.386242	NaN	0.104010	0.985459	0.000421	-0.105544
	Strategy	1.381130	2.124335	0.027474	0.174503	1.745909	0.000670	-0.099950
2014	Benchmark	1.827331	2.640639	NaN	0.180863	2.969360	0.000680	-0.060910
	Strategy	2.572517	3.851068	0.026185	0.288036	5.015941	0.001028	-0.057424
2015	Benchmark	1.141889	1.627925	NaN	0.111761	1.315968	0.000441	-0.084927
	Strategy	1.501829	2.228519	0.026182	0.186473	1.826409	0.000709	-0.102098
2016	Benchmark	-0.348806	-0.477815	NaN	-0.055192	-0.441833	-0.000187	-0.124916
	Strategy	-0.040717	-0.053338	0.026021	-0.019005	-0.131135	-0.000026	-0.144926
2017	Benchmark	1.781590	2.631680	NaN	0.164771	2.937388	0.000623	-0.056094
	Strategy	2.081590	3.169338	0.026087	0.230062	3.802088	0.000846	-0.060509
2018	Benchmark	2.217178	3.021048	NaN	0.154933	2.394617	0.000582	-0.064701
	Strategy	2.672586	3.775402	0.026306	0.224827	3.211474	0.000819	-0.070007
2019	Benchmark	-0.073034	-0.098414	NaN	-0.020106	-0.098856	-0.000042	-0.203386
	Strategy	0.459424	0.638898	0.032276	0.060865	0.309676	0.000282	-0.196545
2020	Benchmark	1.982059	2.866338	NaN	0.209310	2.789236	0.000778	-0.075042
	Strategy	1.985377	2.888472	0.035899	0.232404	3.519935	0.000856	-0.066025
2021	Benchmark	0.973149	1.361176	NaN	0.206974	0.762036	0.000845	-0.271607
	Strategy	1.288668	1.844683	0.026277	0.362819	1.300287	0.001377	-0.279030
2022	Benchmark	1.974657	2.937566	NaN	0.242655	4.061274	0.000887	-0.059749
	Strategy	2.552077	3.854519	0.144989	0.358185	5.011998	0.001247	-0.071466
2023	Benchmark	-0.888999	-1.191521	NaN	-0.198459	-0.782707	-0.000777	-0.253555
	Strategy	-0.363428	-0.500616	0.347299	-0.108911	-0.540601	-0.000345	-0.201463

Strategy 7: Winning Insiders Strategy

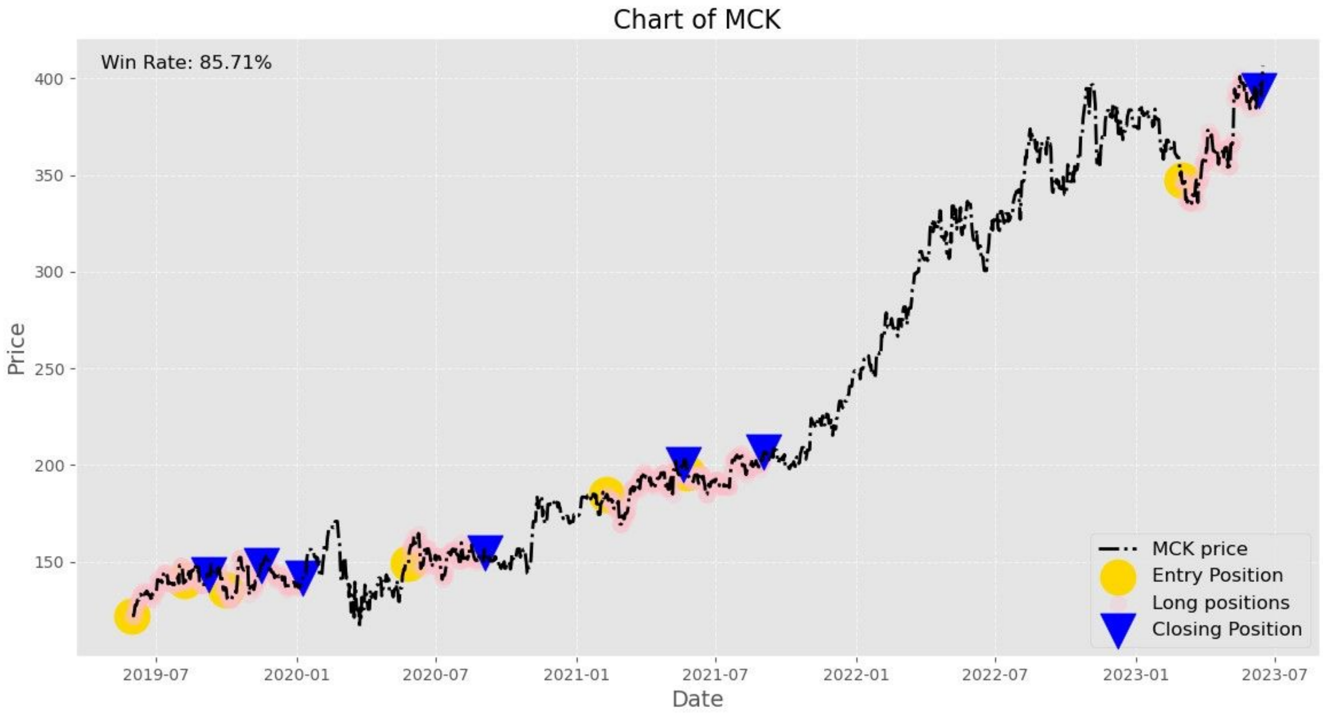
Training set (2006-2017)

- Calculate **accuracy score** for stocks with accurate insider movements
- All insiders with **> 10%** return in the next **100 days** , accuracy score **< 0.7** filtered out

Testing set (2018 - 2023)

- Follow all insider trades
- Enter at **Filing Date + 1**
- Close it at **T+100 days**
- If return **> 8%**, close it **now** instead of T+100

Strategy 7: Winning Insider Strategy



Strategy 7: Winning Insider Strategy

Conclusion

1: Naive

2: Relationship

3: Inside Trade Size

4: Insider percentage holding

5: No. of unique insiders

6: Co-location

Method 1	Benchmark	Strat 1	Strat 2 Dir	Strat 2 TPO	Strat 3	Strat 4	Strat 5	Strat 6
Expected Period Return	0.000442	0.000658	0.000708	0.000500	0.000658	0.000659	0.000658	0.000644
Ann. Sharpe	0.619882	0.783612	0.825495	1.025215	0.781236	0.796574	0.783612	0.771142
Ann. Sortino	0.852706	1.084677	1.155440	1.452726	1.079461	1.106218	1.084677	1.066811
Calmer	0.213628	0.321475	0.340882	0.475743	0.308387	0.331759	0.321475	0.317223
Max DD.	-0.466525	-0.478678	-0.491363	-0.263866	-0.498469	-0.467005	-0.478678	-0.473185
CAGR	0.099663	0.153883	0.167497	0.125532	0.153721	0.154933	0.153883	0.150105
Avg. Daily Turnover	NaN	0.029707	0.032070	0.030063	0.029785	0.031153	0.029707	0.029733

Method 2	Benchmark	Strat 1	Strat 2 Dir	Strat 2 TPO	Strat 3	Strat 4	Strat 5	Strat 6
Expected Period Return	0.000443	0.000616	0.000616	0.000382	0.000619	0.000635	0.000599	0.000632
Ann. Sharpe	1.047961	1.190304	1.190304	1.210151	1.257068	1.258607	1.183100	1.251305
Ann. Sortino	1.567149	1.763584	1.763584	1.815786	1.876099	1.879655	1.755187	1.867011
Calmer	1.476272	1.704210	1.704210	1.712394	1.841342	1.869284	1.673977	1.879270
Max DD.	-0.160861	-0.159825	-0.159825	-0.124283	-0.152329	-0.150968	-0.153240	-0.151519
CAGR	0.116478	0.159218	0.159218	0.092071	0.163609	0.166284	0.153411	0.163493
Avg. Daily Turnover	NaN	0.050850	0.050850	0.069700	0.155367	0.226256	0.095350	0.101821

Overall analysis/conclusions

- Strategy performances appear to consistently outperform the benchmark over test period.
- Since buy transactions for all S&P500 tickers must be reported, eventually the aggregate of buys will resemble insider-weighted S&P Index.
- Interestingly, all strategies show significant outperformance during periods of market uncertainty (2008/09, March 2020 to end 2021)
- This reinforces our economic intuition at the start - Insiders buy on bullish information even during a uncertain market environments.

Further research to be done

- Market neutral implementations
- Impact of transactions costs/slippage
- Extending holding periods to longer term
- Consider insider selling and/or derivative transactions
- Portfolio optimization using ML and NN
- Combine signals into other strategies (e.g. trend following)
- Analyse similar data - Congressmen holdings, US government contracts
- Combinations of strategies to create superior alpha

Q&A

Thank you :)