

Untitled

March 17, 2024

```
[7]: import yfinance as yf
import pandas as pd
import numpy as np
```

```
[10]: apple = yf.Ticker("AAPL")
```

```
[11]: apple = apple.history(period="max")
```

```
[12]: apple.head()
```

```
[12]:
```

	Open	High	Low	Close	Volume	\
Date						
1980-12-12 00:00:00-05:00	0.099192	0.099623	0.099192	0.099192	469033600	
1980-12-15 00:00:00-05:00	0.094448	0.094448	0.094017	0.094017	175884800	
1980-12-16 00:00:00-05:00	0.087548	0.087548	0.087117	0.087117	105728000	
1980-12-17 00:00:00-05:00	0.089273	0.089704	0.089273	0.089273	86441600	
1980-12-18 00:00:00-05:00	0.091861	0.092292	0.091861	0.091861	73449600	

	Dividends	Stock Splits
Date		
1980-12-12 00:00:00-05:00	0.0	0.0
1980-12-15 00:00:00-05:00	0.0	0.0
1980-12-16 00:00:00-05:00	0.0	0.0
1980-12-17 00:00:00-05:00	0.0	0.0
1980-12-18 00:00:00-05:00	0.0	0.0

```
[13]: apple.tail()
```

```
[13]:
```

	Open	High	Low	Close	\
Date					
2024-03-11 00:00:00-04:00	172.940002	174.380005	172.050003	172.750000	
2024-03-12 00:00:00-04:00	173.149994	174.029999	171.009995	173.229996	
2024-03-13 00:00:00-04:00	172.770004	173.190002	170.759995	171.130005	
2024-03-14 00:00:00-04:00	172.910004	174.309998	172.050003	173.000000	
2024-03-15 00:00:00-04:00	171.169998	172.619995	170.289993	172.619995	

	Volume	Dividends	Stock Splits
Date			

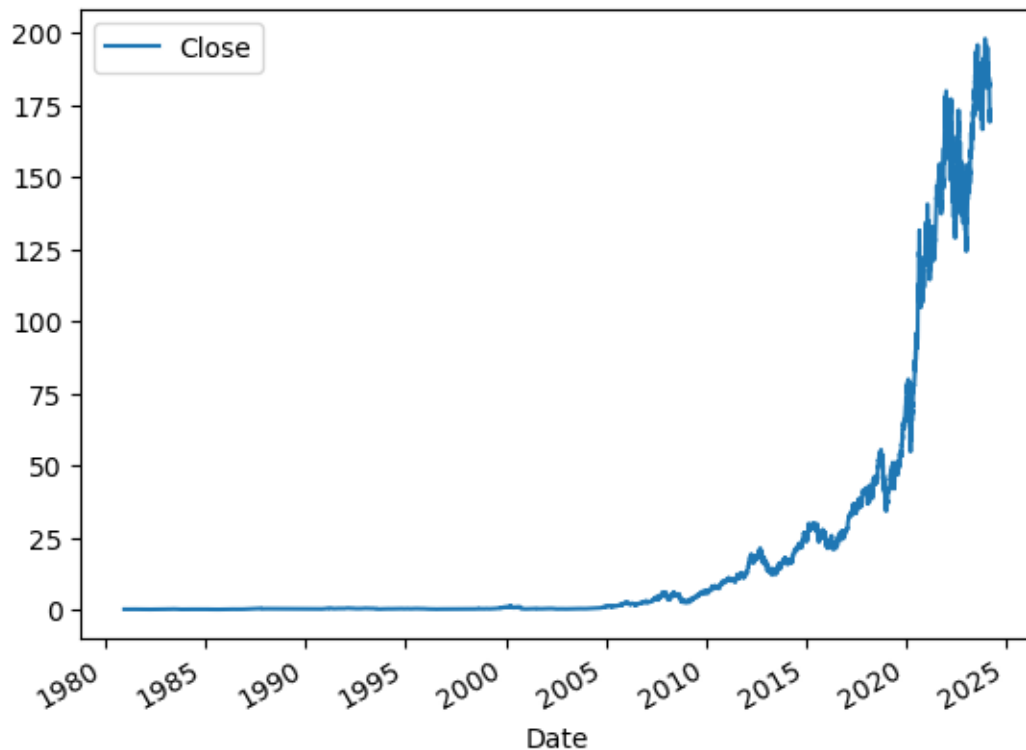
2024-03-11 00:00:00-04:00	60139500	0.0	0.0
2024-03-12 00:00:00-04:00	59825400	0.0	0.0
2024-03-13 00:00:00-04:00	52488700	0.0	0.0
2024-03-14 00:00:00-04:00	72913500	0.0	0.0
2024-03-15 00:00:00-04:00	121664700	0.0	0.0

```
[14]: apple.index
```

```
[14]: DatetimeIndex(['1980-12-12 00:00:00-05:00', '1980-12-15 00:00:00-05:00',
                    '1980-12-16 00:00:00-05:00', '1980-12-17 00:00:00-05:00',
                    '1980-12-18 00:00:00-05:00', '1980-12-19 00:00:00-05:00',
                    '1980-12-22 00:00:00-05:00', '1980-12-23 00:00:00-05:00',
                    '1980-12-24 00:00:00-05:00', '1980-12-26 00:00:00-05:00',
                    ...,
                    '2024-03-04 00:00:00-05:00', '2024-03-05 00:00:00-05:00',
                    '2024-03-06 00:00:00-05:00', '2024-03-07 00:00:00-05:00',
                    '2024-03-08 00:00:00-05:00', '2024-03-11 00:00:00-04:00',
                    '2024-03-12 00:00:00-04:00', '2024-03-13 00:00:00-04:00',
                    '2024-03-14 00:00:00-04:00', '2024-03-15 00:00:00-04:00'],
                    dtype='datetime64[ns, America/New_York]', name='Date',
                    length=10905, freq=None)
```

```
[15]: apple.plot.line(y="Close" , use_index=True)
```

```
[15]: <Axes: xlabel='Date'>
```



```
[17]: del apple["Dividends"]
      del apple["Stock Splits"]
```

```
[18]: apple["Tomorrow"] = apple["Close"].shift(-1) # create a column that is one step
      ahead of the closing price.
```

```
[19]: apple.head()
```

```
[19]:
```

	Open	High	Low	Close	Volume \
Date					
1980-12-12 00:00:00-05:00	0.099192	0.099623	0.099192	0.099192	469033600
1980-12-15 00:00:00-05:00	0.094448	0.094448	0.094017	0.094017	175884800
1980-12-16 00:00:00-05:00	0.087548	0.087548	0.087117	0.087117	105728000
1980-12-17 00:00:00-05:00	0.089273	0.089704	0.089273	0.089273	86441600
1980-12-18 00:00:00-05:00	0.091861	0.092292	0.091861	0.091861	73449600

	Tomorrow
Date	
1980-12-12 00:00:00-05:00	0.094017
1980-12-15 00:00:00-05:00	0.087117
1980-12-16 00:00:00-05:00	0.089273
1980-12-17 00:00:00-05:00	0.091861
1980-12-18 00:00:00-05:00	0.097467

```
[22]: apple["Target"] = (apple["Tomorrow"] > apple["Close"]).astype(int) # generate a
      dummy that equals 1 if price increased from day before
      #and zero otherwise.
```

```
[23]: apple.head()
```

```
[23]:
```

	Open	High	Low	Close	Volume \
Date					
1980-12-12 00:00:00-05:00	0.099192	0.099623	0.099192	0.099192	469033600
1980-12-15 00:00:00-05:00	0.094448	0.094448	0.094017	0.094017	175884800
1980-12-16 00:00:00-05:00	0.087548	0.087548	0.087117	0.087117	105728000
1980-12-17 00:00:00-05:00	0.089273	0.089704	0.089273	0.089273	86441600
1980-12-18 00:00:00-05:00	0.091861	0.092292	0.091861	0.091861	73449600

	Tomorrow	Target
Date		
1980-12-12 00:00:00-05:00	0.094017	0
1980-12-15 00:00:00-05:00	0.087117	0
1980-12-16 00:00:00-05:00	0.089273	1
1980-12-17 00:00:00-05:00	0.091861	1
1980-12-18 00:00:00-05:00	0.097467	1

```
[24]: apple = apple.loc["1990-01-01":].copy() # keep observations after year 1990.
```

```
[25]: apple.head()
```

```
[25]:
```

	Open	High	Low	Close	Volume \
Date					
1990-01-02 00:00:00-05:00	0.248953	0.264843	0.247187	0.263078	183198400
1990-01-03 00:00:00-05:00	0.268375	0.268375	0.264843	0.264843	207995200
1990-01-04 00:00:00-05:00	0.270141	0.273672	0.263078	0.265727	221513600
1990-01-05 00:00:00-05:00	0.266610	0.270141	0.261312	0.266610	123312000
1990-01-08 00:00:00-05:00	0.264843	0.268375	0.261312	0.268375	101572800

	Tomorrow	Target
Date		
1990-01-02 00:00:00-05:00	0.264843	1
1990-01-03 00:00:00-05:00	0.265727	1
1990-01-04 00:00:00-05:00	0.266610	1
1990-01-05 00:00:00-05:00	0.268375	1
1990-01-08 00:00:00-05:00	0.265727	0

```
[27]: from sklearn.ensemble import RandomForestClassifier
model = RandomForestClassifier(n_estimators=120, min_samples_split=120,
    ↪random_state=1) # using a random forest model. n_estimators is the number of
#individual decision trees you want to train. min_sample split protects against
    ↪overfitting. the higher the value the less the accuracy but less overfit
# random_states is we run the model twice we get the same results. (like set
    ↪seed in Stata).
train = apple.iloc[:-120] # train data except the last 100.
test = apple.iloc[-120:] # test data last 100 observations
predictors = ["Close", "Volume", "Open", "High", "Low"]
model.fit(train[predictors], train["Target"])
```

```
[27]: RandomForestClassifier(min_samples_split=100, random_state=1)
```

```
[28]: from sklearn.metrics import precision_score
```

```
preds = model.predict(test[predictors])
preds= pd.Series(preds, index=test.index)
```

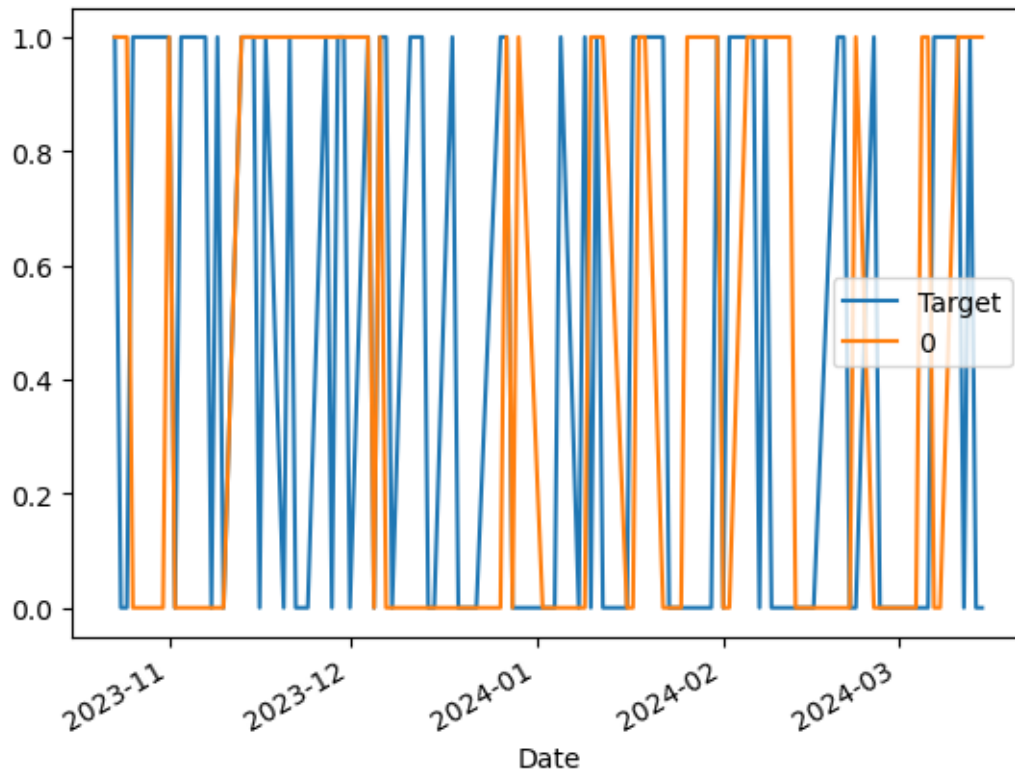
```
[30]: precision_score(test["Target"], preds)
```

```
[30]: 0.4888888888888889
```

```
[32]: combined = pd.concat([test["Target"], preds], axis=1)
```

```
[33]: combined.plot()
```

```
[33]: <Axes: xlabel='Date'>
```



```
[63]: def predict(train, test, predictors, model):
    model.fit(train[predictors], train["Target"])
    preds = model.predict(test[predictors])
    preds = pd.Series(preds, index=test.index, name= "Predictions")
    combined = pd.concat([test["Target"], preds], axis=1)
    return combined

[64]: def backtest(data, model, predictors, start=2500, step=250): # there are 250
    ↪ trading days per year.
    #We are testing by year steps and using the first 10 years as a starting
    ↪ point. ie. backtest year 11 on the 10 years prior, year 12 on the 11 years
    # prior etc.
    all_predictions = []

    for i in range(start, data.shape[0], step): #the data.shape[0] is the
    ↪ number of rows in dataset.
        train = data.iloc[0:i].copy()
        test = data.iloc[i:(i+step)].copy()
        predictions = predict(train, test, predictors, model)
        all_predictions.append(predictions)
    return pd.concat(all_predictions)
```

```
[65]: predictions = backtest(apple, model, predictors)
```

```
[66]: predictions["Predictions"].value_counts()
```

```
[66]: Predictions
0      4170
1      1947
Name: count, dtype: int64
```

```
[67]: precision_score(predictions["Target"], predictions["Predictions"])
```

```
[67]: 0.5125834617360041
```

```
[69]: predictions["Target"].value_counts()/predictions.shape[0]
```

```
[69]: Target
1      0.520353
0      0.479647
Name: count, dtype: float64
```

```
[71]: horizons = [2,5,60,250,1000]
new_predictors = []

for horizon in horizons:
    rolling_averages = apple.rolling(horizon).mean()
    ratio_column = f"Close_Ratio_{horizon}"
    apple[ratio_column] = apple["Close"]/rolling_averages["Close"]

    trend_column = f"Trend_{horizon}"
    apple[trend_column] = apple.shift(1).rolling(horizon).sum()["Target"]

    new_predictors += [ratio_column, trend_column]
```

```
[73]: apple.head(10)
```

```
[73]:
```

	Open	High	Low	Close	Volume \
Date					
1990-01-02 00:00:00-05:00	0.248953	0.264843	0.247187	0.263078	183198400
1990-01-03 00:00:00-05:00	0.268375	0.268375	0.264843	0.264843	207995200
1990-01-04 00:00:00-05:00	0.270141	0.273672	0.263078	0.265727	221513600
1990-01-05 00:00:00-05:00	0.266610	0.270141	0.261312	0.266610	123312000
1990-01-08 00:00:00-05:00	0.264843	0.268375	0.261312	0.268375	101572800
1990-01-09 00:00:00-05:00	0.268375	0.268375	0.261312	0.265727	86139200
1990-01-10 00:00:00-05:00	0.265727	0.265727	0.252484	0.254250	199718400

1990-01-11 00:00:00-05:00	0.256016	0.256016	0.243656	0.243656	211052800
1990-01-12 00:00:00-05:00	0.241891	0.245422	0.238359	0.243656	171897600
1990-01-15 00:00:00-05:00	0.243657	0.252484	0.241891	0.241891	161739200

Date	Tomorrow	Target	Close_Ratio_2	Trend_2	\
1990-01-02 00:00:00-05:00	0.264843	1	NaN	NaN	
1990-01-03 00:00:00-05:00	0.265727	1	1.003344	NaN	
1990-01-04 00:00:00-05:00	0.266610	1	1.001665	2.0	
1990-01-05 00:00:00-05:00	0.268375	1	1.001659	2.0	
1990-01-08 00:00:00-05:00	0.265727	0	1.003300	2.0	
1990-01-09 00:00:00-05:00	0.254250	0	0.995041	1.0	
1990-01-10 00:00:00-05:00	0.243656	0	0.977929	0.0	
1990-01-11 00:00:00-05:00	0.243656	0	0.978723	0.0	
1990-01-12 00:00:00-05:00	0.241891	0	1.000000	0.0	
1990-01-15 00:00:00-05:00	0.246305	1	0.996364	0.0	

Date	Close_Ratio_5	Trend_5	Close_Ratio_60	Trend_60	\
1990-01-02 00:00:00-05:00	NaN	NaN	NaN	NaN	
1990-01-03 00:00:00-05:00	NaN	NaN	NaN	NaN	
1990-01-04 00:00:00-05:00	NaN	NaN	NaN	NaN	
1990-01-05 00:00:00-05:00	NaN	NaN	NaN	NaN	
1990-01-08 00:00:00-05:00	1.009967	NaN	NaN	NaN	
1990-01-09 00:00:00-05:00	0.998011	4.0	NaN	NaN	
1990-01-10 00:00:00-05:00	0.962567	3.0	NaN	NaN	
1990-01-11 00:00:00-05:00	0.938137	2.0	NaN	NaN	
1990-01-12 00:00:00-05:00	0.955017	1.0	NaN	NaN	
1990-01-15 00:00:00-05:00	0.968198	0.0	NaN	NaN	

Date	Close_Ratio_250	Trend_250	Close_Ratio_1000	\
1990-01-02 00:00:00-05:00	NaN	NaN	NaN	
1990-01-03 00:00:00-05:00	NaN	NaN	NaN	
1990-01-04 00:00:00-05:00	NaN	NaN	NaN	
1990-01-05 00:00:00-05:00	NaN	NaN	NaN	
1990-01-08 00:00:00-05:00	NaN	NaN	NaN	
1990-01-09 00:00:00-05:00	NaN	NaN	NaN	
1990-01-10 00:00:00-05:00	NaN	NaN	NaN	
1990-01-11 00:00:00-05:00	NaN	NaN	NaN	
1990-01-12 00:00:00-05:00	NaN	NaN	NaN	
1990-01-15 00:00:00-05:00	NaN	NaN	NaN	

Date	Trend_1000
1990-01-02 00:00:00-05:00	NaN
1990-01-03 00:00:00-05:00	NaN

1990-01-04 00:00:00-05:00	NaN
1990-01-05 00:00:00-05:00	NaN
1990-01-08 00:00:00-05:00	NaN
1990-01-09 00:00:00-05:00	NaN
1990-01-10 00:00:00-05:00	NaN
1990-01-11 00:00:00-05:00	NaN
1990-01-12 00:00:00-05:00	NaN
1990-01-15 00:00:00-05:00	NaN

```
[74]: apple = apple.dropna()
```

```
[75]: apple
```

```
[75]:
```

	Open	High	Low	Close \
Date				
1993-12-14 00:00:00-05:00	0.215567	0.219251	0.213724	0.214645
1993-12-15 00:00:00-05:00	0.213724	0.219251	0.213724	0.219251
1993-12-16 00:00:00-05:00	0.217409	0.219251	0.213724	0.216488
1993-12-17 00:00:00-05:00	0.217409	0.219251	0.214645	0.217409
1993-12-20 00:00:00-05:00	0.215567	0.219251	0.208196	0.210039
...
2024-03-08 00:00:00-05:00	169.000000	173.699997	168.940002	170.729996
2024-03-11 00:00:00-04:00	172.940002	174.380005	172.050003	172.750000
2024-03-12 00:00:00-04:00	173.149994	174.029999	171.009995	173.229996
2024-03-13 00:00:00-04:00	172.770004	173.190002	170.759995	171.130005
2024-03-14 00:00:00-04:00	172.910004	174.309998	172.050003	173.000000

	Volume	Tomorrow	Target	Close_Ratio_2 \
Date				
1993-12-14 00:00:00-05:00	293664000	0.219251	1	0.993604
1993-12-15 00:00:00-05:00	123883200	0.216488	0	1.010615
1993-12-16 00:00:00-05:00	126369600	0.217409	1	0.993658
1993-12-17 00:00:00-05:00	145152000	0.210039	0	1.002123
1993-12-20 00:00:00-05:00	189033600	0.202669	0	0.982758
...
2024-03-08 00:00:00-05:00	76114600	172.750000	1	1.005092
2024-03-11 00:00:00-04:00	60139500	173.229996	1	1.005881
2024-03-12 00:00:00-04:00	59825400	171.130005	0	1.001387
2024-03-13 00:00:00-04:00	52488700	173.000000	1	0.993902
2024-03-14 00:00:00-04:00	72913500	172.619995	0	1.005434

	Trend_2	Close_Ratio_5	Trend_5	Close_Ratio_60 \
Date				
1993-12-14 00:00:00-05:00	1.0	0.978993	1.0	1.007241
1993-12-15 00:00:00-05:00	1.0	1.014492	2.0	1.025699
1993-12-16 00:00:00-05:00	1.0	1.005994	2.0	1.010468
1993-12-17 00:00:00-05:00	1.0	1.001698	3.0	1.011960

1993-12-20 00:00:00-05:00	1.0	0.974358	2.0	0.975653
...
2024-03-08 00:00:00-05:00	1.0	0.999508	1.0	0.914759
2024-03-11 00:00:00-04:00	2.0	1.014124	2.0	0.927380
2024-03-12 00:00:00-04:00	2.0	1.013242	3.0	0.931998
2024-03-13 00:00:00-04:00	1.0	0.998611	3.0	0.922912
2024-03-14 00:00:00-04:00	1.0	1.004832	4.0	0.935041

Date	Trend_60	Close_Ratio_250	Trend_250	\
1993-12-14 00:00:00-05:00	22.0	0.694753	111.0	
1993-12-15 00:00:00-05:00	23.0	0.711547	111.0	
1993-12-16 00:00:00-05:00	22.0	0.704569	110.0	
1993-12-17 00:00:00-05:00	23.0	0.709636	110.0	
1993-12-20 00:00:00-05:00	22.0	0.687599	110.0	
...	
2024-03-08 00:00:00-05:00	22.0	0.950643	128.0	
2024-03-11 00:00:00-04:00	22.0	0.961397	128.0	
2024-03-12 00:00:00-04:00	22.0	0.963608	128.0	
2024-03-13 00:00:00-04:00	21.0	0.951525	127.0	
2024-03-14 00:00:00-04:00	22.0	0.961538	127.0	

Date	Close_Ratio_1000	Trend_1000
1993-12-14 00:00:00-05:00	0.637248	462.0
1993-12-15 00:00:00-05:00	0.651010	462.0
1993-12-16 00:00:00-05:00	0.642898	461.0
1993-12-17 00:00:00-05:00	0.645728	461.0
1993-12-20 00:00:00-05:00	0.623946	460.0
...
2024-03-08 00:00:00-05:00	1.178999	520.0
2024-03-11 00:00:00-04:00	1.192018	521.0
2024-03-12 00:00:00-04:00	1.194363	522.0
2024-03-13 00:00:00-04:00	1.178938	522.0
2024-03-14 00:00:00-04:00	1.190895	522.0

[7616 rows x 17 columns]

```
[78]: model = RandomForestClassifier(n_estimators=200, min_samples_split=50,
↳ random_state=1)
```

```
[79]: def predict(train, test, predictors, model):
    model.fit(train[predictors], train["Target"])
    preds = model.predict_proba(test[predictors])[:,1]
    preds[preds >= 0.6] = 1
    preds[preds < 0.6] = 0
    preds = pd.Series(preds, index=test.index, name= "Predictions")
```

```
combined = pd.concat([test["Target"], preds], axis=1)
return combined
```

```
[80]: predictions= backtest(apple, model, new_predictors)
```

```
[83]: predictions["Predictions"].value_counts()
```

```
[83]: Predictions
0.0    4577
1.0     539
Name: count, dtype: int64
```

```
[84]: precision_score(predictions["Target"], predictions["Predictions"])
```

```
[84]: 0.5306122448979592
```