Question 1

Q1 1.

S&P-500

```
    Date    Return  True Label
0   2016-01-04  0.000000    +
1   2016-01-05  0.001692    +
2   2016-01-06  -0.012614   -
3   2016-01-07  -0.023992   -
4   2016-01-08  -0.010977   -
... ... ... ...
1253    2020-12-23  0.000899    +
1254    2020-12-24  0.003890    +
1255    2020-12-28  0.008591    +
1256    2020-12-29  -0.001908   -
1257    2020-12-30  0.001427    +
1258 rows × 3 columns
```

KO stock

```
    Date    Return  True Label
0   2016-01-04  0.000000    +
1   2016-01-05  0.003538    +
2   2016-01-06  -0.005405   -
3   2016-01-07  -0.016541   -
4   2016-01-08  -0.002643   -
... ... ... ...
1253    2020-12-23  0.006065    +
1254    2020-12-24  0.006782    +
1255    2020-12-28  0.013473    +
1256    2020-12-29  -0.000554   -
1257    2020-12-30  0.005727    +
```

Q1 2.

S&P-500 p* = 0.5543766578249337
KO p* = 0.5411140583554377

Q1 3.

S&P-500 k=1:
-- : 0.32432432432432434
-+ : 0.6756756756756757
S&P-500 k=2:
--- : 0.3076923076923077

--+ : 0.6923076923076923
S&P-500 k=3:
---- : 0.2857142857142857
---+ : 0.7142857142857143

KO k=1:
-- : 0.3708609271523179
-+ : 0.6291390728476821
KO k=2:
--- : 0.31343283582089554
--+ : 0.6865671641791045
KO k=3:
---- : 0.3103448275862069
---+ : 0.6896551724137931

Q1 4.

S&P-500 k=1:
++ : 0.41690962099125367
+- : 0.5830903790087464
S&P-500 k=2:
+++ : 0.38285714285714284
++- : 0.6171428571428571
S&P-500 k=3:
++++ : 0.30952380952380953
+++- : 0.6904761904761905

KO k=1:
++ : 0.43283582089552236
+- : 0.5671641791044776
KO k=2:
+++ : 0.3614457831325301
++- : 0.6385542168674698
KO k=3:
++++ : 0.38095238095238093
+++- : 0.6190476190476191

Question 2

Q2 1.

S&P-500

```
    Date    Return  True Label  Predict Label 2 Predict Label 3 Predict Label 4
754 2019-01-02  0.001040    +   +   +   -
755 2019-01-03  -0.023863   -   +   +   +
756 2019-01-04  0.033496    +   +   +   +
757 2019-01-07  0.007885    +   +   +   -
```

```
758 2019-01-08  0.009395    +   +   +   +
... ... ... ... ... ... ...
1253    2020-12-23  0.000899    +   +   +   +
1254    2020-12-24  0.003890    +   +   +   +
1255    2020-12-28  0.008591    +   +   +   +
1256    2020-12-29  -0.001908   -   +   -   -
1257    2020-12-30  0.001427    +   +   +   +
504 rows × 6 columns
```

KO

```
    Date    Return  True Label  Predict Label 2 Predict Label 3 Predict Label 4
754 2019-01-02  -0.008870   -   +   +   +
755 2019-01-03  -0.006179   -   +   +   +
756 2019-01-04  0.019940    +   +   +   +
757 2019-01-07  -0.013034   -   +   +   +
758 2019-01-08  0.011289    +   +   +   -
... ... ... ... ... ... ...
1253    2020-12-23  0.006065    +   +   +   +
1254    2020-12-24  0.006782    +   +   +   +
1255    2020-12-28  0.013473    +   +   -   -
1256    2020-12-29  -0.000554   -   +   +   +
1257    2020-12-30  0.005727    +   +   +   +
504 rows × 6 columns
```

Q2 2.

S&P-500
W = 2 accuracy of '+' : 1.0
W = 2 accuracy of '-' : 0.0
W = 2 total accuracy : 0.5853174603174603

W = 3 accuracy of '+' : 0.8372881355932204
W = 3 accuracy of '-' : 0.22966507177033493
W = 3 total accuracy : 0.5853174603174603

W = 4 accuracy of '+' : 0.8
W = 4 accuracy of '-' : 0.2583732057416268
W = 4 total accuracy : 0.5753968253968254

KO
W = 2 accuracy of '+' : 1.0
W = 2 accuracy of '-' : 0.0
W = 2 accuracy - 0.5337301587301587

W = 3 accuracy of '+' : 0.8661710037174721
W = 3 accuracy of '-' : 0.12340425531914893
W = 3 accuracy - 0.5198412698412699

W = 4 accuracy of '+' : 0.6468401486988847
W = 4 accuracy of '-' : 0.28936170212765955
W = 4 accuracy - 0.4801587301587302

Q2 3.

W=2 accuracy is the highest for the KO stock
W=2 and W=3 accuracies are the highest for the S&P-500 stock

Question 3

Q3 1.

S&P-500

```
    Date    Return  True Label  Predict Label 2 Predict Label 3 Predict Label 4 
Ensemble Predict
754 2019-01-02  0.001040    +   +   +   -   +
755 2019-01-03  -0.023863   -   +   +   +   +
756 2019-01-04  0.033496    +   +   +   +   +
757 2019-01-07  0.007885    +   +   +   -   +
758 2019-01-08  0.009395    +   +   +   +   +
... ... ... ... ... ... ... ...
1253    2020-12-23  0.000899    +   +   +   +   +
1254    2020-12-24  0.003890    +   +   +   +   +
1255    2020-12-28  0.008591    +   +   +   +   +
1256    2020-12-29  -0.001908   -   +   -   -   -
1257    2020-12-30  0.001427    +   +   +   +   +
504 rows × 7 columns
```

KO

```
    Date    Return  True Label  Predict Label 2 Predict Label 3 Predict Label 4 
Ensemble Predict
754 2019-01-02  -0.008870   -   +   +   +   +
755 2019-01-03  -0.006179   -   +   +   +   +
756 2019-01-04  0.019940    +   +   +   +   +
757 2019-01-07  -0.013034   -   +   +   +   +
758 2019-01-08  0.011289    +   +   +   -   +
... ... ... ... ... ... ... ...
1253    2020-12-23  0.006065    +   +   +   +   +
1254    2020-12-24  0.006782    +   +   +   +   +
1255    2020-12-28  0.013473    +   +   -   -   -
1256    2020-12-29  -0.000554   -   +   +   +   +
1257    2020-12-30  0.005727    +   +   +   +   +
504 rows × 7 columns
```

Q3 2.

S&P-500
Ensemble accuracy of '+' : 0.9220338983050848
Ensemble accuracy of '-' : 0.11961722488038277
Ensemble total accuracy : 0.5892857142857143

KO
Ensemble accuracy of '+' : 0.9368029739776952
Ensemble accuracy of '-' : 0.05106382978723404
Ensemble total accuracy : 0.5238095238095238

Q3 3.

For S&P-500 the accuracy of predicting '-' in ensemble is better than only W=2
For KO the accuracy of predicting '-' in ensemble is better than only W=2

Q3 4.

For S&P-500 the accuracy of predicting '+' in ensemble is better than W=3 and W=4
For KO the accuracy of predicting '+' in ensemble is better than W=3 and W=4

Question 4

Q4 1., 2., 3., 4., 5., 6.

S&P-500
W=2
TP - 295 , FP - 209 , TN - 0 , FN - 0
TPR - 1.0
TNR - 0.0

W=3
TP - 247 , FP - 161 , TN - 48 , FN - 48
TPR - 0.8372881355932204
TNR - 0.22966507177033493

W=4
TP - 236 , FP - 155 , TN - 54 , FN - 59
TPR - 0.8
TNR - 0.2583732057416268

Ensemble
TP - 272 , FP - 184 , TN - 25 , FN - 23
TPR - 0.9220338983050848
TNR - 0.11961722488038277

KO
W=2
TP - 269 , FP - 235 , TN - 0 , FN - 0
TPR - 1.0
TNR - 0.0

W=3
TP - 233 , FP - 206 , TN - 29 , FN - 36
TPR - 0.8661710037174721
TNR - 0.12340425531914893

W=4
TP - 174 , FP - 167 , TN - 68 , FN - 95
TPR - 0.6468401486988847
TNR - 0.28936170212765955

Ensemble
TP - 252 , FP - 223 , TN - 12 , FN - 17
TPR - 0.9368029739776952
TNR - 0.05106382978723404

Q4 7.

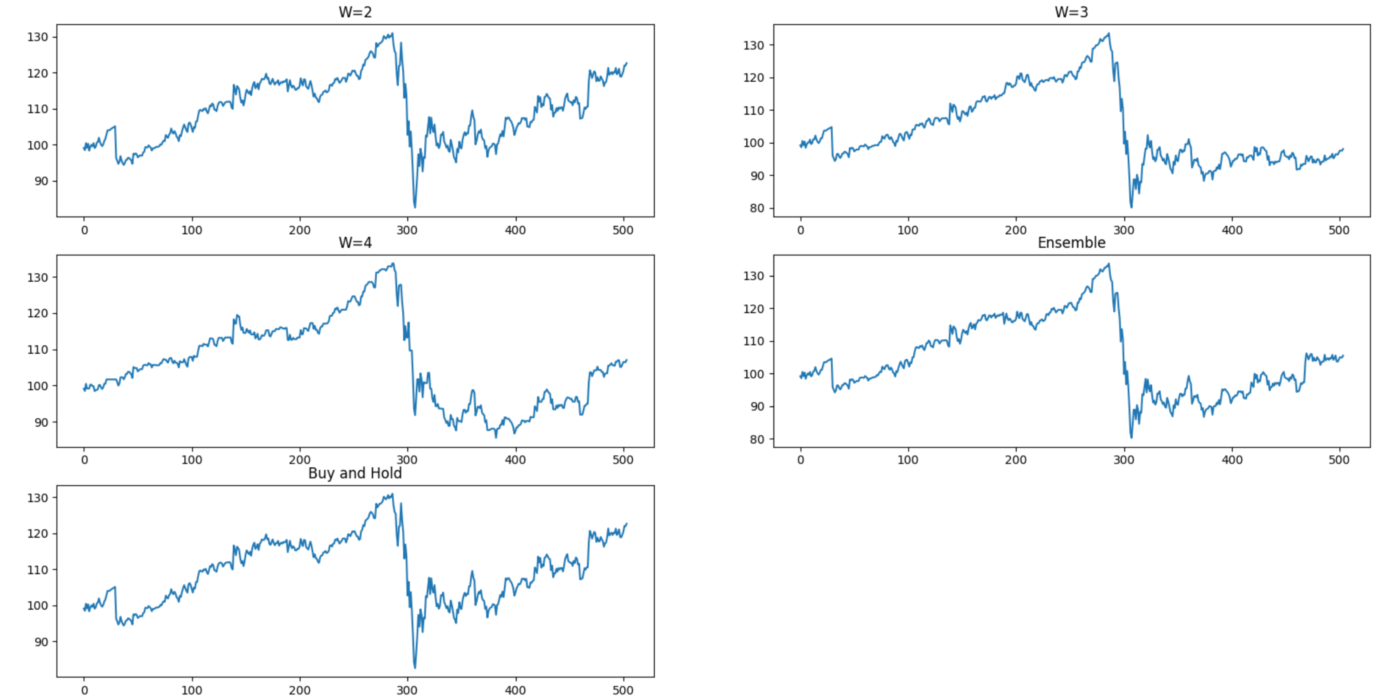
index	W	ticker	TP	FP	TN	FN	accuracy	TPR	TNR
0	2	S&P-500	295.0	209.0	0.0	0.0	0.585317	1.000000	0.000000
1	3	S&P-500	247.0	161.0	48.0	48.0	0.585317	0.837288	0.229665
2	4	S&P-500	236.0	155.0	54.0	59.0	0.575397	0.800000	0.258373
3	Ensemble	S&P-500	272.0	184.0	25.0	23.0	0.589286	0.922034	0.119617
4	2	KO	269.0	235.0	0.0	0.0	0.533730	1.000000	0.000000
5	3	KO	233.0	206.0	29.0	36.0	0.519841	0.866171	0.123404
6	4	KO	174.0	167.0	68.0	95.0	0.480159	0.646840	0.289362
7	Ensemble	KO	252.0	223.0	12.0	17.0	0.523810	0.936803	0.051064

Q4 8.

w2 has highest TP and FP while it has the least TN and FN for both SPY and Ko ticker.

Question 5

Q5 1.



Q5 2.

There is a huge dip in returns of the stock during the beginning of 2020 and then there was considerable rise of the returns.
W=2 graph is the most similar to the Buy and Hold graph