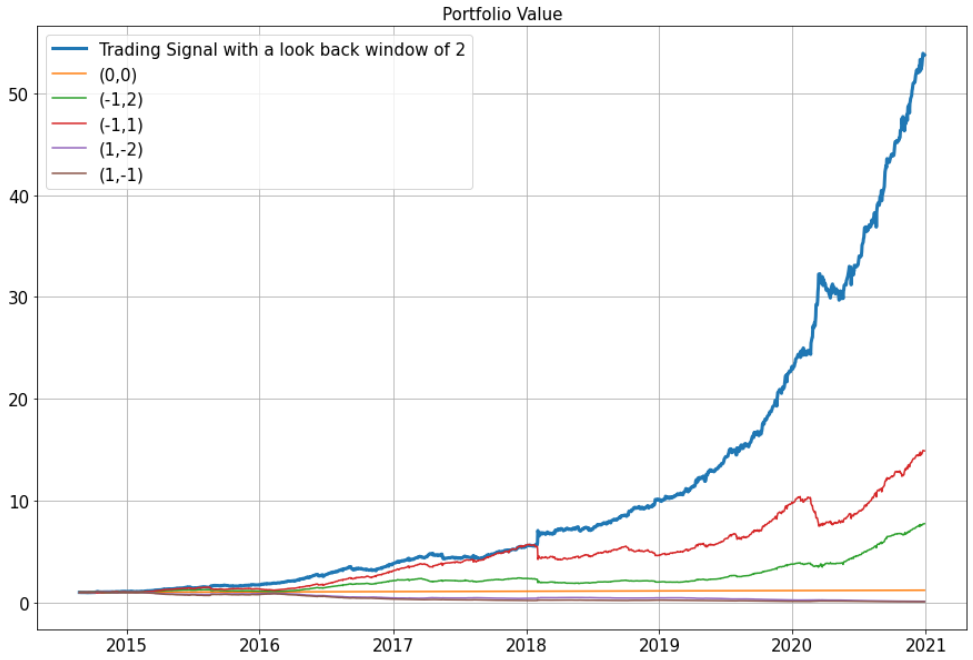
FIM590-001 HW3 Yuan Chun Lin

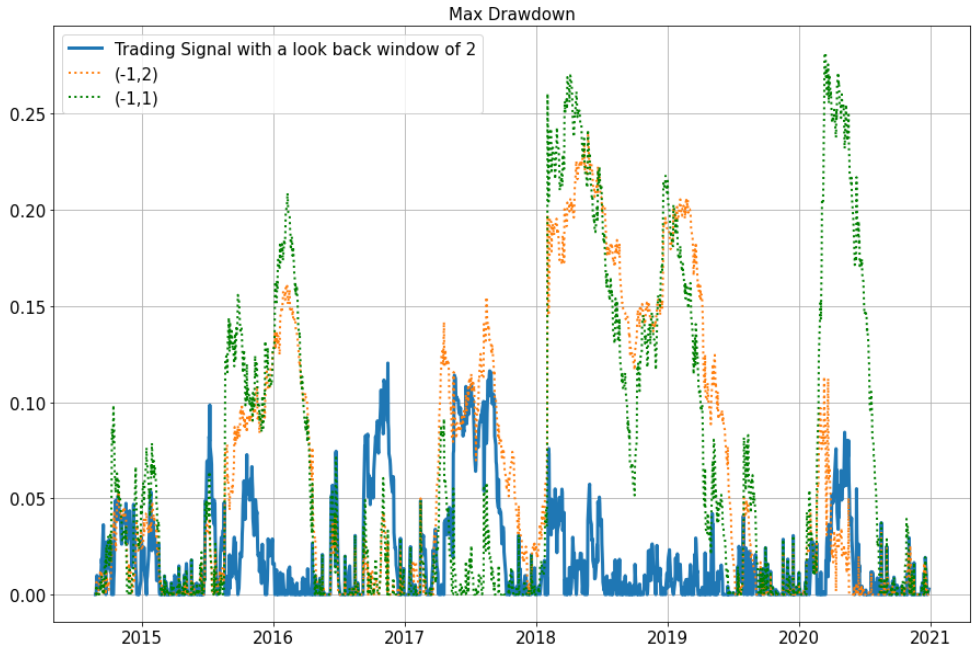
Problem #1 (Implementing Lookback)

Based on the Python scripts on the FIM590 Moodle page, implement the VIX multinomial trading signal with a dense neural network and a lookback window of 2, 5, 8 and 10 days. Which length of window works best? Use the following block of code to put your labelled data into lookback form.

1. *Lookback window of 2 days:*



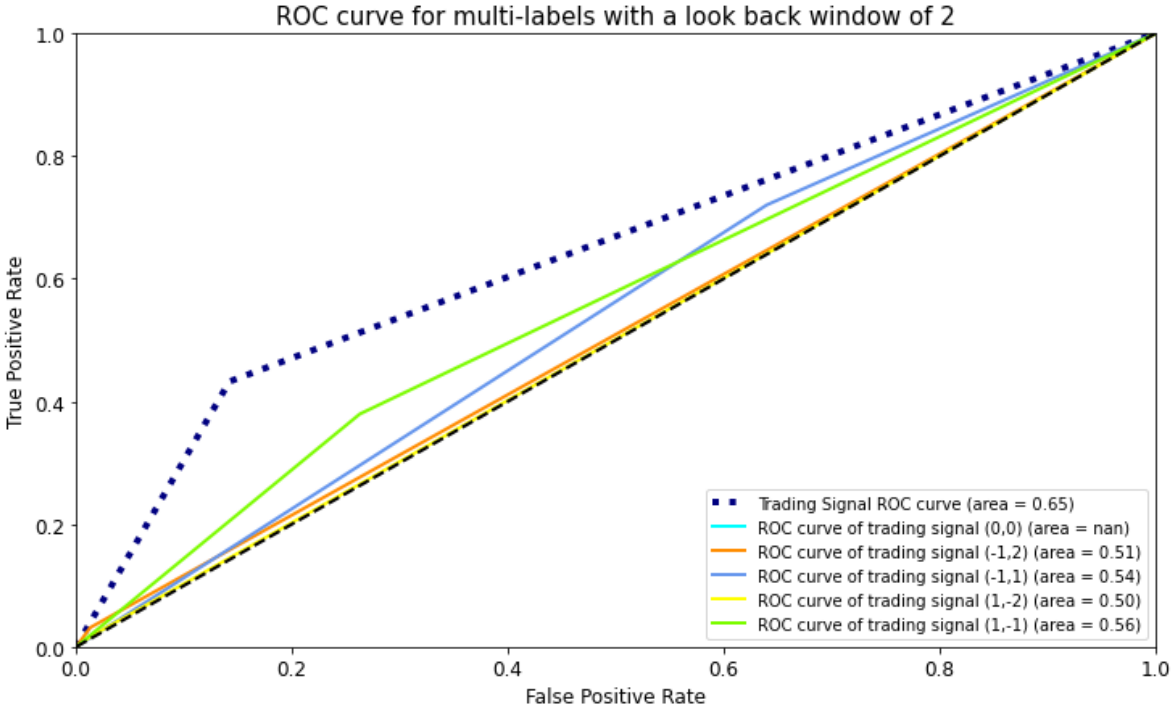

```
Accuracy Score : 43%
Cumulative Return : 63%
Position Return:  [ 0.02999821  0.3227896   0.42591766 -0.34330771 -0.40489336]
```

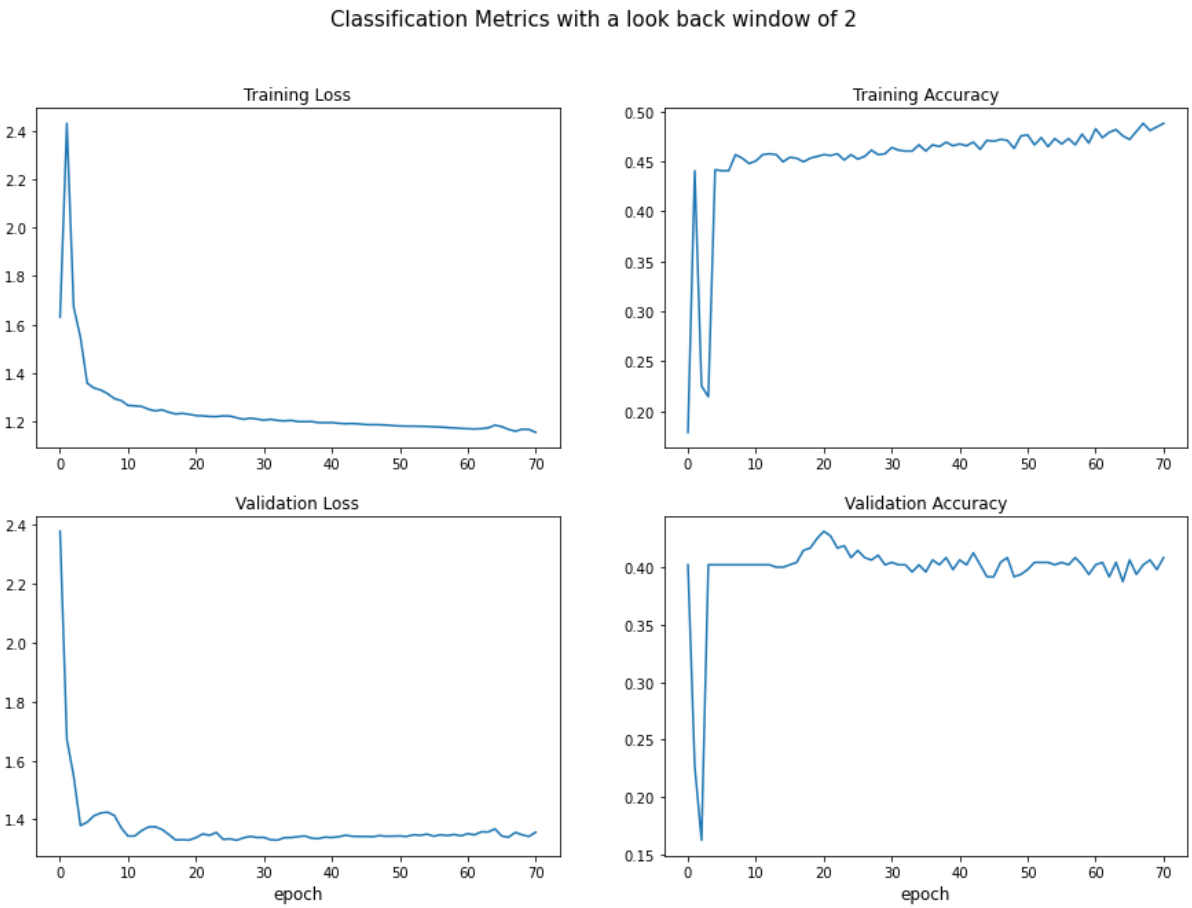


```
1 model.summary()
```

```
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 flatten_9 (Flatten)          (None, 22)                0

 dense_45 (Dense)             (None, 1500)              34500

 dense_46 (Dense)             (None, 1500)              2251500

 dense_47 (Dense)             (None, 1500)              2251500

 dense_48 (Dense)             (None, 1500)              2251500

 dense_49 (Dense)             (None, 5)                 7505

=================================================================
Total params: 6,796,505
Trainable params: 6,796,505
Non-trainable params: 0
```

	precision	recall	f1-score	support
(0,0)	0.00	0.00	0.00	0
(-1,2)	0.35	0.03	0.06	288
(-1,1)	0.48	0.72	0.58	726
(1,-2)	0.13	0.02	0.03	173
(1,-1)	0.33	0.38	0.35	411
micro avg	0.43	0.43	0.43	1598
macro avg	0.26	0.23	0.20	1598
weighted avg	0.38	0.43	0.37	1598
samples avg	0.43	0.43	0.43	1598





**** We can see the performance indicator for model with lookback window size = 2:**

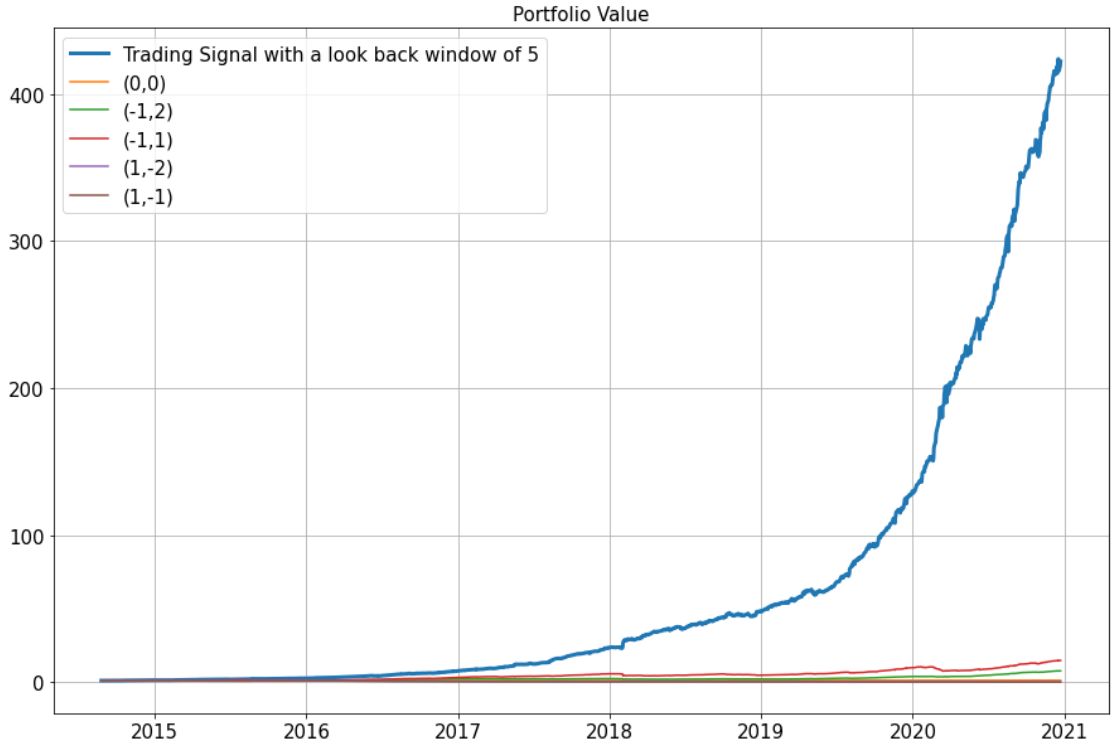
1. Accuracy score: 43%

2. Cumulative return: 63%

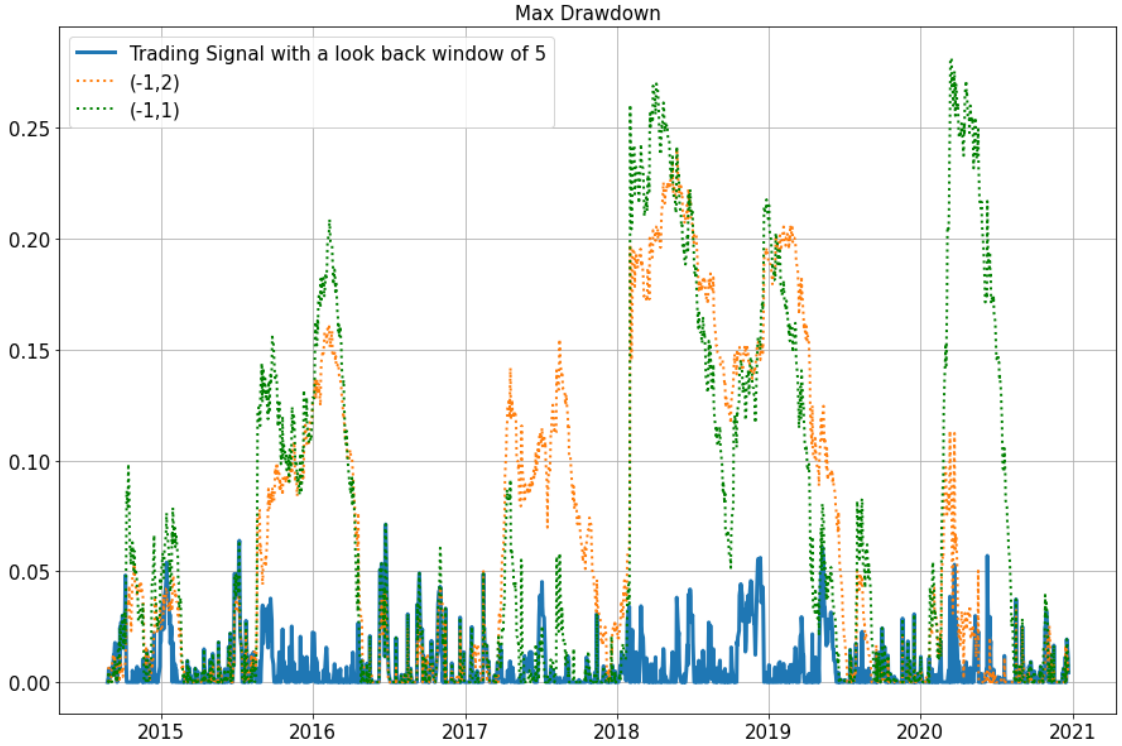
3. Max drawdown: lower than others trading strategy

4. ROC curve: 0.65

2. *Lookback window of 5 days:*



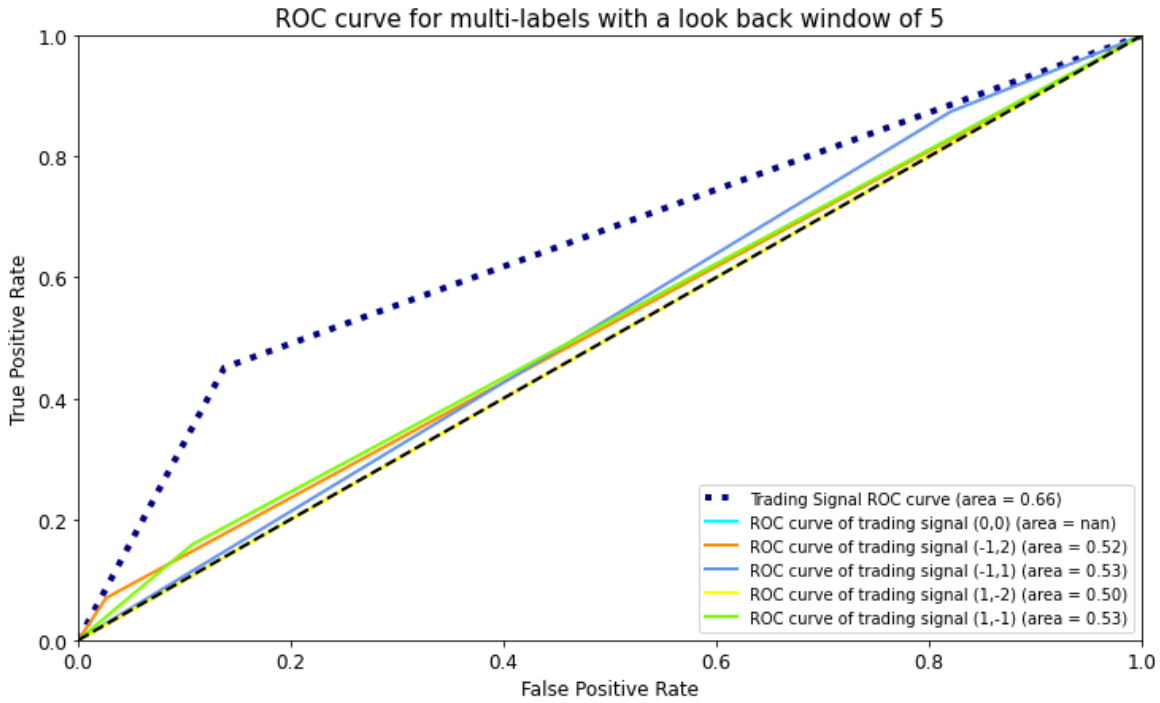

```
Accuracy Score : 45%
Cumulative Return : 96%
Position Return:  [ 0.02999821  0.32084901  0.42474424 -0.34139168 -0.40377395]
```

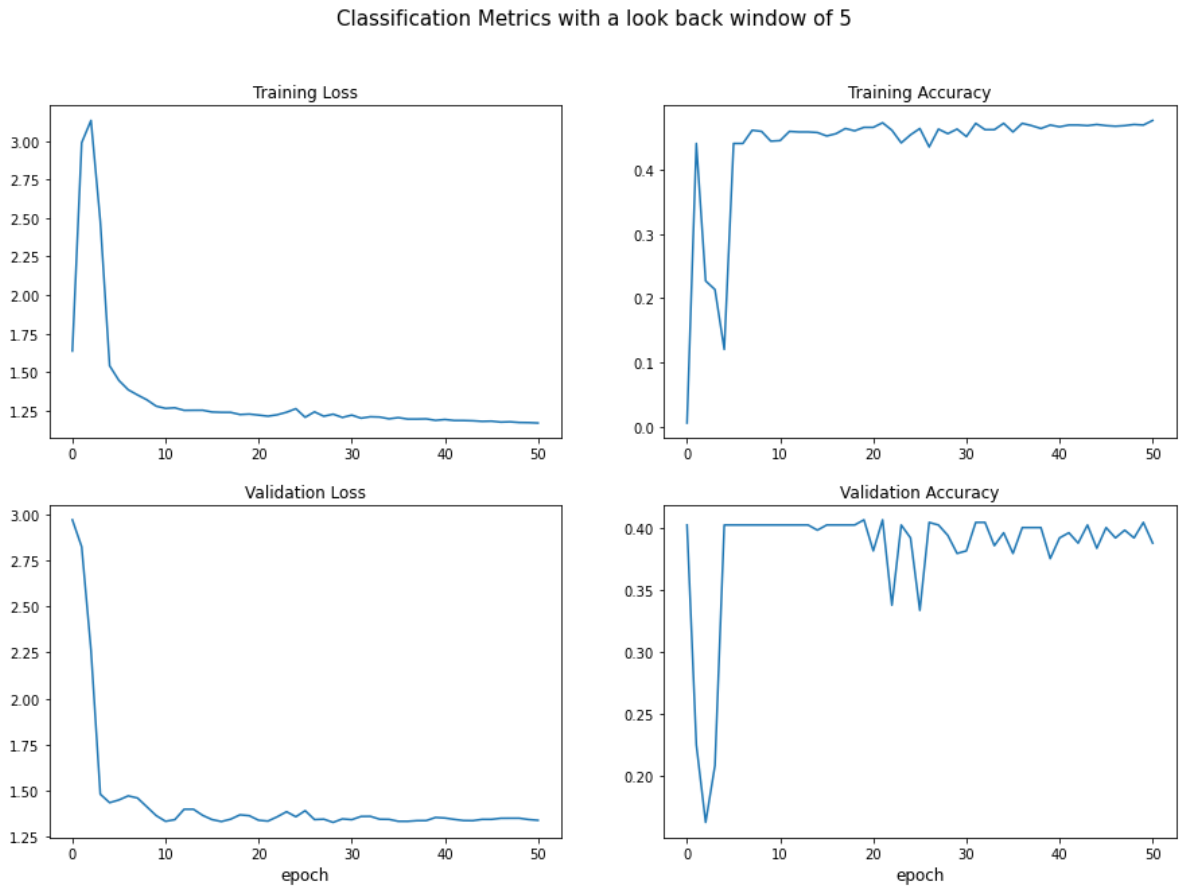


```
1 model.summary()
```

```
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 flatten (Flatten)            (None, 55)                0

 dense (Dense)                (None, 1000)              56000

 dense_1 (Dense)              (None, 1000)              1001000

 dense_2 (Dense)              (None, 1000)              1001000

 dense_3 (Dense)              (None, 1000)              1001000

 dense_4 (Dense)              (None, 5)                 5005

=================================================================
Total params: 3,064,005
Trainable params: 3,064,005
Non-trainable params: 0
```

	precision	recall	f1-score	support
(0,0)	0.00	0.00	0.00	0
(-1,2)	0.37	0.07	0.12	288
(-1,1)	0.47	0.87	0.61	725
(1,-2)	0.00	0.00	0.00	171
(1,-1)	0.34	0.16	0.22	411
micro avg	0.45	0.45	0.45	1595
macro avg	0.24	0.22	0.19	1595
weighted avg	0.37	0.45	0.35	1595
samples avg	0.45	0.45	0.45	1595





**** We can see the performance indicator for model with lookback window size = 5:**

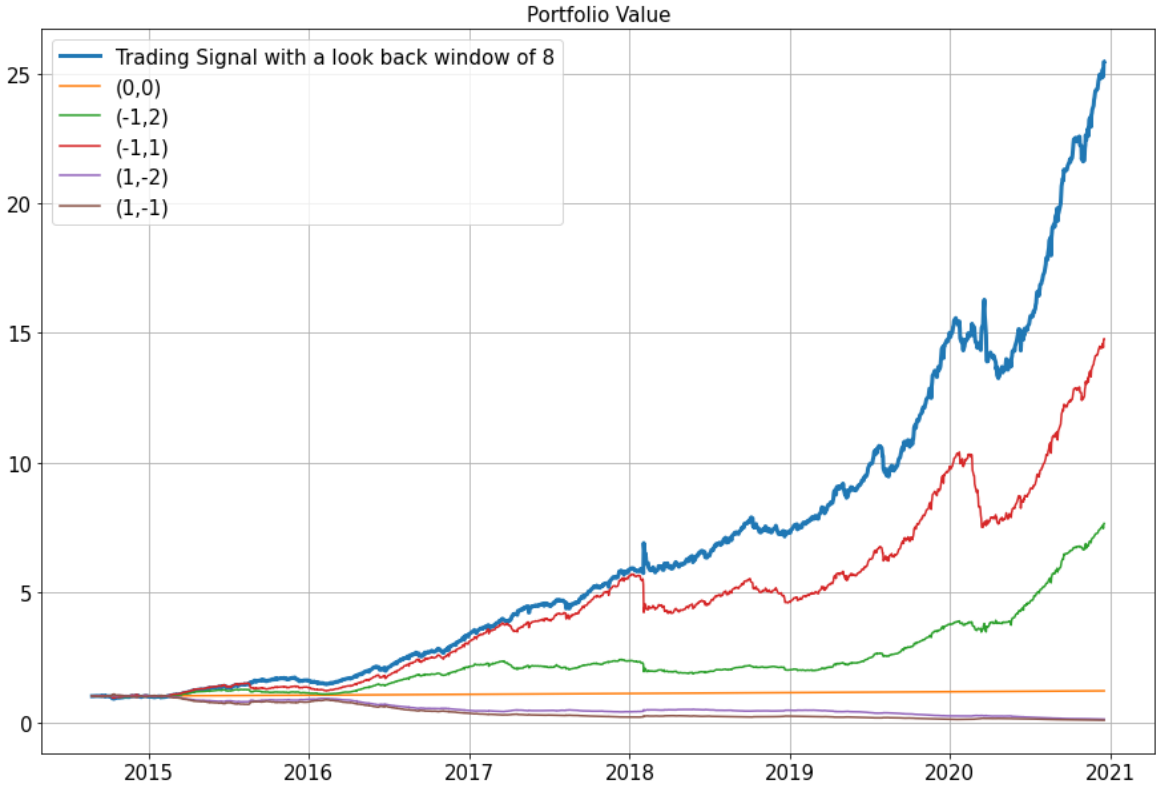
1. Accuracy score: 45%

2. Cumulative return: 96%

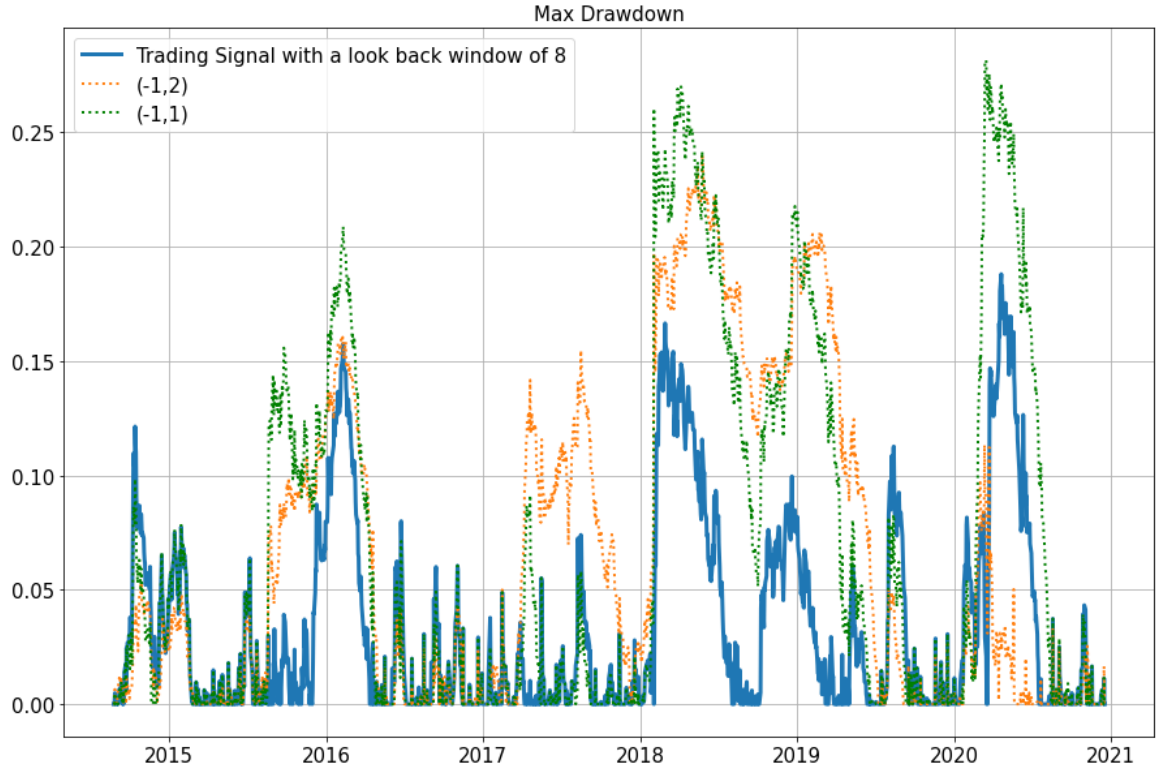
3. Max drawdown: lower than others trading strategy

4. ROC curve: 0.66

3. *Lookback window of 8 days:*



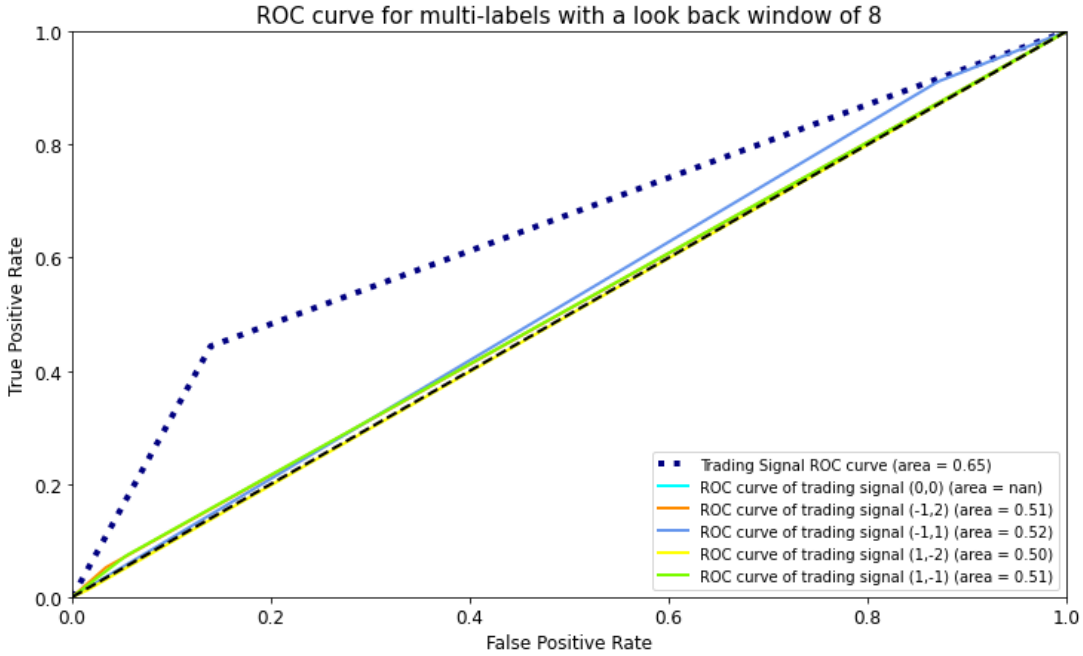

```
Accuracy Score : 44%
Cumulative Return : 51%
Position Return:  [ 0.02999821  0.32221133  0.42617557 -0.34274539 -0.40520127]
```

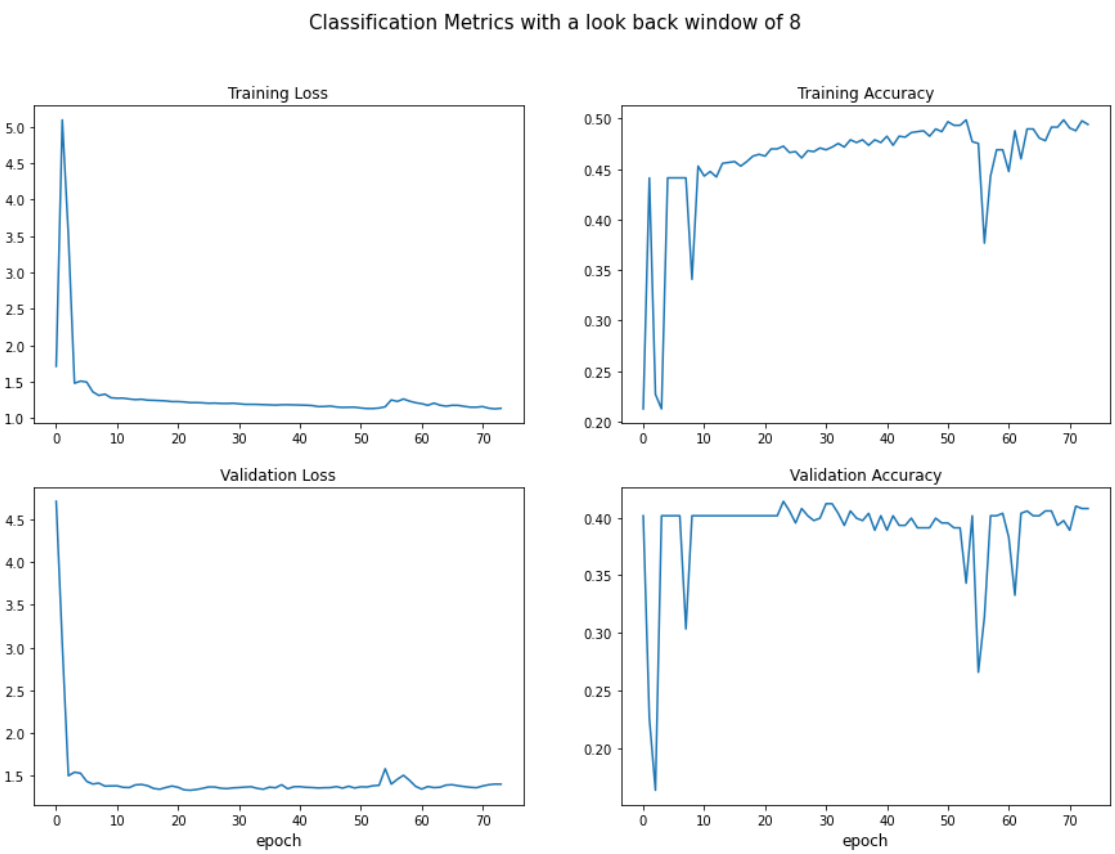


```
1 model.summary()
```

```
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 flatten_1 (Flatten)          (None, 88)                0

 dense_5 (Dense)              (None, 1000)              89000

 dense_6 (Dense)              (None, 1000)              1001000

 dense_7 (Dense)              (None, 1000)              1001000

 dense_8 (Dense)              (None, 1000)              1001000

 dense_9 (Dense)              (None, 5)                 5005

=================================================================
Total params: 3,097,005
Trainable params: 3,097,005
Non-trainable params: 0
```

	precision	recall	f1-score	support
(0,0)	0.00	0.00	0.00	0
(-1,2)	0.25	0.05	0.09	288
(-1,1)	0.47	0.91	0.62	723
(1,-2)	0.09	0.01	0.02	170
(1,-1)	0.32	0.07	0.12	411
micro avg	0.44	0.44	0.44	1592
macro avg	0.23	0.21	0.17	1592
weighted avg	0.35	0.44	0.33	1592
samples avg	0.44	0.44	0.44	1592





**** We can see the performance indicator for model with lookback window size = 8:**

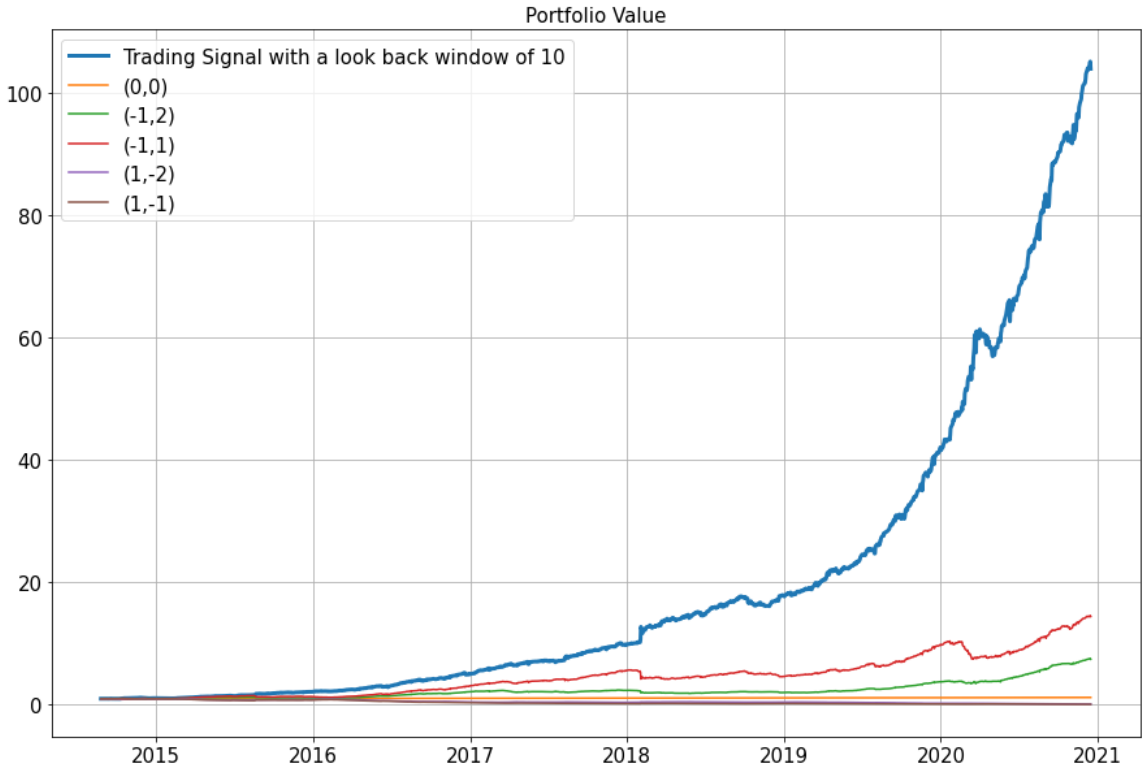
1. Accuracy score: 44%

2. Cumulative return: 51%

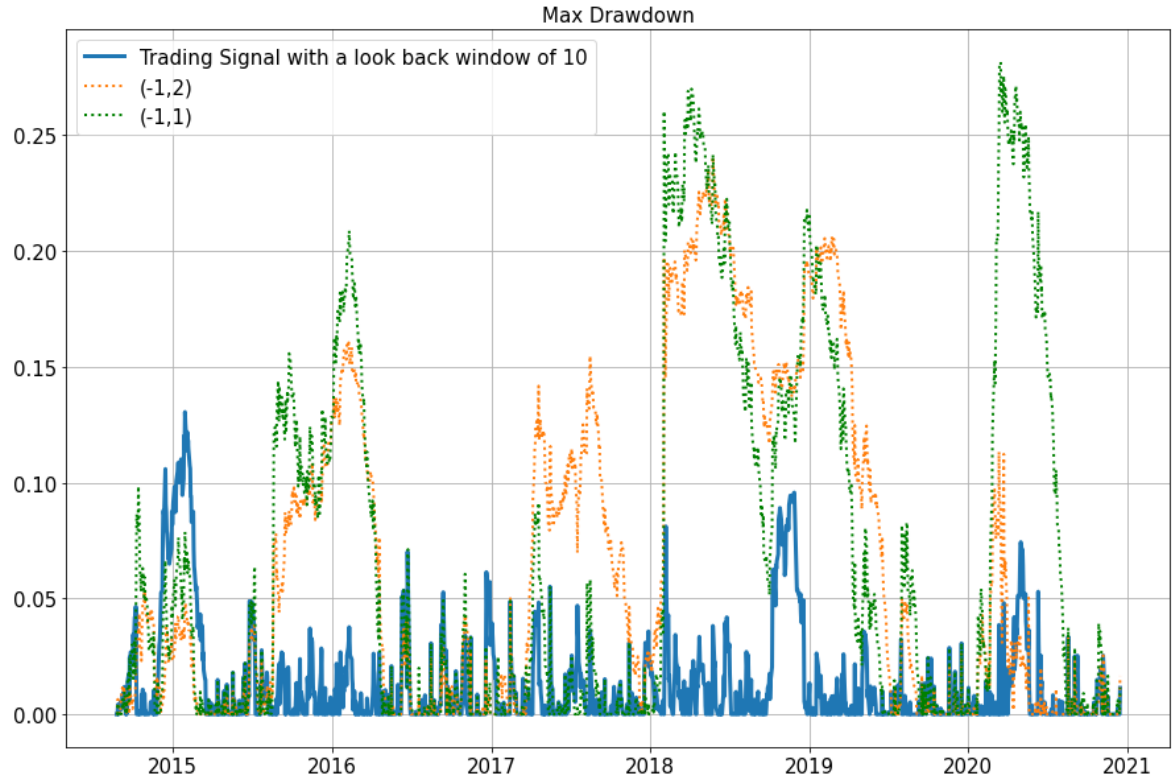
3. Max drawdown: lower than other trading strategy, but closed to others.

4. ROC curve: 0.65

4. *Lookback window of 10 days:*



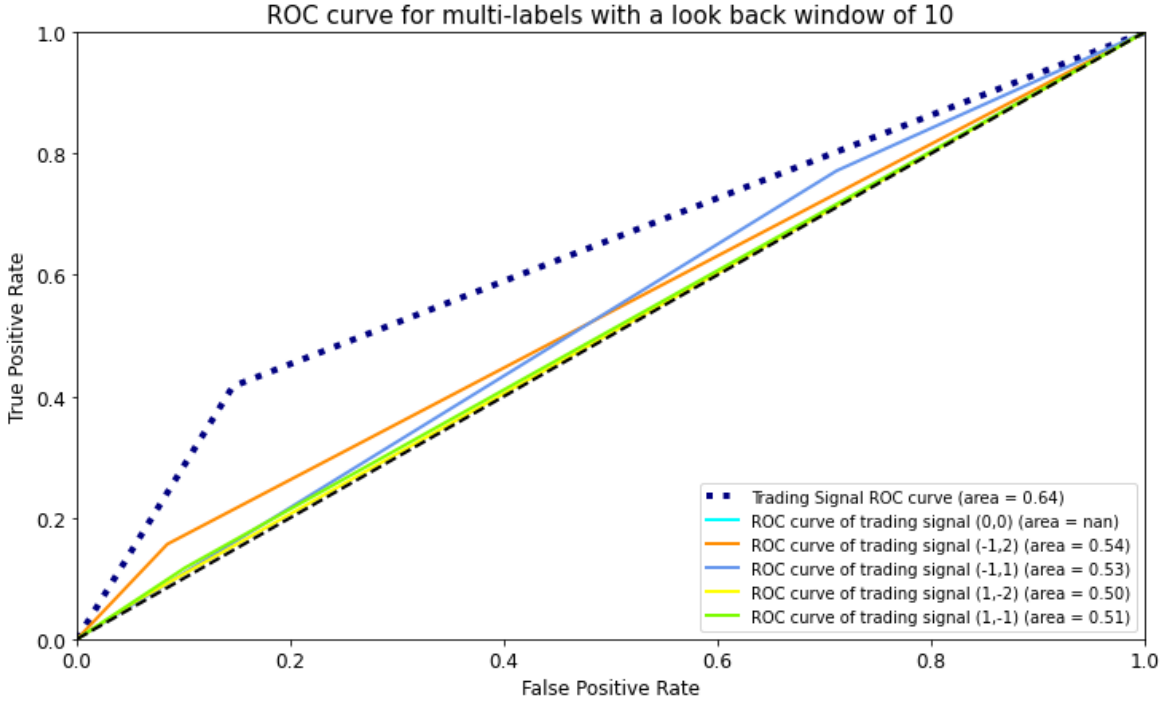

```
Accuracy Score : 42%
Cumulative Return : 74%
Position Return:  [ 0.02999821  0.31855589  0.42311594 -0.33903671 -0.40211071]
```

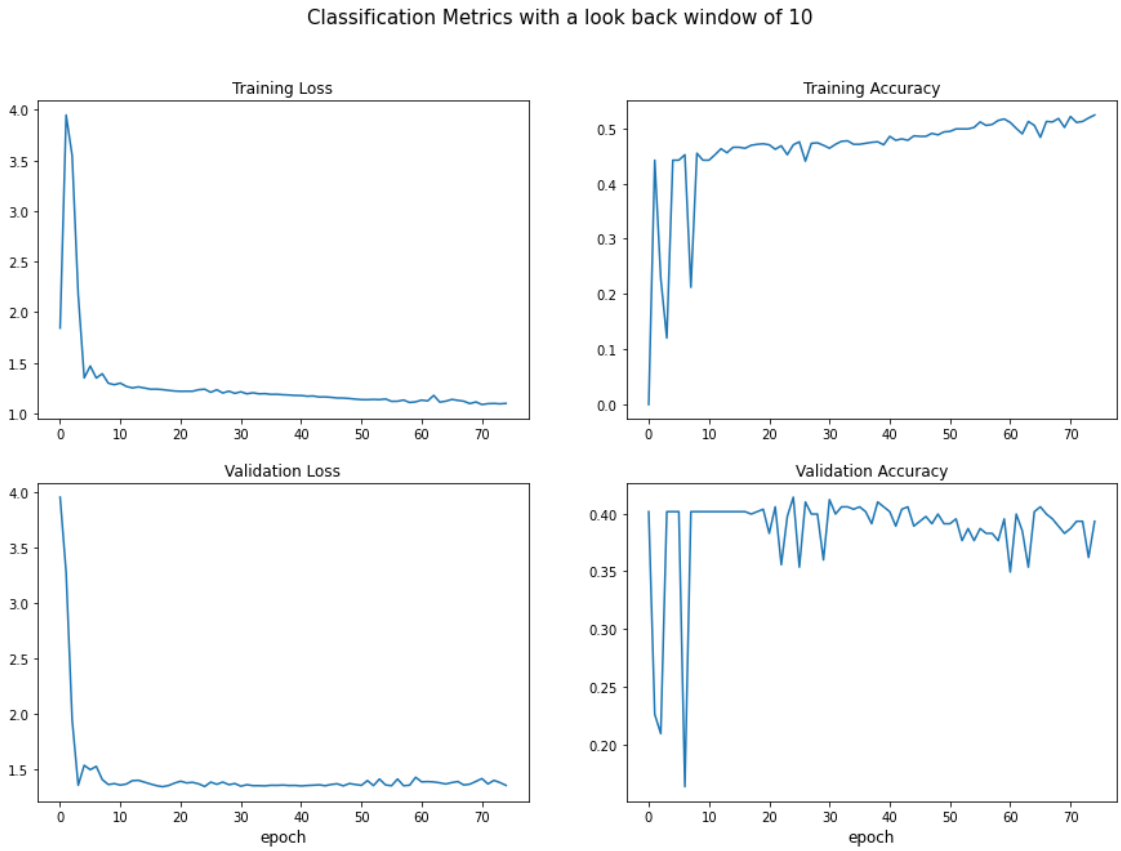


```
1 model.summary()
```

```
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 flatten_2 (Flatten)          (None, 110)               0

 dense_10 (Dense)             (None, 1000)              111000

 dense_11 (Dense)             (None, 1000)              1001000

 dense_12 (Dense)             (None, 1000)              1001000

 dense_13 (Dense)             (None, 1000)              1001000

 dense_14 (Dense)             (None, 5)                 5005

=================================================================
Total params: 3,119,005
Trainable params: 3,119,005
Non-trainable params: 0
```

	precision	recall	f1-score	support
(0,0)	0.00	0.00	0.00	0
(-1,2)	0.29	0.16	0.20	288
(-1,1)	0.47	0.77	0.59	723
(1,-2)	0.12	0.07	0.08	169
(1,-1)	0.29	0.12	0.17	410
micro avg	0.42	0.42	0.42	1590
macro avg	0.23	0.22	0.21	1590
weighted avg	0.36	0.42	0.36	1590
samples avg	0.42	0.42	0.42	1590





**** We can see the performance indicator for model with lookback window size = 8:**

1. Accuracy score: 42%
2. Cumulative return: 74%
3. Max drawdown: lower than other trading strategy, but closed to others.
4. ROC curve: 0.64

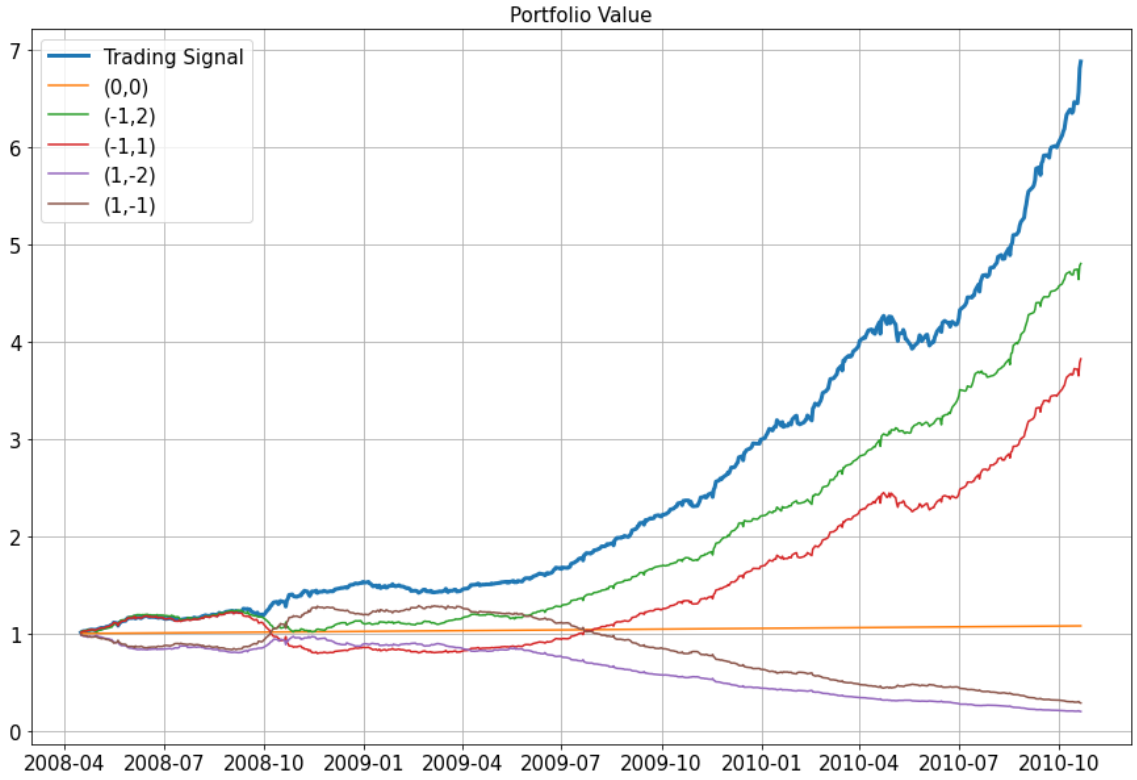
***** As the conclusion of problem #1, I think the trading signal with lookback window of 5 days is the best strategy. It has the higher accuracy score and annualized cumulative return. We also can see its max drawdown is lower and smoother than others. Besides, ROC curve is doing well. Thus, I think the trading signal with lookback window of 5 days is the best.**

Problem #2 (Cross Validation of Lookback)

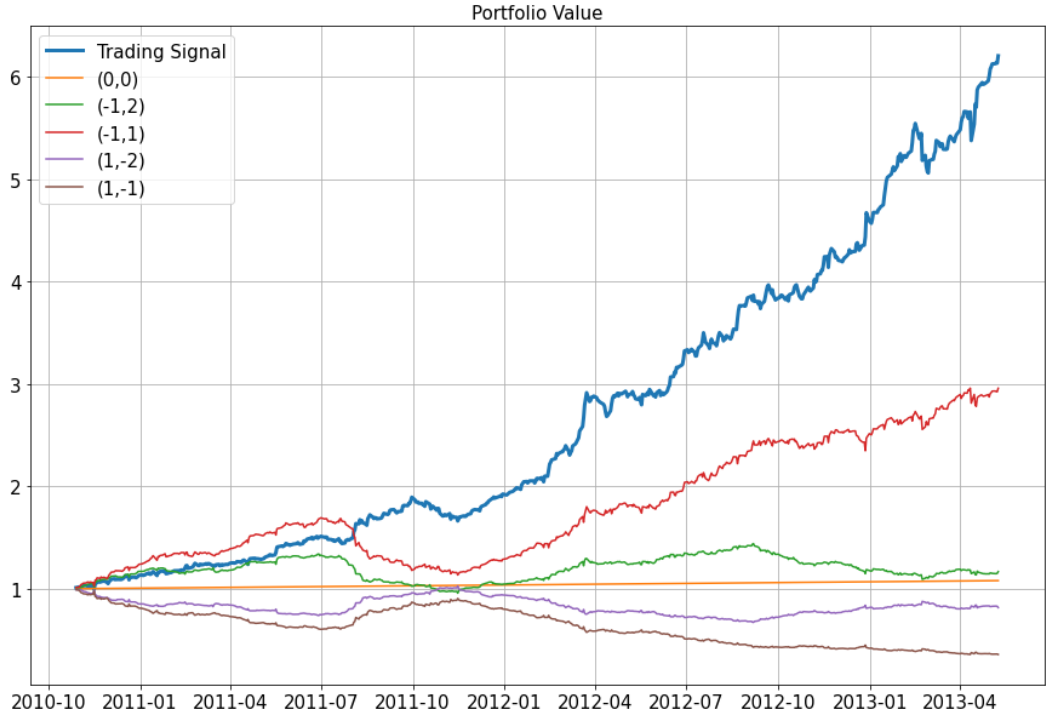
Perform a K-fold cross validation for the best lookback window from part #1. Based these cross validations, does the lookback provide improved performance in comparison to the trading signal without lookback?

**** Based on problem #1, we choose lookback window size = 5 as the best method to perform a K-fold cross validation.**

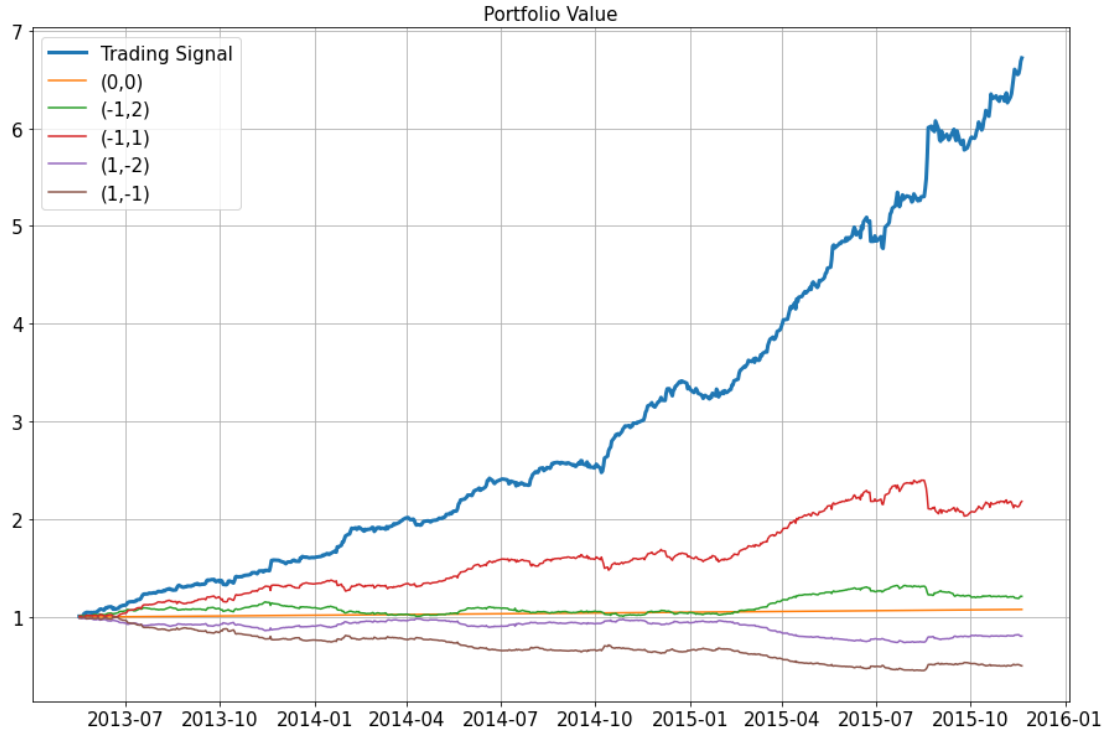
```
K-Folds Cross Validation:  1
Total Data Size:  3201
Training Fold Size:  2560
Training Dates:  2010-10-29 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2008-04-16 00:00:00  to  2010-10-28 00:00:00
Testing Fold Size:  641


Epoch 64: early stopping
Cumulative Return (percentage annualized) : 228.4139
Sharpe ratio (percentage) : 5.2263
```



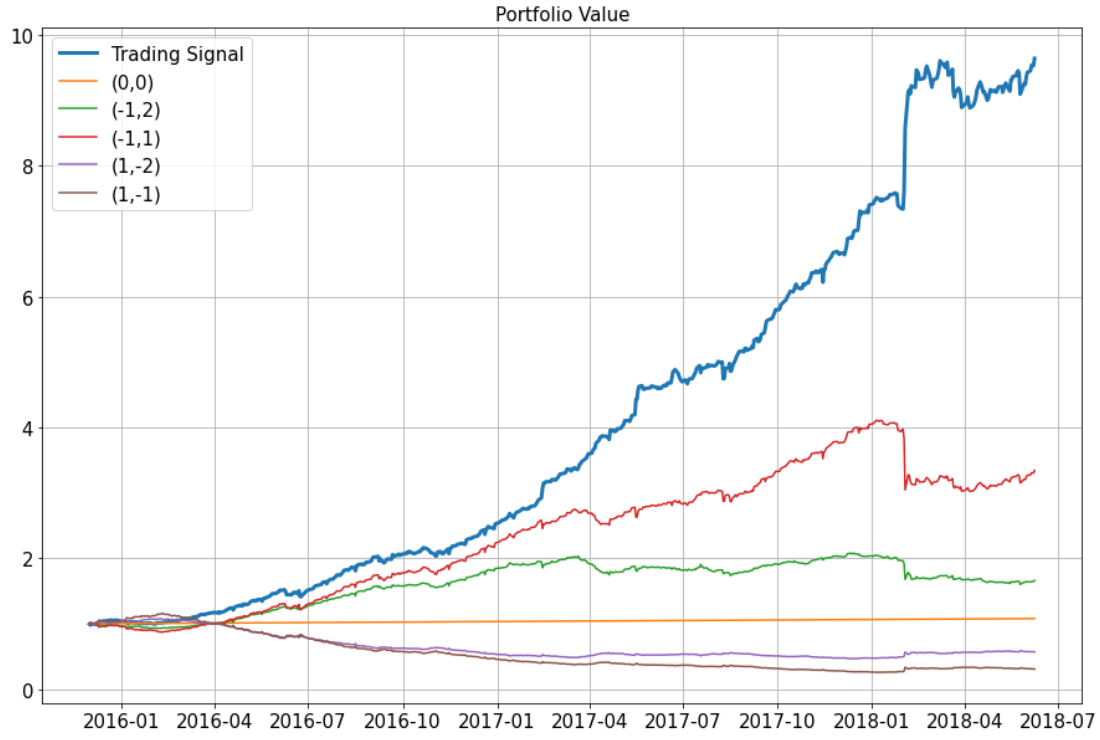
```
K-Folds Cross Validation:  2
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2010-10-29 00:00:00  to  2013-05-16 00:00:00
Testing Fold Size:  640


Epoch 75: early stopping
Cumulative Return (percentage annualized) : 202.3720
Sharpe ratio (percentage) : 3.9777
```



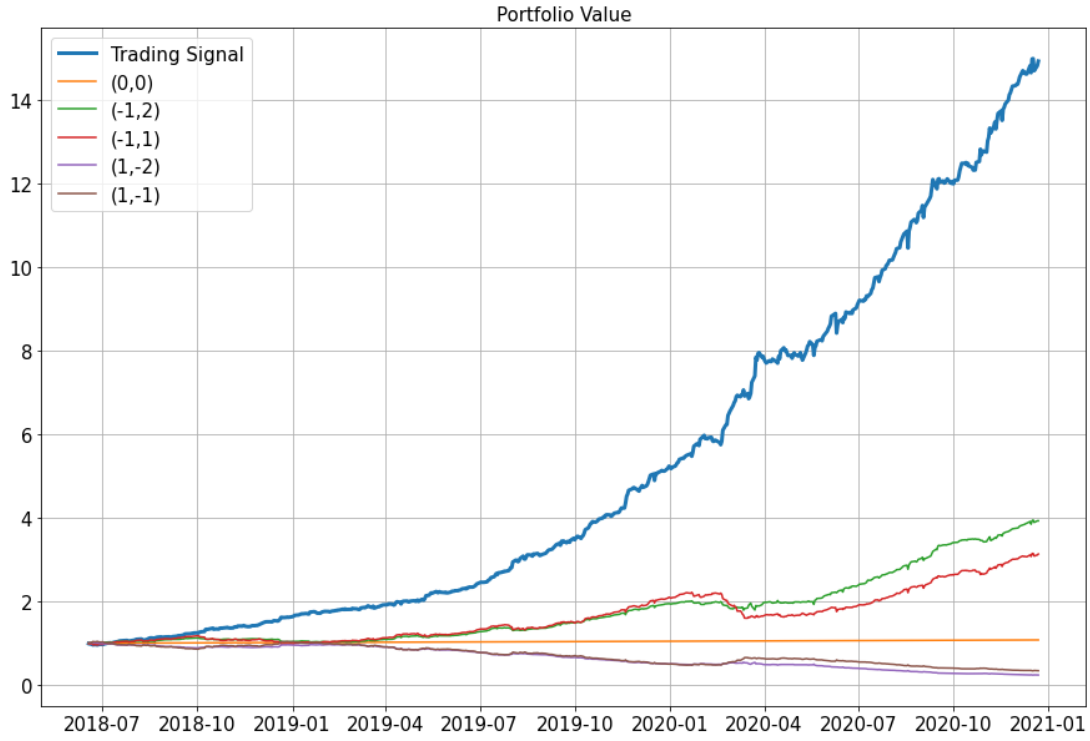

```
K-Folds Cross Validation:  3
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2013-05-17 00:00:00  to  2015-11-30 00:00:00
Testing Fold Size:  640


Epoch 65: early stopping
Cumulative Return (percentage annualized) : 223.0610
Sharpe ratio (percentage) : 5.2289
```



```
K-Folds Cross Validation:  4
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2015-12-01 00:00:00  to  2018-06-15 00:00:00
Testing Fold Size:  640


Epoch 74: early stopping
Cumulative Return (percentage annualized) : 342.5148
Sharpe ratio (percentage) : 4.7687
```

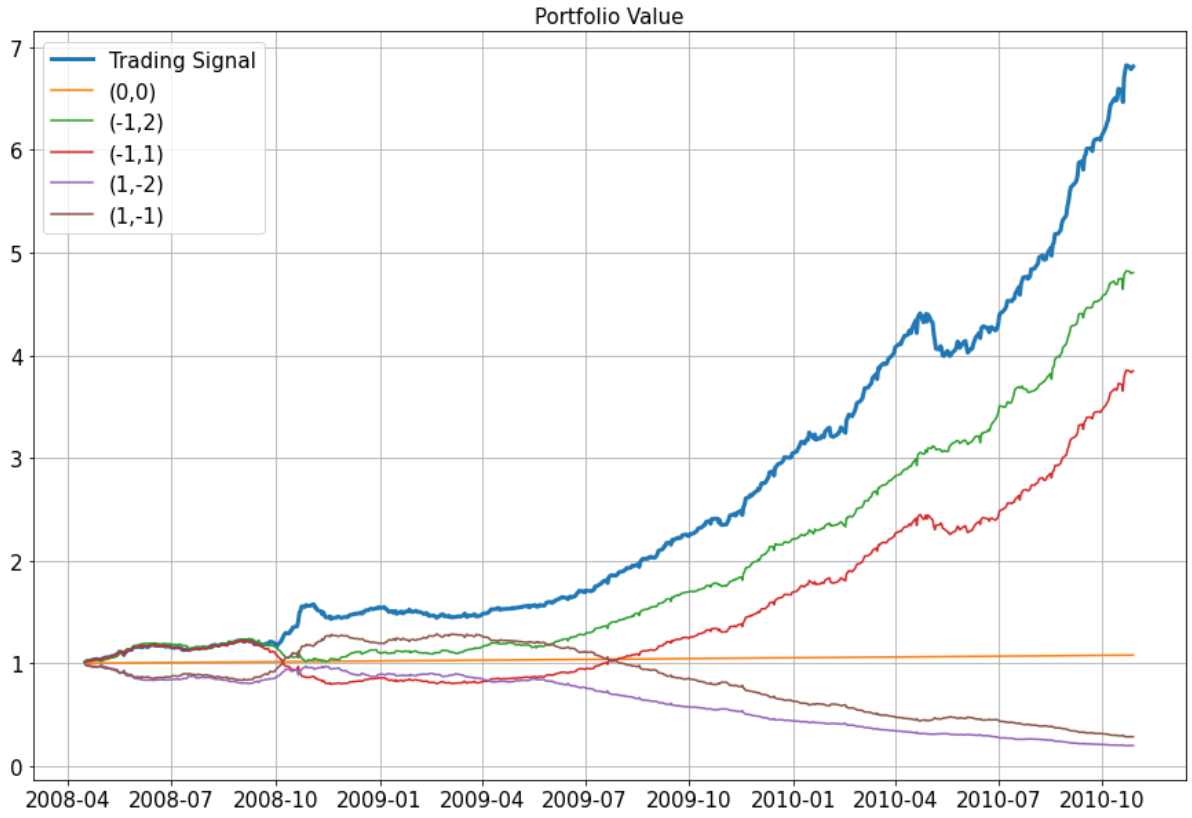



```
K-Folds Cross Validation:  5
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2018-06-15 00:00:00
Testing Dates:  2018-06-18 00:00:00  to  2020-12-30 00:00:00
Testing Fold Size:  640


Epoch 61: early stopping
Cumulative Return (percentage annualized) : 553.0596
Sharpe ratio (percentage) : 6.5580
```

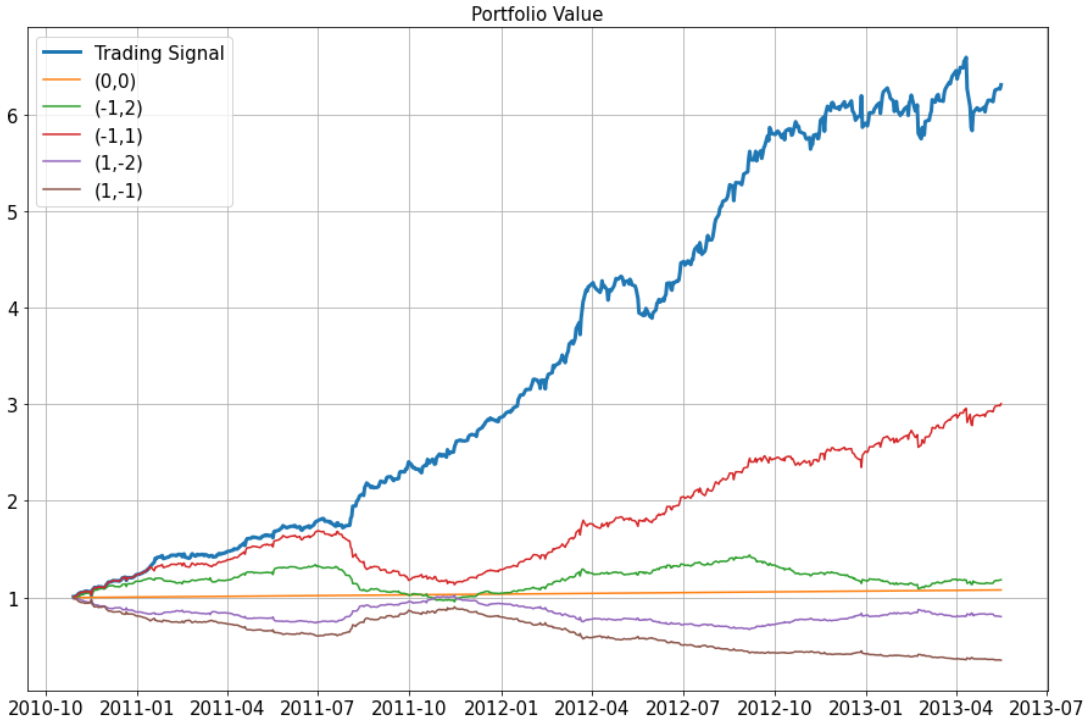


**** We perform a K-fold cross validation without look back window, in order to compare with first part approach.**

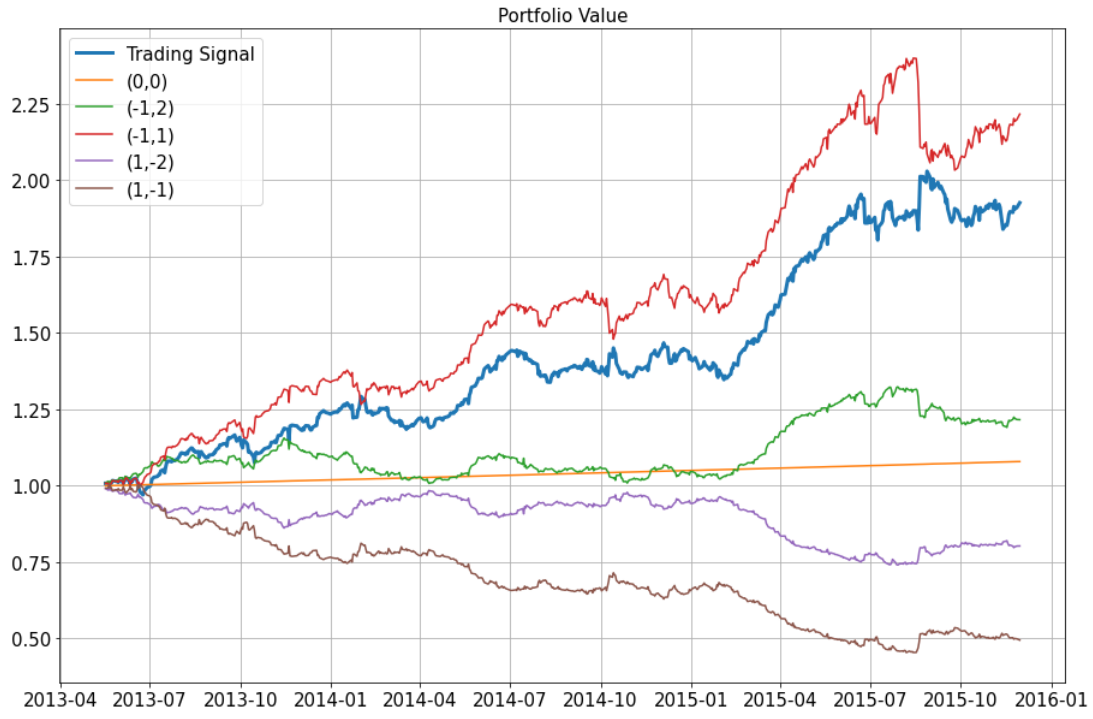
```
K-Folds Cross Validation:  1
Total Data Size:  3201
Training Fold Size:  2560
Training Dates:  2010-10-29 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2008-04-16 00:00:00  to  2010-10-28 00:00:00
Testing Fold Size:  641


Epoch 51: early stopping
Cumulative Return (percentage annualized) : 225.6096
Sharpe ratio (percentage) : 5.0955
```



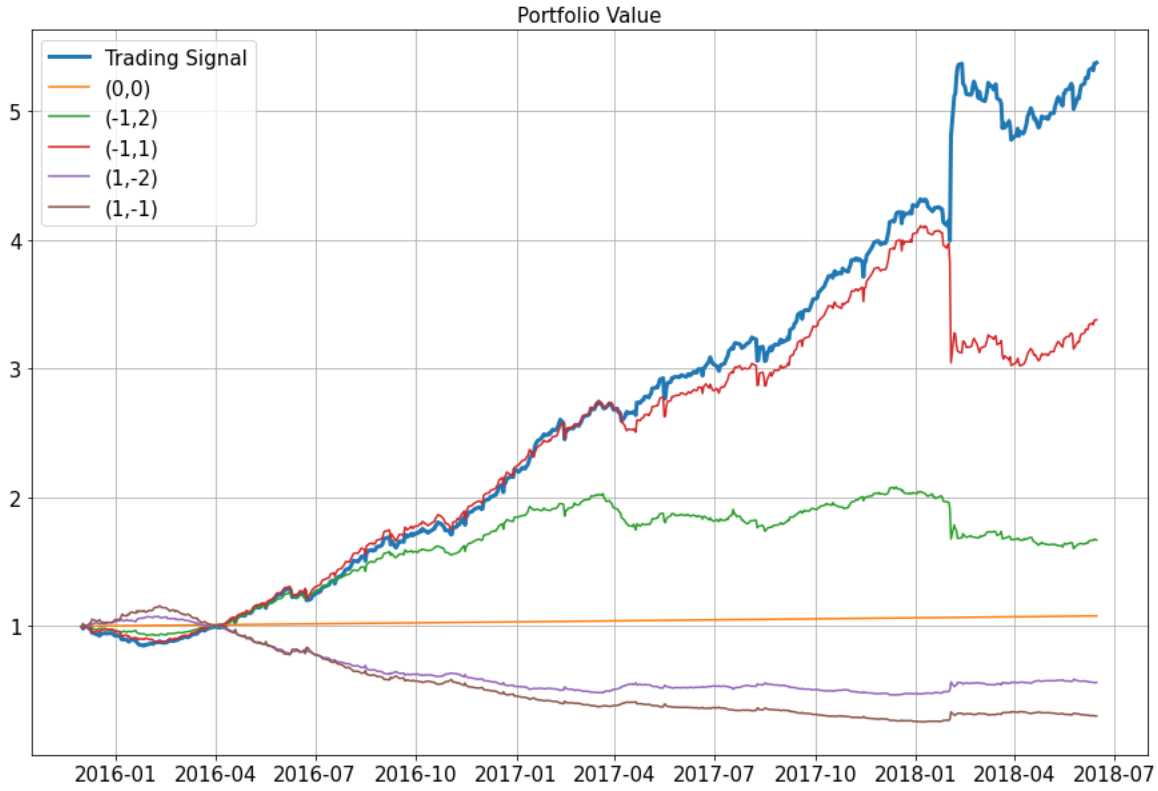
```
K-Folds Cross Validation:  2
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2010-10-29 00:00:00  to  2013-05-16 00:00:00
Testing Fold Size:  640


Epoch 71: early stopping
Cumulative Return (percentage annualized) : 206.3603
Sharpe ratio (percentage) : 3.9699
```



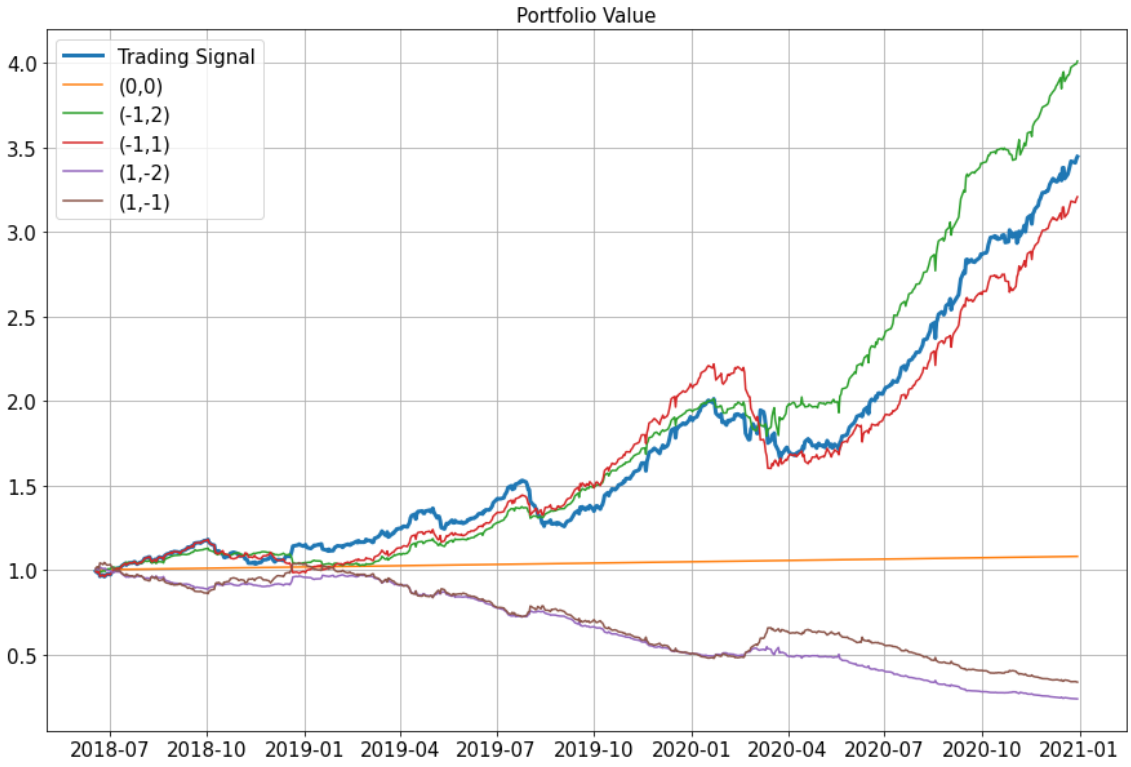

```
K-Folds Cross Validation:  3
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2013-05-17 00:00:00  to  2015-11-30 00:00:00
Testing Fold Size:  640


Epoch 64: early stopping
Cumulative Return (percentage annualized) : 35.8789
Sharpe ratio (percentage) : 1.7663
```



```
K-Folds Cross Validation:  4
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2020-12-30 00:00:00
Testing Dates:  2015-12-01 00:00:00  to  2018-06-15 00:00:00
Testing Fold Size:  640


Epoch 68: early stopping
Cumulative Return (percentage annualized) : 173.6165
Sharpe ratio (percentage) : 3.1411
```



```
K-Folds Cross Validation:  5
Total Data Size:  3201
Training Fold Size:  2561
Training Dates:  2008-04-16 00:00:00  to  2018-06-15 00:00:00
Testing Dates:  2018-06-18 00:00:00  to  2020-12-30 00:00:00
Testing Fold Size:  640


Epoch 70: early stopping
Cumulative Return (percentage annualized) : 97.3928
Sharpe ratio (percentage) : 2.8982
```



***** As the conclusion of problem #2, based on these cross validations, I think the lookback method provide higher improved performance in comparison to the trading signal without lookback. Due to the graphs of above, with lookback window of 5 days, we can see our trading signal has higher cumulative return than other trading strategy in all folds. However, without lookback window, our trading signal lose in fold 3 and fold 5. It means the trading signal without lookback window don't always have higher performance in all folds. Thus, based on these cross validations, I think the lookback method provide higher improved performance in comparison to the trading signal without lookback.**