Quantitative Investing

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UNION COLLEGE STUDENT INVESTMENT FUND

What is it

~~"Life is relationships~~; the rest is just details." –Gary Smalley

"Make money; the rest is just details." ~~–someone~~

^

trading securities

–me

What is it

- Quantitative models instead of fundamental analysis
- Data driven

But why

- Unbiased
- Backtesting
    - Short Feedback Loop

Why not?

- Overfitting
- Can be a black box

Examples (Strategies)

- Pairs Trading
- Sentiment Analysis
- High Frequency Trading (HFT)
- Market Making
- Mean Reversion
- Momentum
- Factor Investing

Examples (Firms)

Books/Podcasts

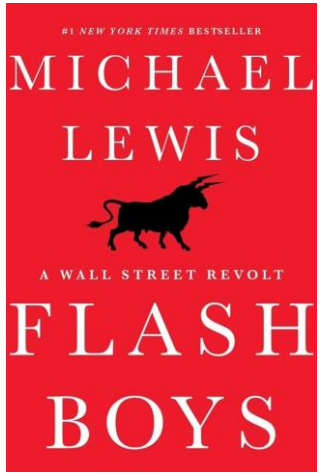
Flash Boys - Michael Lewis

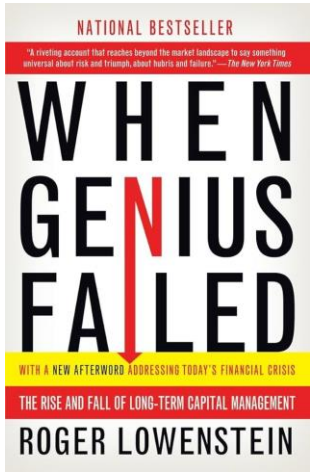
When Genius Failed: The Rise and Fall of Long-Term Capital Management - Roger Lowenstein

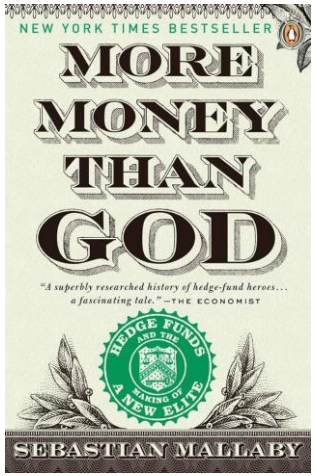
More Money Than God: Hedge Funds and the Making of a New Elite - Sebastian Mallaby

Acquired Podcast episode on Renaissance Technologies/Jim Simmons

Flirting with Models

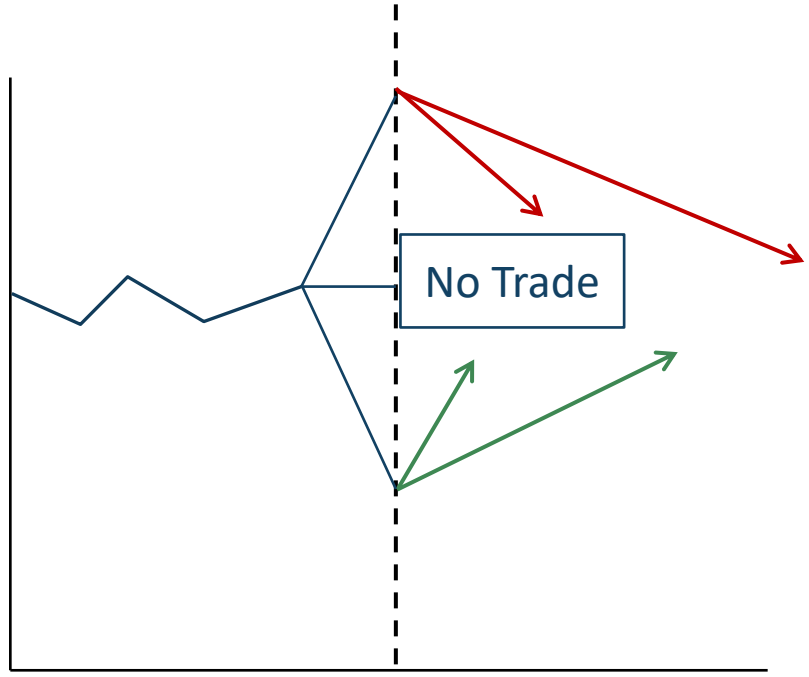




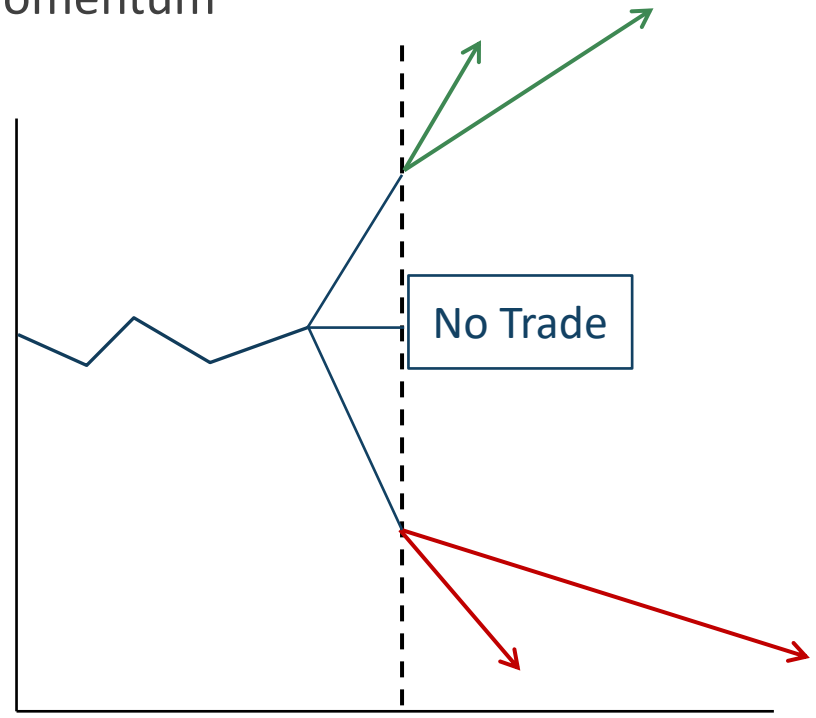


My Strategy

Mean Reversion

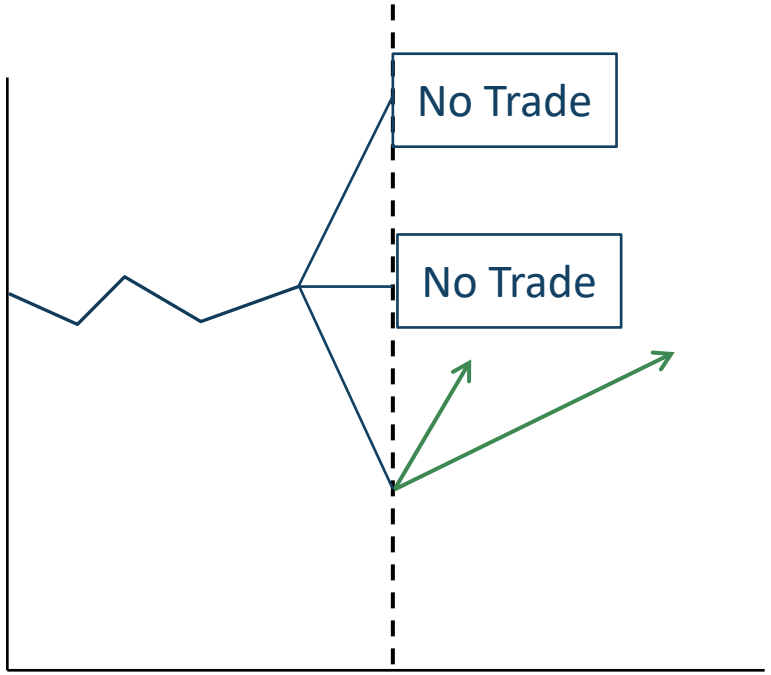


Momentum

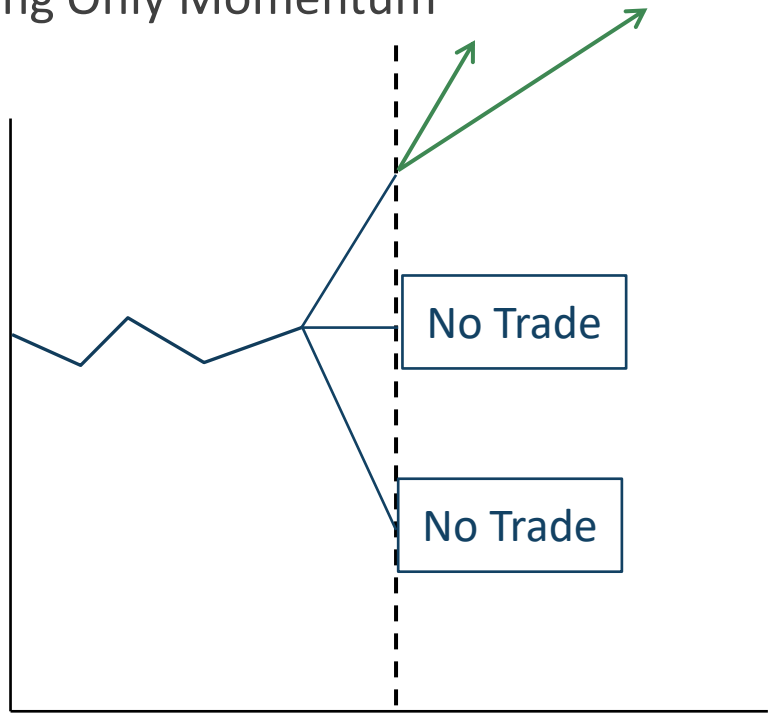


My Strategy

Long Only Mean Reversion



Long Only Momentum



How

Ticker	Name	Last_Sale	Net_Change	Percent_Change	Market_Cap	Country	IPO_Year	Volume	Sector	Industry	Exchange
A	Agilent Technologies Inc. Common Stock	$140.09	-1.860	-1.31%	4.025173e+10	United States	1999.0	2612065	Industrials	Biotechnology: Laboratory Analytical Instruments	NYSE
AA	Alcoa Corporation Common Stock	$33.83	-1.090	-3.121%	8.739647e+09	United States	2016.0	9044364	Industrials	Aluminum	NYSE
AACT	Ares Acquisition Corporation II Class A Ordina...	$10.81	-0.005	-0.046%	0.000000e+00	NaN	2023.0	564337	Finance	Blank Checks	NYSE
AAM	AA Mission Acquisition Corp. Class A Ordinary ...	$9.99	0.010	0.10%	0.000000e+00	NaN	2024.0	212652	NaN	NaN	NYSE
AAN	Aarons Holdings Company Inc. Common Stock	$10.02	-0.020	-0.199%	3.077420e+08	United States	2020.0	1573979	Consumer Discretionary	Diversified Commercial Services	NYSE
...	...	...	...	...	...	...	...	...	...	...	...
ZURA	Zura Bio Limited Class A Ordinary Shares	$4.44	0.140	3.256%	2.983995e+08	Cayman Islands	NaN	4563183	Health Care	Biotechnology: Biological Products (No Diagnos...	NASDAQ
ZVRA	Zevra Therapeutics Inc. Common Stock	$8.06	0.040	0.499%	4.240994e+08	United States	NaN	5159085	Health Care	Biotechnology: Pharmaceutical Preparations	NASDAQ
ZVSA	ZyVersa Therapeutics Inc. Common Stock	$2.20	-0.070	-3.084%	1.668449e+06	United States	2022.0	41342	Health Care	Biotechnology: Pharmaceutical Preparations	NASDAQ
ZYME	Zymeworks Inc. Common Stock	$13.09	0.040	0.307%	9.300103e+08	United States	NaN	1576190	Health Care	Biotechnology: Pharmaceutical Preparations	NASDAQ
ZYXI	Zynex Inc. Common Stock	$8.12	-0.210	-2.521%	2.577493e+08	United States	NaN	322447	Health Care	Biotechnology: Electromedical & Electrotherape...	NASDAQ

6726 rows × 11 columns

How

Date	Open	High	Low	Close	Adj Close	Volume
2015-01-02	27.847500	27.860001	26.837500	27.332500	24.373957	212818400
2015-01-05	27.072500	27.162500	26.352501	26.562500	23.687304	257142000
2015-01-06	26.635000	26.857500	26.157499	26.565001	23.689533	263188400
2015-01-07	26.799999	27.049999	26.674999	26.937500	24.021713	160423600
2015-01-08	27.307501	28.037500	27.174999	27.972500	24.944683	237458000
...	...	...	...	...	...	...
2024-09-04	221.660004	221.779999	217.479996	220.850006	220.850006	43840200
2024-09-05	221.630005	225.479996	221.520004	222.380005	222.380005	36615400
2024-09-06	223.949997	225.240005	219.770004	220.820007	220.820007	48423000
2024-09-09	220.820007	221.270004	216.710007	220.910004	220.910004	67180000
2024-09-10	218.919998	221.479996	216.729996	220.110001	220.110001	51591000

2438 rows × 6 columns

Date	Dates_Numeric	Adj_Close	Size_Category
2015-01-02	5480	24.819241	mid
2015-01-05	5483	24.120045	mid
2015-01-06	5484	24.122320	mid
2015-01-07	5485	24.460564	mid
2015-01-08	5486	25.400398	mid
...	...	...	...
2024-09-04	9013	220.850006	mega
2024-09-05	9014	222.380005	mega
2024-09-06	9015	220.820007	mega
2024-09-09	9018	220.910004	mega
2024-09-10	9019	220.110001	mega

2438 rows × 3 columns

How

Date	Dates_Numeric	Adj_Close	Size_Category	Intercept_60	Dates_Numeric_Coeff_60	Std_Dev_30
2015-01-02	5480	24.819241	mid	13.937909	0.002000	0.680853
2015-01-05	5483	24.120045	mid	13.959455	0.002003	0.698723
2015-01-06	5484	24.122320	mid	13.970087	0.002005	0.755726
2015-01-07	5485	24.460564	mid	13.980274	0.002006	0.794332
2015-01-08	5486	25.400398	mid	13.994239	0.002009	0.805481
...	...	...	...	...	...	...
2024-09-04	9013	220.850006	mega	95.707011	0.013823	5.893780
2024-09-05	9014	222.380005	mega	95.870873	0.013847	5.852028
2024-09-06	9015	220.820007	mega	96.073247	0.013877	5.836777
2024-09-09	9018	220.910004	mega	96.163029	0.013890	5.796304
2024-09-10	9019	220.110001	mega	96.210564	0.013897	5.763205

2438 rows × 6 columns

How

Date	Dates_Numeric	Adj_Close	Intercept_60	Dates_Numeric_Coeff_60	Std_Dev_30	Size_Category	Theo_Value	Theo_Diff
2015-01-02	5480	24.819241	13.937909	0.002000	0.680853	mid	24.899550	0.117954
2015-01-05	5483	24.120045	13.959455	0.002003	0.698723	mid	24.944296	1.179654
2015-01-06	5484	24.122320	13.970087	0.002005	0.755726	mid	24.965501	1.115723
2015-01-07	5485	24.460564	13.980274	0.002006	0.794332	mid	24.985909	0.661368
2015-01-08	5486	25.400398	13.994239	0.002009	0.805481	mid	25.013085	-0.480848
...	...	...	...	...	...	...	...	...
2024-09-04	9013	220.850006	95.707011	0.013823	5.893780	mega	220.295666	-0.094055
2024-09-05	9014	222.380005	95.870873	0.013847	5.852028	mega	220.688331	-0.289075
2024-09-06	9015	220.820007	96.073247	0.013877	5.836777	mega	221.169907	0.059947
2024-09-09	9018	220.910004	96.163029	0.013890	5.796304	mega	221.419225	0.087853
2024-09-10	9019	220.110001	96.210564	0.013897	5.763205	mega	221.543128	0.248669

2438 rows × 8 columns

```
aapl.loc[:,'Theo_Value'] = aapl['Intercept_60'] + aapl['Dates_Numeric'] * aapl['Dates_Numeric_Coeff_60']
aapl.loc[:,'Theo_Diff'] = (aapl['Theo_Value'] - aapl['Adj_Close'])/aapl['Std_Dev_30']
display(aapl)
```

✓ 0.0s Python

How

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 7883 entries, 1993-06-02 to 2024-09-20
Columns: 86391 entries, ('Dates_Numeric_Coeff_30', 'BWA') to ('Volume_Value', 'ZYXI')
dtypes: float64(79992), int64(30), object(6369)
memory usage: 5.1+ GB
```

None

	Dates_Numeric_Coeff_30	Volume	Adj_Close	Market_Cap		Intercept_60
	BWA	BDJ	G	ALSN	SRE	BLBX
Date						
1993-06-02	NaN	NaN	NaN	NaN	NaN	NaN
1993-06-03	NaN	NaN	NaN	NaN	NaN	NaN
1993-06-04	NaN	NaN	NaN	NaN	NaN	NaN
1993-06-07	NaN	NaN	NaN	NaN	NaN	NaN
1993-06-08	NaN	NaN	NaN	NaN	NaN	NaN
...	...	...	...	...	...	...
2024-09-16	0.002723	391600.0	39.000000	7.679461e+09	5.293099e+10	100.169420
2024-09-17	0.002720	383600.0	38.549999	7.708217e+09	5.315259e+10	100.161822
2024-09-18	0.002722	452000.0	38.330002	7.717802e+09	5.251312e+10	100.158849
2024-09-19	0.002724	524400.0	38.480000	7.928676e+09	5.224087e+10	100.162960
2024-09-20	0.002731	332157.0	38.680000	7.934775e+09	5.266507e+10	100.155678

7883 rows × 86391 columns

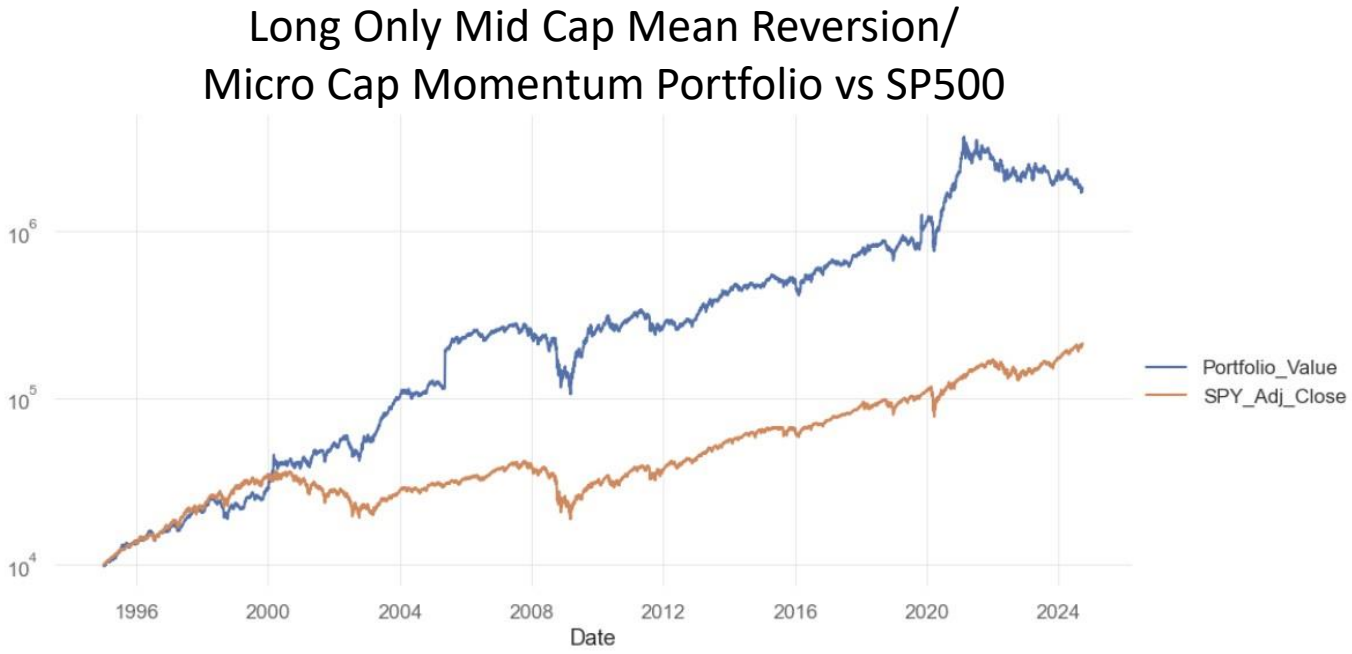
How

```python
class Position:
    def __init__(self, date_opened, ticker, shares):
        self.date_opened = date_opened
        self.ticker = ticker
        self.shares = shares
        self.cost_basis = shares*stock_data.at[date_opened,('Adj_Close',ticker)]
        self._current_value = shares*stock_data.at[date_opened,('Adj_Close',ticker)]
        self._current_theo = shares*stock_data.at[date_opened,(theo_var,ticker)]
        self._current_std_dev = shares*stock_data.at[date_opened,(std_dev_var,ticker)]
        self._current_price_diff = stock_data.at[date_opened,(price_diff_var,ticker)]
        self._last_date_checked = date_opened

    def __repr__(self):
        return (f"Position(date_opened={self.date_opened}, ticker='{self.ticker}', "
                f"shares={self.shares}, cost_basis={self.cost_basis}, "
                f"current_value={self._current_value}, "
                f"current_theo={self._current_theo}, "
                f"current_std_dev={self._current_std_dev}, "
                f"current_price_diff={self._current_price_diff}),"
                f"last_date_checked={self._last_date_checked}")

    def get_ticker(self):
        return(self.ticker)

    def days_old(self, date:str):
        """returns the number of days old a position is

        Args:
            date (str): date formated 'YYYY-MM-DD'
        """
        if type(self.date_opened) == str:
            opened = datetime.datetime.strptime(self.date_opened, '%Y-%m-%d').date()
        else:
            opened = self.date_opened
        if type(date)==str:
            current = datetime.datetime.strptime(date, '%Y-%m-%d').date()
        else:
            current = date
        return((current-opened).days)

    def __refresh__(self,current_date):
        self._last_date_checked = current_date
        self._current_value = self.shares*stock_data.at[current_date,('Adj_Close',self.ticker)]
        self._current_theo = stock_data.at[current_date,(theo_var, self.ticker)]
        self._current_std_dev = stock_data.at[current_date,(theo_var, self.ticker)]
        self._current_price_diff = stock_data.at[current_date,(price_diff_var, self.ticker)]
        # recalculate current_value as well as all other values that change over time,
        pass

    def get_current_value(self, current_date):
        self.__refresh__(current_date=current_date)
        return(self._current_value)

    def get_current_theo(self, current_date):
        self.__refresh__(current_date=current_date)
        return(self._current_theo)

    def get_current_std_dev(self, current_date):
        self.__refresh__(current_date=current_date)
        return(self._current_std_dev)

    def get_current_price_diff(self, current_date):
        self.__refresh__(current_date=current_date)
        return(self._current_price_diff)
```

```python
class Portfolio:
    def __init__(self, cash: float, date, trading_cost =0.005):
        """create portfolio object

        Args:
            cash (float): starting amount of cash in account
            date (_type_): starting date
            trading_cost (float, optional): cost of trading- each time we transact, we lose this amount. Defaults to 0.005.
        """
        self.position_df = pd.DataFrame(columns=['Position', 'Exposure', 'Value', 'Date_Opened', 'Days_Old'])
        self.position_df.index.name = 'Ticker'
        # Ensure 'Value' is explicitly set to float type
        self.position_df.loc['cash_position'] = ['N/A', 'N/A', float(cash), date, 0]  # Cast cash to float
        self.position_df = self.position_df.astype({'Value': 'float64'})  # Ensure Value column remains float
        self._last_date_checked = date
        self.trading_cost = trading_cost
        # log portfolio opening
        # logger.info(f'Portfolio opened on {date}')

    # def __repr__(self):
    #     returnString = f"Current Portfolio Value: {self.get_portfolio_value(self._last_date_checked)}\n"
    #     returnString += f"Cash: {self.position_df.loc['cash_position', 'Value']}\n"
    #     for pos in self.position_df['Position']:
    #         returnString += repr(pos)
    #     return returnString

    def get_cash(self):
        """returns size of cash_position
        """
        return(self.position_df.at['cash_position','Value'])

    def get_exposure(self):
        exposure = self.position_df['Value'].iloc[1:].sum()
        return(exposure)

    def position_count(self):
        return(len(self.position_df.index)-1)

    def open_position(self, position):
        # Assuming position has attributes `cost_basis`, `get_ticker()`, and `date_opened`
        if position.cost_basis > self.position_df.loc['cash_position', 'Value']:
            print('Position not opened; too expensive')
            print(f"Available cash: {self.position_df.loc['cash_position', 'Value']}\nPosition cost: {position.cost_basis}")
        else:
            # Explicit cast to ensure correct dtype when modifying Value
            self.position_df.loc['cash_position', 'Value'] = float(self.position_df.loc['cash_position', 'Value']) - (position.cost_basis * (1+self.trading_cost))
            # Add new row for the position
            self.position_df.loc[position.get_ticker()] = [position, position.shares, position.cost_basis, position.date_opened, 0]
            # log purchase

    def close_position(self, ticker: str, current_date: str):
        """close a currently open position"""
        self._last_date_checked = current_date
        if ticker == 'cash_position':
            print('Cannot sell cash position')
        else:
            position_value = self.position_df.loc[ticker, 'Position'].get_current_value(current_date)
            self.position_df.loc['cash_position', 'Value'] += (position_value * (1-self.trading_cost))
            self.position_df.drop(index=ticker, inplace=True)
            # log sale

    def get_portfolio_value(self, date):
        """gets the value of all the positions in the portfolio on the given date"""
        self.refresh_position_df(date)
        self._last_date_checked = date
        value = 0
        for ticker in self.position_df.index:
            value += self.position_df.loc[ticker, 'Value']
        return value

    def refresh_position_df(self, date):
        self._last_date_checked = date
        for ticker in self.position_df.index[1:]:  # Skipping the cash position
            self.position_df.loc[ticker, 'Value'] = self.position_df.loc[ticker, 'Position'].get_current_value(date)
            self.position_df.loc[ticker,'Days_Old'] = self.position_df.loc[ticker, 'Position'].days_old(date)

    def to_string(self, date: str):
        """returns a string summarizing portfolio's value"""
        self.refresh_position_df(date)
        return_string = f"Current Portfolio Value: {self.get_portfolio_value(date)}\n"
        return_string += f"Cash: {self.position_df.loc['cash_position', 'Value']}\n"
        for ticker in self.position_df.index[1:]:
            return_string += repr(self.position_df.loc[ticker, 'Position']) +'\n'
        return return_string
```

```python
def best_on_date(stock_data:pd.DataFrame,date:str,metric:str,abs_val:bool=True,how_many:int=1, max_or_min = 'max',exclude_extremes=True, min_trading_volume=10000, min_trading_volume_value=100000, size_categories=['mega','large','mid','small','micro'], min_market_cap=0):
    '''gets the ticker(s) of the best stock or stocks on a specific
    date according to the numerical value of either a specific metric,
    or the absolute value of a specific metric. If there is not enough tickers with data then the
    return value will be None and a warning will be printed and logged

    Args:
        stock_data (pd.DataFrame): the dataframe to use for reference
        date (str): date in the format of 'YYYY-MM-DD'
        metric (str): the name of the colum to be used for evaluation
        abs_val (bool, optional): do you want the highest values in the colum, or the values furthest from 0. Defaults to True.
        how_many (int, optional): top __ ticker(s). Defaults to 1.
    '''

    # takes a slice of dataframe for current date with .xs(date)
    # unstack if because .xs puts it in long format
    # transpose so tickers are the index column
    date_slice = stock_data.xs(date).unstack().transpose()

    # numeric_cols = date_slice.select_dtypes(include=['float', 'int']).columns
    # date_slice[numeric_cols] = date_slice[numeric_cols].apply(pd.to_numeric, errors='coerce')
    # date_slice[metric] = pd.to_numeric(date_slice[metric], errors='coerce')
    with warnings.catch_warnings():
        warnings.simplefilter('ignore', category=RuntimeWarning)
        warnings.simplefilter('ignore', category=FutureWarning)
        date_slice[metric] = pd.to_numeric(date_slice[metric], errors='coerce')


    # simplify to just relevant data and drop na columns so we don't return useless data
    date_slice = date_slice[date_slice['Market_Cap']>=min_market_cap]
    date_slice = date_slice[date_slice['Size_Category'].isin(size_categories)]
    date_slice = date_slice[date_slice['Volume']>=min_trading_volume]
    date_slice = date_slice[date_slice['Volume_Value']>=min_trading_volume_value]
    date_slice = date_slice.filter(items=['Adj_Close', 'Volume', metric]).dropna()
    # date_slice = date_slice.query(abs(metric)<100)# excludes extremes
    date_slice = date_slice[np.abs(date_slice[metric])<50]



    # if there is not enough data to return the number of tickers wanted, returns
    if len(date_slice.index)<how_many:
        warningString = f"Warning: not enough data on {date} to run best_on_date. There is only {len(date_slice.index)} non-NaN values in {metric} but you want the top {how_many}. Returning (None)"
        warnings.warn(warningString)
        # logger.warning(warningString)
        return(None)
    else:
        if max_or_min =='max':
            if(abs_val):
                # gets the id (Tickers) of the 2 highest absolute value for price_diff_var
                max_tickers = abs(date_slice).nlargest(how_many,[metric]).index.tolist()
            else:
                # gets the id (Tickers) of the 2 highest value for price_diff_var
                max_tickers = date_slice.nlargest(how_many,[metric]).index.tolist()
            return(max_tickers)
        if max_or_min == 'min':
            if(abs_val):
                # gets the id (Tickers) of the 2 highest absolute value for price_diff_var
                min_tickers = abs(date_slice).nsmallest(how_many,[metric]).index.tolist()
            else:
                # gets the id (Tickers) of the 2 highest value for price_diff_var
                min_tickers = date_slice.nsmallest(how_many,[metric]).index.tolist()
            return(min_tickers)
```

Results



Portfolio Stats

Annualized Return (CAGR): 12.810%
Volatility (Standard Deviation): 25.456%
Max Drawdown: -62.379%
Alpha: 0.104
Beta: 0.837
Sharpe Ratio: 0.807
Sortino Ratio: 1.319

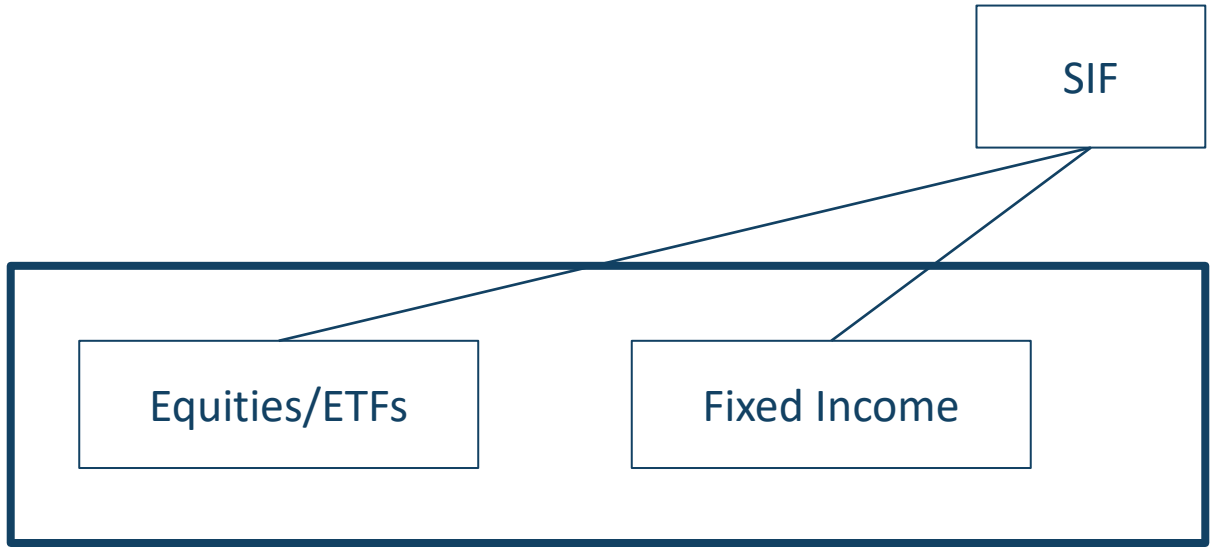
SPY Stats

Annualized Return (CAGR): 7.343%
Volatility (Standard Deviation): 19.083%
Max Drawdown: -55.189%
Alpha: 0.000
Beta: 1.000
Sharpe Ratio: 0.634
Sortino Ratio: 0.901

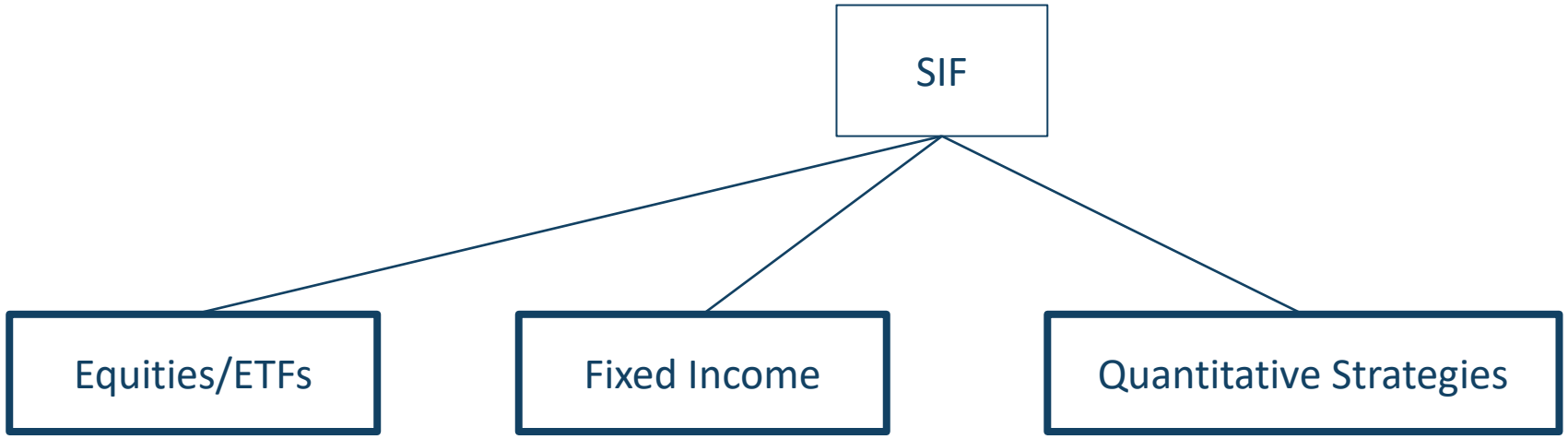
My Strategy– What's Missing

- Dynamic Position Entry/Exit
- More Accurate Trade Cost Estimation
- Trade Analyzer

The Pitch



The Pitch



Questions?

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Sources

- https://www.investopedia.com/terms/p/pairstrade.asp
- https://www.schwab.com/learn/story/using-sentiment-analysis-tools-your-trading
- https://www.investopedia.com/terms/h/high-frequency-trading.asp
- https://www.investopedia.com/terms/m/marketmaker.asp
- https://www.investopedia.com/terms/m/meanreversion.asp
- https://www.investopedia.com/terms/m/momentum_investing.asp
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