FRE7251 Algo Trading & High-frequency Finance HW3

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1 Problem 1

Select security (stock, index, or a mutual fund), time period (at least two years) and download relevent daily closing prices from https://finance.yahoo.com

- Select CVS Health Corp (Ticker: CVS) to use MACD strategy to do analysis.
- Use 5-year daily Adj Close data from 4/21/2011 to 4/20/2015.

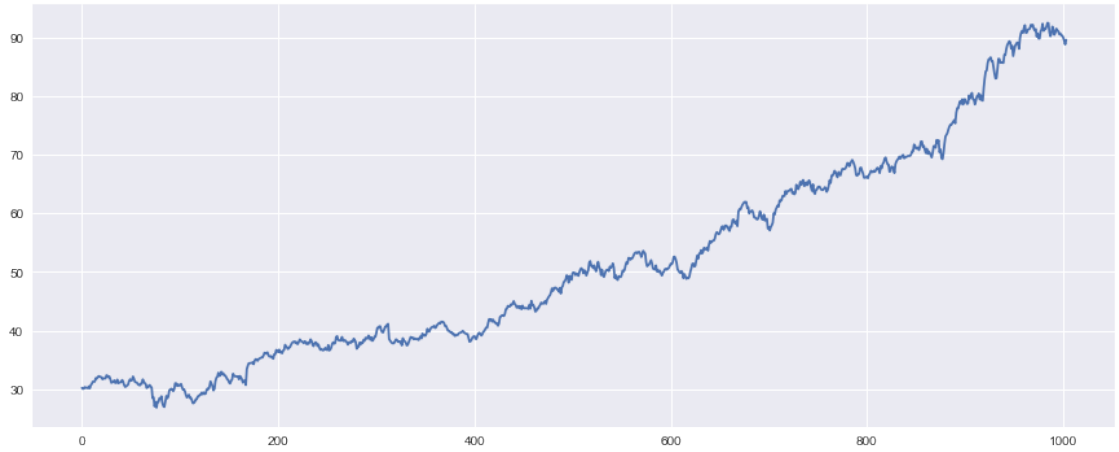
```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        import seaborn as sns
        sns.set()
```

```
In [2]: df = pd.read_csv('CVS.csv')
        df.head()
```

Out[2]:

	Date	Open	High	Low	Close	Adj Close	Volume
0	2011-04-21	36.240002	36.340000	36.130001	36.209999	30.202391	4603300
1	2011-04-25	36.049999	36.220001	35.930000	36.020000	30.043913	3879700
2	2011-04-26	36.139999	36.630001	36.080002	36.090000	30.102303	9300000
3	2011-04-27	36.160000	36.480000	36.049999	36.369999	30.335857	7989700
4	2011-04-28	36.250000	36.320000	36.020000	36.250000	30.235748	8127800

```
In [3]: plt.figure(figsize=(15,6))
        plt.plot(df['Adj Close'])
        plt.show()
```



1.1 Moving Average Convergence/Divergence (MACD)

- MACD is calculated by subtracting the 26-period EMA from the 12-period EMA.
- An exponential moving average (EMA) is a type of moving average (MA) that places a greater weight and significance on the most recent data points.
- A 9-day EMA of the MACD called the "signal line".
- MACD triggers technical signals when it crosses above (to buy) or below (to sell) its signal line.
- The speed of crossovers is also taken as a signal of a market is overbought or oversold.

$$ema(P_t, \beta) = \beta * P_t + (1 - \beta) * ema(P_{t-1}, \beta) \beta = \frac{2}{n+1}, \beta < 1 \text{starting with sma}$$

```
In [4]: df['EMA_12day'] = df[['Adj Close']].ewm(span=12, min_periods=12, adjust=False).mean()
        df['EMA_26day'] = df[['Adj Close']].ewm(span=26, min_periods=26, adjust=False).mean()
        df['MACD'] = df['EMA_12day'] - df['EMA_26day']
        df['Signal_line'] = df[['MACD']].ewm(span=9, min_periods=9, adjust=False).mean()
        df['Signal'] = np.where((df['MACD']-df['Signal_line'])>0, 'Buy', 'Sell')

In [5]: df.iloc[60:70,:]

Out[5]:          Date       Open       High        Low      Close  Adj Close  \
        60  2011-07-19  36.799999  37.189999  36.680000  37.119999  30.961409
        61  2011-07-20  36.860001  37.099998  36.709999  36.950001  30.923750
        62  2011-07-21  37.860001  38.820000  37.500000  37.820000  31.651878
        63  2011-07-22  37.880001  38.000000  37.299999  37.349998  31.258505
        64  2011-07-25  37.119999  37.310001  36.950001  37.060001  31.015810
        65  2011-07-26  37.259998  37.270000  36.799999  36.860001  30.848429
        66  2011-07-27  36.709999  36.860001  35.980000  36.060001  30.178915
        67  2011-07-28  36.020000  36.840000  36.009998  36.419998  30.480186
        68  2011-07-29  36.070000  36.540001  35.970001  36.349998  30.421604
        69  2011-08-01  36.779999  37.160000  36.230000  36.680000  30.697779
```

	Volume	EMA_12day	EMA_26day	MACD	Signal_line	Signal
60	6626500	31.061309	31.156936	-0.095627	-0.038895	Sell
61	4815200	31.040146	31.139663	-0.099517	-0.051019	Sell
62	25907700	31.134259	31.177605	-0.043346	-0.049485	Buy
63	9280200	31.153374	31.183598	-0.030224	-0.045633	Buy
64	5090700	31.132210	31.171169	-0.038959	-0.044298	Buy
65	6365700	31.088551	31.147262	-0.058711	-0.047180	Sell
66	10394500	30.948607	31.075533	-0.126926	-0.063129	Sell
67	8919400	30.876543	31.031433	-0.154891	-0.081482	Sell
68	8812700	30.806552	30.986261	-0.179709	-0.101127	Sell
69	11393400	30.789818	30.964892	-0.175074	-0.115916	Sell

2 Problem 2

Find technical strategy that yields **positive** total return for chosen time period. The sample should accommodate at least **four** round-trip trades (buy-sells and/or sell-buys)/

```
In [6]: df['Action'] = '-'
        num_trades = 0
        num_pos_trades = 0
        # return_list is used to calculate the return of each round
        return_list = []
        # close is uese to save the adj close during trading period
        close = pd.Series()
        # Suppose we can't buy sell
        # Find the first buy signal
        begin = df[df['Signal']=='Buy'].index.tolist()[0]

        for i in range(begin, len(df)):
            if df['Signal'].iloc[i]=='Buy' and df['Signal'].iloc[i-1]=='Sell':
                df.loc[i, 'Action']='Buy'
                mark = i
            if df['Signal'].iloc[i]=='Sell' and df['Signal'].iloc[i-1]=='Buy':
                df['Action'].iloc[i]='Sell'
                close = pd.Series.append(close, df['Adj Close'].iloc[mark:i+1],
                                         ignore_index=True)
                num_trades += 1
                r = df.loc[i, 'Adj Close']/df.loc[mark, 'Adj Close']-1
                return_list.append(r)
                if r > 0:
                    num_pos_trades += 1

        return_list = pd.DataFrame(return_list, columns={'return'})
        df.head()
```

```
/anaconda3/lib/python3.6/site-packages/pandas/core/indexing.py:194: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame
```

```
See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#
  self._setitem_with_indexer(indexer, value)
```

Out[6]:

	Date	Open	High	Low	Close	Adj Close	Volume	\
0	2011-04-21	36.240002	36.340000	36.130001	36.209999	30.202391	4603300	
1	2011-04-25	36.049999	36.220001	35.930000	36.020000	30.043913	3879700	
2	2011-04-26	36.139999	36.630001	36.080002	36.090000	30.102303	9300000	
3	2011-04-27	36.160000	36.480000	36.049999	36.369999	30.335857	7989700	
4	2011-04-28	36.250000	36.320000	36.020000	36.250000	30.235748	8127800	

	EMA_12day	EMA_26day	MACD	Signal_line	Signal	Action
0	NaN	NaN	NaN	NaN	Sell	-
1	NaN	NaN	NaN	NaN	Sell	-
2	NaN	NaN	NaN	NaN	Sell	-
3	NaN	NaN	NaN	NaN	Sell	-
4	NaN	NaN	NaN	NaN	Sell	-

In [7]:
```
close = pd.DataFrame(close)
close
```

Out[7]:

	0
0	31.670403
1	31.436844
2	31.495220
3	32.145805
4	31.778820
5	31.228313
6	31.169924
7	31.111551
8	30.836300
9	31.651878
10	31.258505
11	31.015810
12	30.848429
13	28.823111
14	28.429762
15	28.739414
16	29.752073
17	29.927818
18	30.053370
19	29.944571
20	29.651655
21	29.969681
22	30.990692
23	30.982327
24	30.547134

```
25   30.781473
26   30.597355
27   30.689407
28   30.881901
29   30.312809
..         ...
468  79.018867
469  78.718987
470  83.058456
471  84.249168
472  84.407913
473  85.651550
474  86.321877
475  86.339516
476  86.657043
477  86.039650
478  86.022003
479  84.945938
480  83.878716
481  88.071732
482  88.762161
483  89.063095
484  89.408302
485  89.240112
486  88.160248
487  88.611671
488  86.885651
489  91.169731
490  90.842224
491  91.656555
492  92.143387
493  90.833397
494  90.904182
495  91.399879
496  92.488586
497  90.930748

[498 rows x 1 columns]
```

In [8]:
```
cum_return = (1+return_list).cumprod()
total_return_pct = 100*(cum_return.iloc[-1] - 1)
total_return_pct = total_return_pct[0].round(2)
total_return_pct
```

Out[8]:
```
79.049999999999997
```

In [9]:
```
win_trades = num_pos_trades/num_trades
win_trades_pct = 100*win_trades
win_trades_pct
```

```
Out[9]: 63.63636363636363
```

```
In [10]: df['drawdown'] = close/close.cummax()-1
         max_drawdown = -df['drawdown'].min()
         max_drawdown_pct = (max_drawdown*100).round(2)
         max_drawdown_pct
```

```
Out[10]: 11.56
```

3 Problem 3

Desrcibe performance measures other than total return, and P/L histogram.

```
In [11]: result = pd.DataFrame(data=[['Empirical', num_trades, total_return_pct, win_trades_pct,
                                columns=['Sample', '# of round-trip trades', 'Total return, %', '
                                index={'CVS'})
         # result.round({'Winning trades, %':2})
         result
```

```
Out[11]:         Sample  # of round-trip trades  Total return, %  Winning trades, %  \
         CVS  Empirical                     33            79.05          63.636364

              Max drawdown, %
         CVS            11.56
```

Summary: - According to the table above, during the 5 years, using MACD strategy, it has 33 round-trip rates. Moreover, the total return in 5 years is 79.05%. The max drawdown is 11.56%. Hence, it's a satisfied strategy which balances return and volatility.

```
In [12]: m = return_list.mean()
         std = return_list.std()
         normal_dist = np.random.normal(m, std, 1000)
```

```
In [13]: return_list = return_list.values
         m = return_list.mean()
         std = return_list.std()
         normal_dist = np.random.normal(m, std, 1000)
         plt.figure(figsize=(15,6))
         plt.title('Returns P/L %', fontsize=18)
         plt.xlabel('Return of each round, %', fontsize=18)
         plt.ylabel('count', fontsize=18)
         plt.hist([return_list, normal_dist], density = True, label =['CVS','Normal'])
         plt.legend()

         # plt.title('Returns P/L', fontsize=18)

         # sns.distplot( return_list , color="skyblue", label="CVS");
         # sns.distplot( normal_dist , color="red", label="Normal");
         # plt.legend()
```

Out[13]: <matplotlib.legend.Legend at 0x10baeffd0>