

# Quantitative strategies on High Frequency Data

## submission of research project

Philipp Pecher

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### Approaches undertaken

In the following I will present the approach and result of my research project in Quantitative strategies on High Frequency Data. I considered three different entry and exit techniques for a various number of measures. The approach for choosing the best or rather the appropriate entry/exit technique as well as the appropriate strategy was similar for both groups and all assets. I created a for loop for every asset and entry/exit technique which covers the scale of a particular measure. After running the sample data, I plotted for every quarter a heatmap which I scalded down to the top measures for the whole sample and chose the appropriate extent of the respective measure. In the end, I compared the measures and entry-exit techniques to find the appropriate strategy for the out-of-sample data for each group and asset.

The first entry/exit technique is those of Two Moving Averages. In this technique, a slow- and a fast-moving average are required. If these measures intersect, i.e. the slow measure equals the fast measure, we go either short or long depending on the strategy and if the measures are below or above after the intersection. I considered a single moving average and an exponential for both slow- and fast-moving averages. For the slow-moving average, I considered averages from 10 to 45 and for the fast-moving averages from 60 to 180. The Volatility Based Breakout Model was the second entry/exit technique I considered. This technique uses a slow-moving measure as a signal and a fast-moving measure which is multiplied by a scale and a volatility measure. The scale is one time positive and another time negative such that they form an upper and lower border. If the signal measure intersects those borders, we either go long or short depending on the strategy and which border. I considered an exponential moving average and a moving median as a signal measure from 10 to 45. Additionally, I used an exponential moving average from 60 to 180, a volatility standard deviation from 60 to 120, and a multiplier from 1 to 3. Lastly, I considered the pair trading strategy an entry/exit technique that trades two assets at the same time. This technique uses the measures of two correlation assets. If those measures intersect, we either go short/long for one asset and do the opposite for the other asset. I considered a volatility standard deviation from 60 to 180 as well as a multiplier from 0.5 to 5 for av. ratio and sds. ratio.

In addition, I did not trade before and after a break for both groups and assets and I did not use the data of 10 minutes before and after a break in my calculations. This approach is done as a safety measure since in that time the volatility rapidly increases, and the market is less predictable.

## Group 1 – summary of results (including out-of-sample)

### Finally selected strategy for group 1

After examining all possible options of entry/exit techniques and measures I have chosen the Volatility Breakout Model for both assets in group 1. The Two Moving averages had very little profit such that the Volatility Breakout Model was in all cases superior. The Pair trading strategy had higher profits in some quarters but also high losses in other quarters such that the Volatility Breakout Model generated positive profits over a more constant period.

For the NASDAQ (NQ) I have chosen an exponential moving average of 10 as the signal, a fast exponential moving average of 60, a volatility standard deviation of 120, and a multiplier of 2. For the SP500 (SP) I have chosen an exponential moving average of 20 as the signal, a fast exponential moving average of 180, a volatility standard deviation of 60, and a multiplier also of 2. For both assets, the Momentum Strategy was significantly better than the Mean-Reverting Strategy.

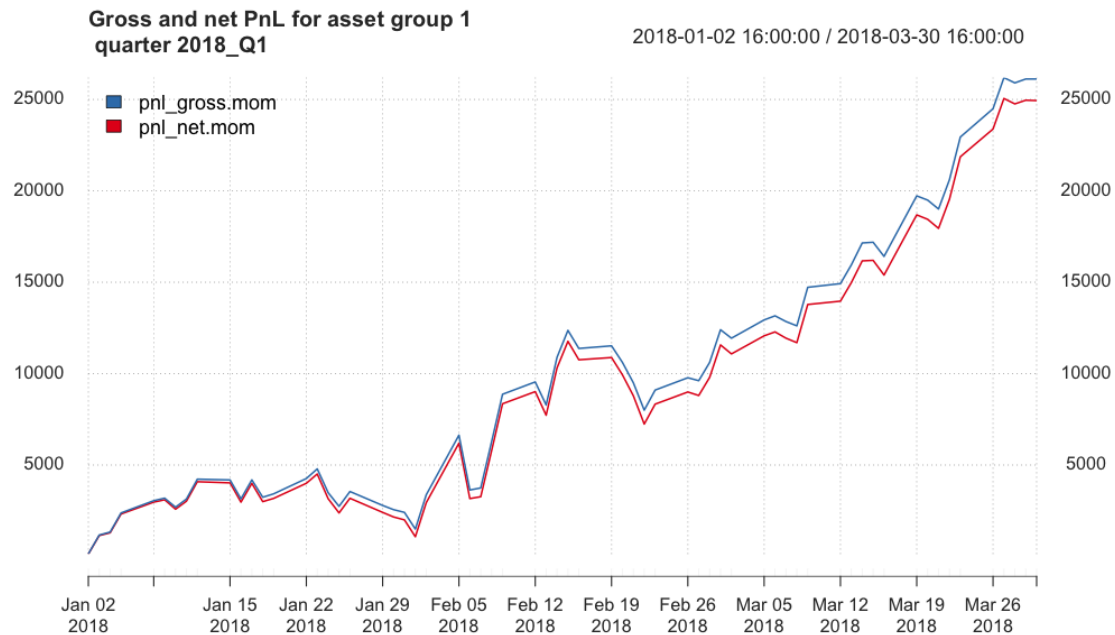
### Summary of results for group 1

quarter	grossSR	netSR	av.ntrades	grossPnL	netPnL	stat
2018_Q1	5.29	5.04	3.12	26119.80	24939.80	14.59
2018_Q2	1.32	0.98	3.20	4702.00	3502.00	0.60
2018_Q3	0.48	0.06	3.48	1547.30	207.30	0.69
2018_Q4	1.87	1.72	3.48	17259.18	15899.18	3.38
2019_Q1	0.35	0.04	3.90	1672.54	212.54	0.71
2019_Q2	1.45	1.15	3.32	5844.48	4634.48	1.00
2019_Q3	-0.80	-1.07	3.67	-4065.15	-5465.15	-2.66
2019_Q4	-0.23	-0.71	3.51	-629.25	-1949.25	-0.80
2020_Q1	1.28	1.16	3.53	14637.20	13277.20	1.70
2020_Q2	0.07	-0.05	3.42	769.45	-520.55	0.36
2020_Q3	-0.32	-0.46	3.21	-2883.85	-4153.85	-1.37
2020_Q4	2.32	2.11	3.29	13408.90	12258.90	4.05

Examining the summary of the result from the out of the sample data, the chosen approach worked out pretty well. Especially in Q1 and Q4 of 2018 as well as in Q1 and Q4 in 2020 the strategy generated a netPnL above 12.000. However, there is also four quarter with a negative netPnL which is not a big issue since the losses are marginal compared to the profits of the other quarters.

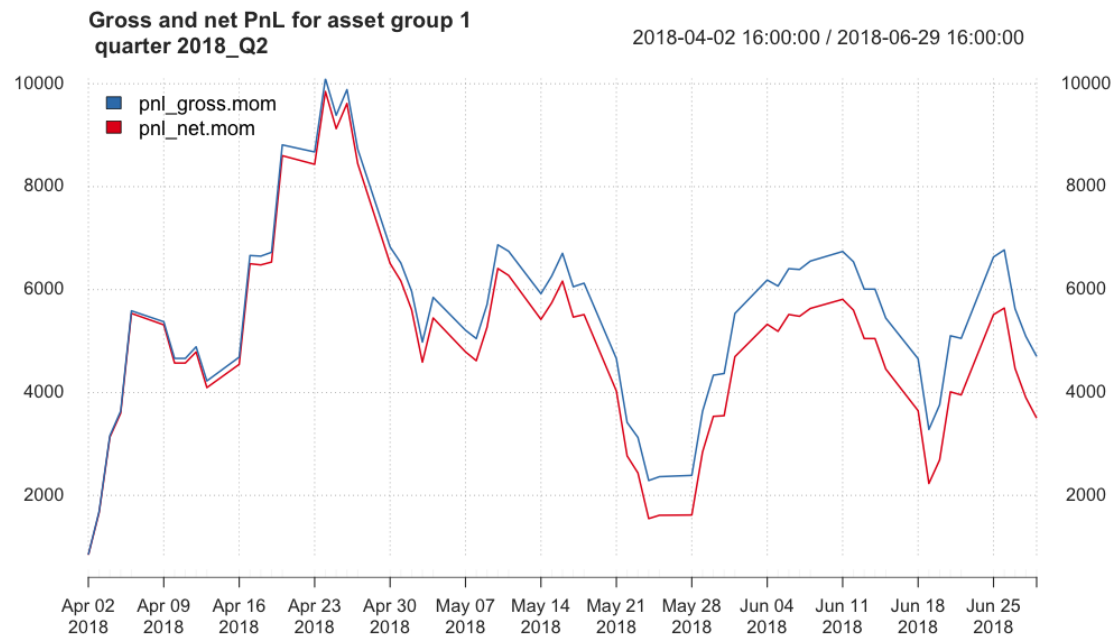
In the end, the chosen strategy generated a total netSR of approx. 9.98, a total netPnL of approx. 62,842.60, and a total stat of 22.23. In the following, I will highlight positive aspects but also improvements of the chosen strategy for group 1. The basis for that will be the inter quarter results of netPnL.

## PnL of results for group 1 – quarter 2018Q1



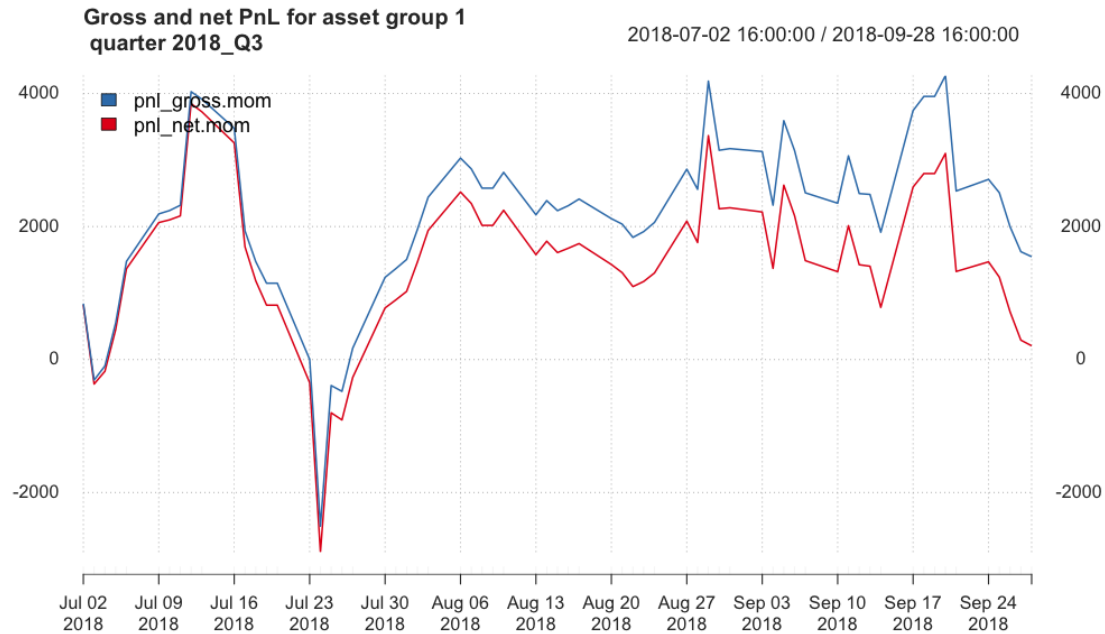
In the first quarter of 2018, the chosen strategy worked very well. From the beginning to the end the netPnL was positive and increased almost until 25,000.

## PnL of results for group 1 – quarter 2018Q2



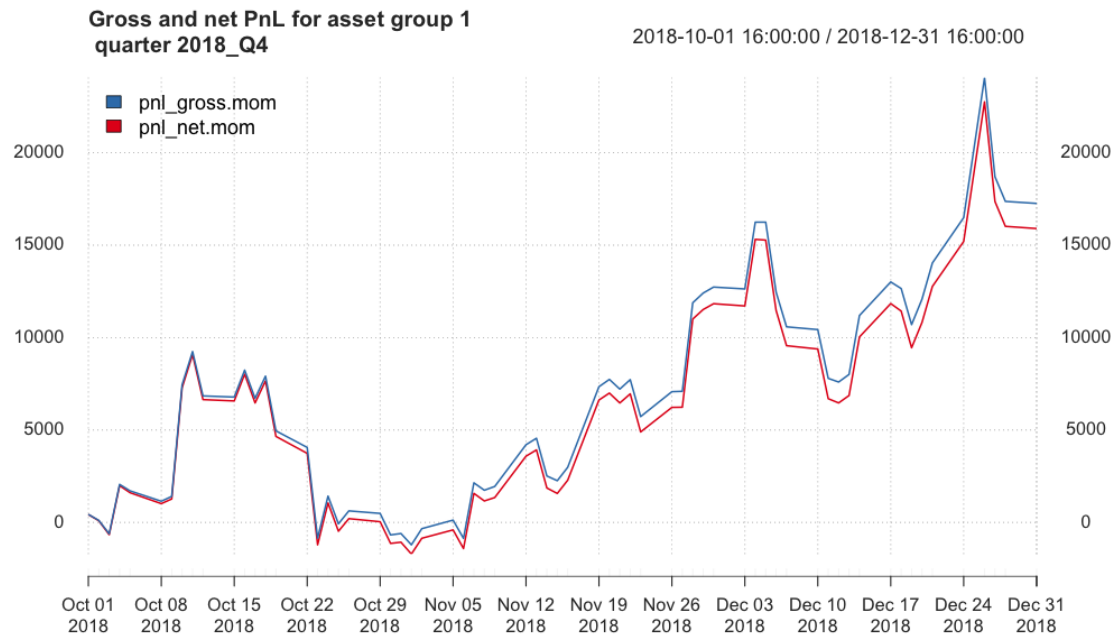
In the second of 2018, the situation is different. The netPnL increases rapidly to approx 10,000 until the 23rd of April and then fall to approx. 2,000 on the 28th of May. Afterward, it recovers with a dip around the 18th of June to close to 6,000 netPnL. However, in the end, the netPnL fall again to below 4,000 netPnL. From the many changes of the netPnL one can assume that another entry/exit technique or measures of the current technique would result in better outcomes. Nevertheless, the netPnL is positive after all.

### PnL of results for group 1 – quarter 2018Q3



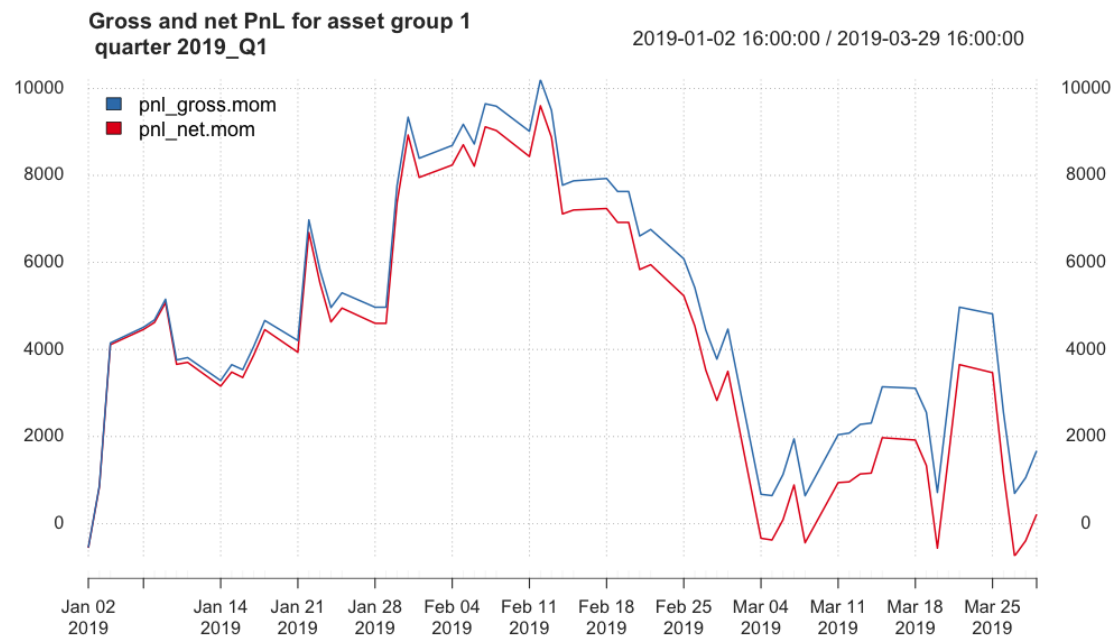
In the third quarter of 2018, the highest netPnL reached was approx. 4,000. After a substantial dip around July 23rd, the netPnL recovers but was close to zero in the end. The graph shows an increase in the spread between net and gross PnL which indicates an increase in the number of trades to the end of the quarter. Another entry/exit technique or measures for the current technique would possibly be more suitable for this quarter.

## PnL of results for group 1 – quarter 2018Q4



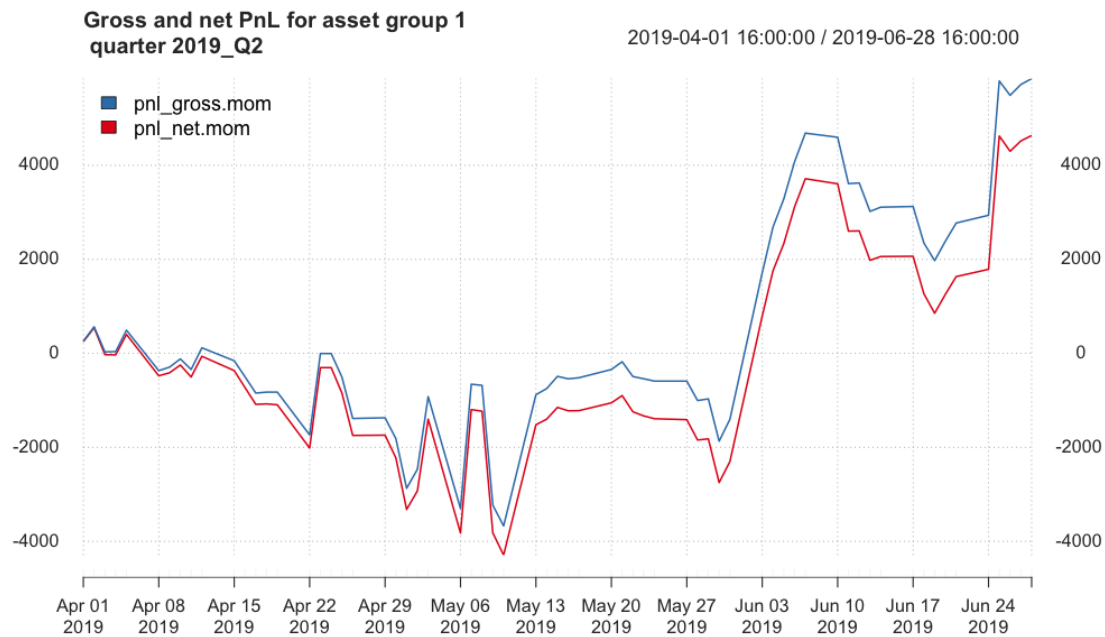
In the fourth quarter of 2018, the netPnL increased more or less steadily until the 24th of December to above 20,000 but then fell to approx. 16,000. Thus, leaving the market before the end of the quarter would result in a much better outcome. However, the outcome of 16,000 netPnL is still a good result which indicates that the chosen technique and measures work well.

## PnL of results for group 1 – quarter 2019Q1



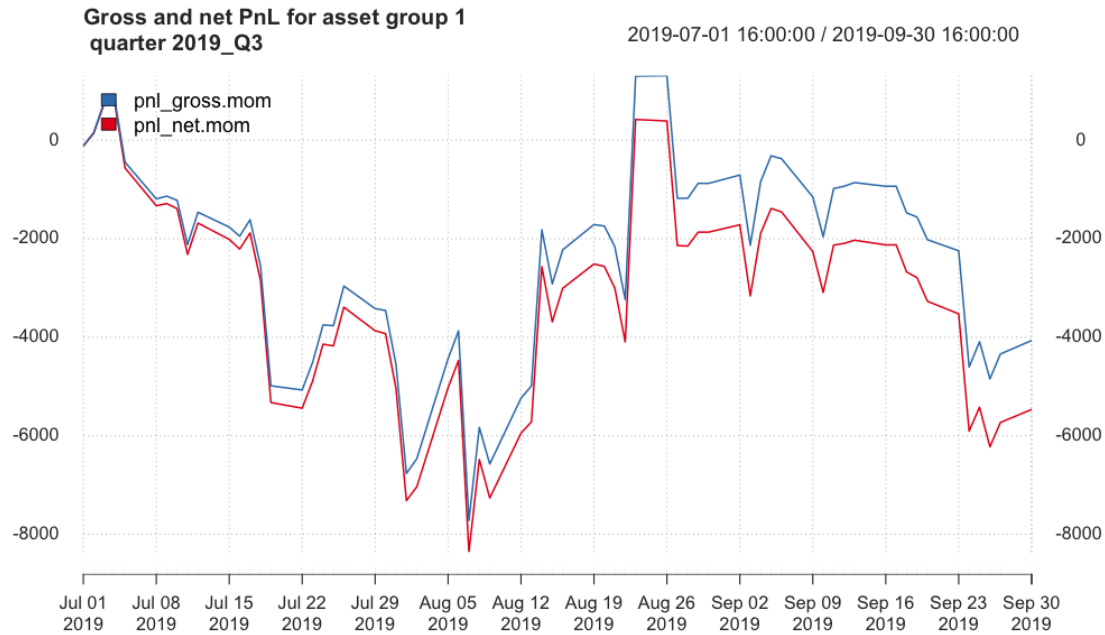
In the first quarter of 2019, the outcome is close to zero in the end. In the middle of the quarter the netPnl increase close to 10,000 which indicates that another technique or additional filters would improve the outcome. In addition, the netPnl increase to almost 4,000 shortly before the end of the quarter but then fell again. Thus, leaving the market before the end of the quarter could also improve the outcome.

### PnL of results for group 1 – quarter 2019Q2



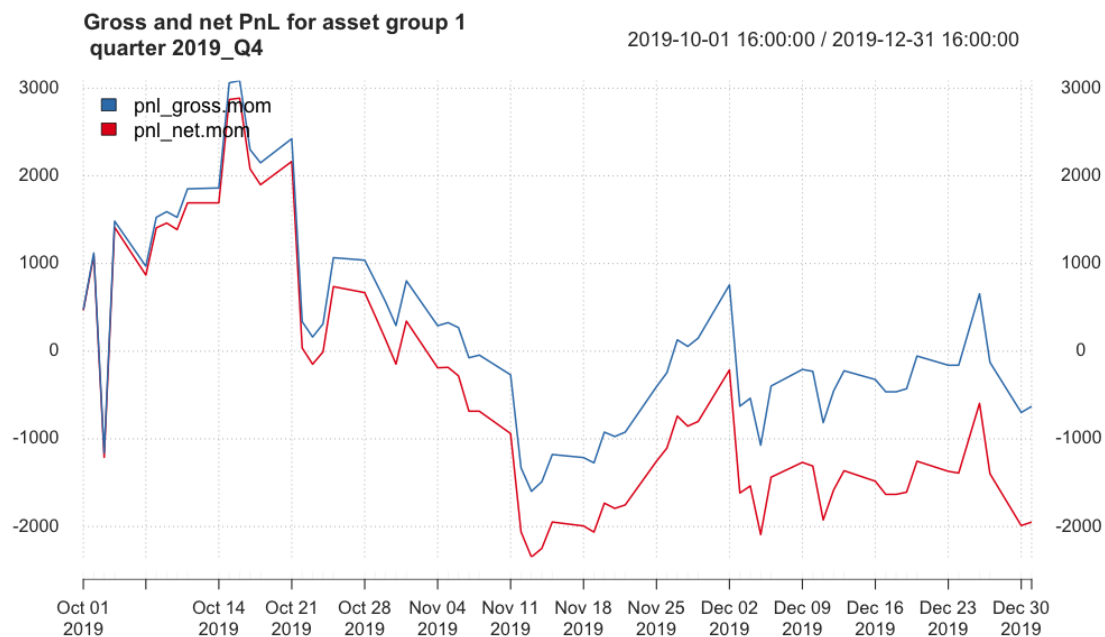
In the second quarter of 2019, the netPnl was positive with an appropriate amount. Maybe another technique or measure could reach a higher outcome.

## PnL of results for group 1 – quarter 2019Q3



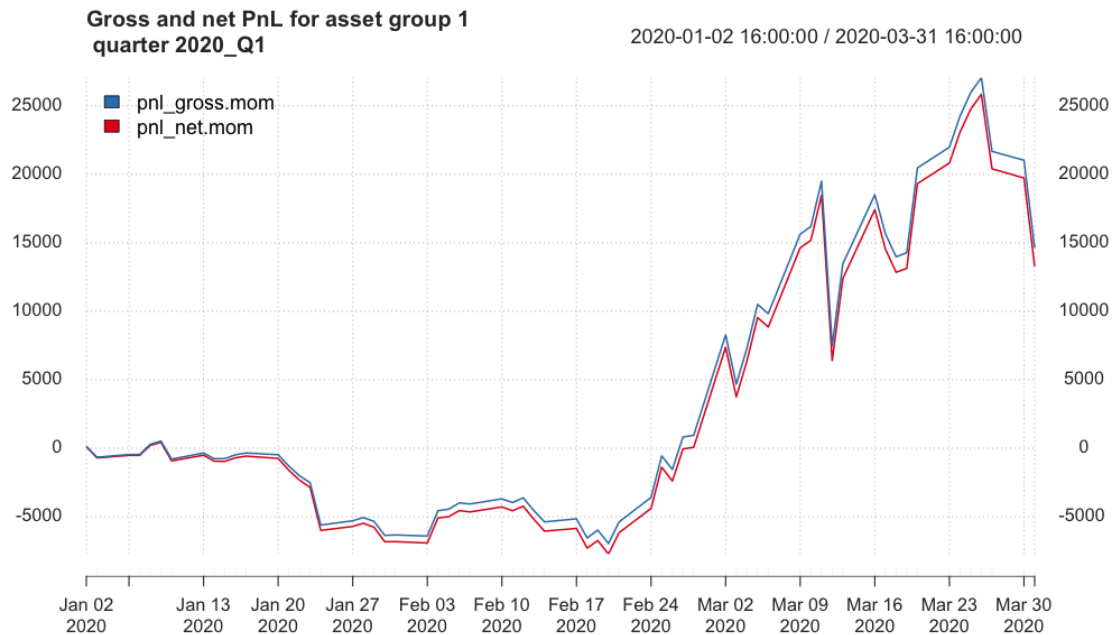
In the third quarter of 2019, the netPnL was almost no time positive. Thus, another entry/exit technique, measures for the current technique, or a change to the Mean-Reverting Strategy would be more appropriate.

## PnL of results for group 1 – quarter 2019Q4



In the fourth quarter of 2019, the netPnL fell from the highest outcome on the 14th of October to a netPnL of approx. -2,000 at the end of the quarter. This indicates that another entry/exit technique, measures for the current technique, or a change to the Mean-Reverting Strategy would be more appropriate.

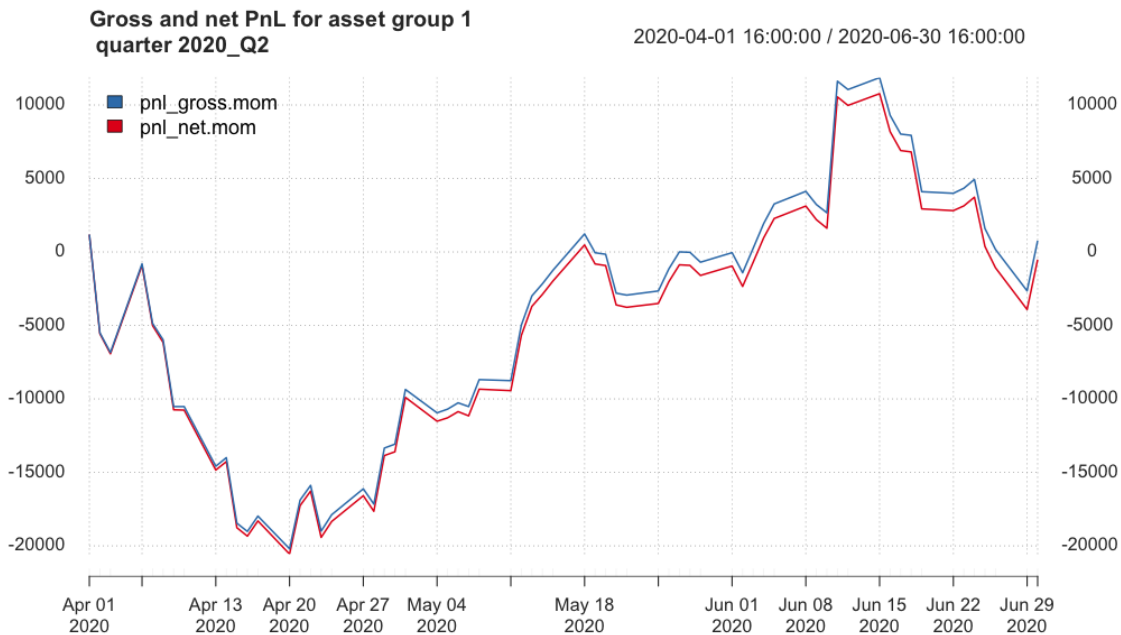
### PnL of results for group 1 – quarter 2020Q1



In the first quarter of 2020, the netPnL to above 25,000 on the 23rd of March but then fall to approx. 15,000 at the end of the quarter. This graph shows again that the chosen trading strategy works out well but a stop of trading at the end of the quarter could improve the outcome.

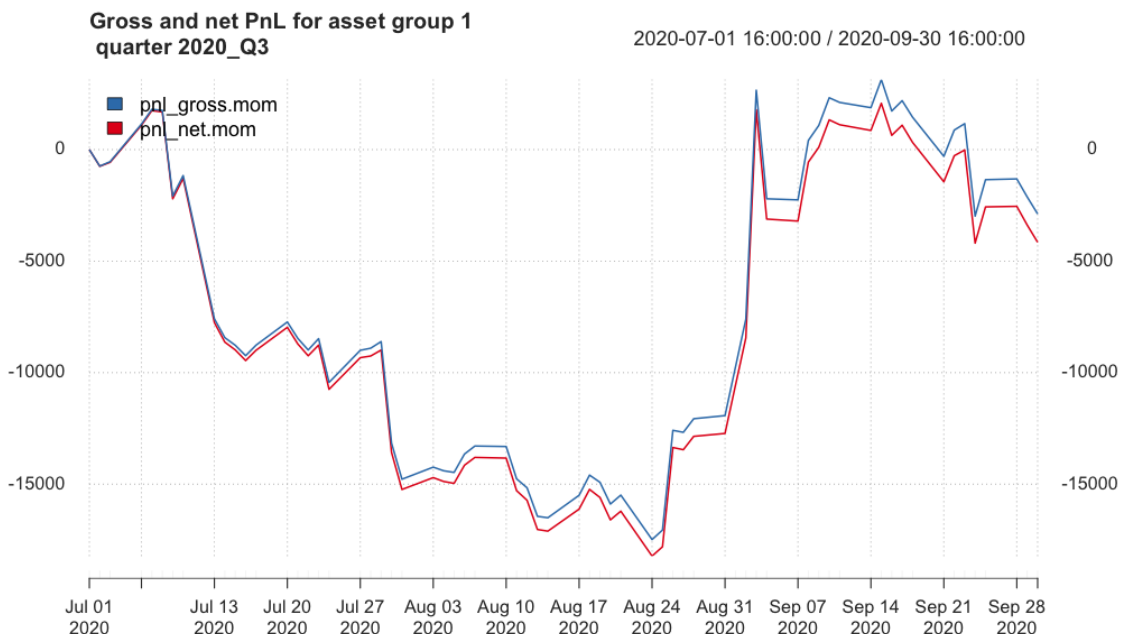


## PnL of results for group 1 – quarter 2020Q2



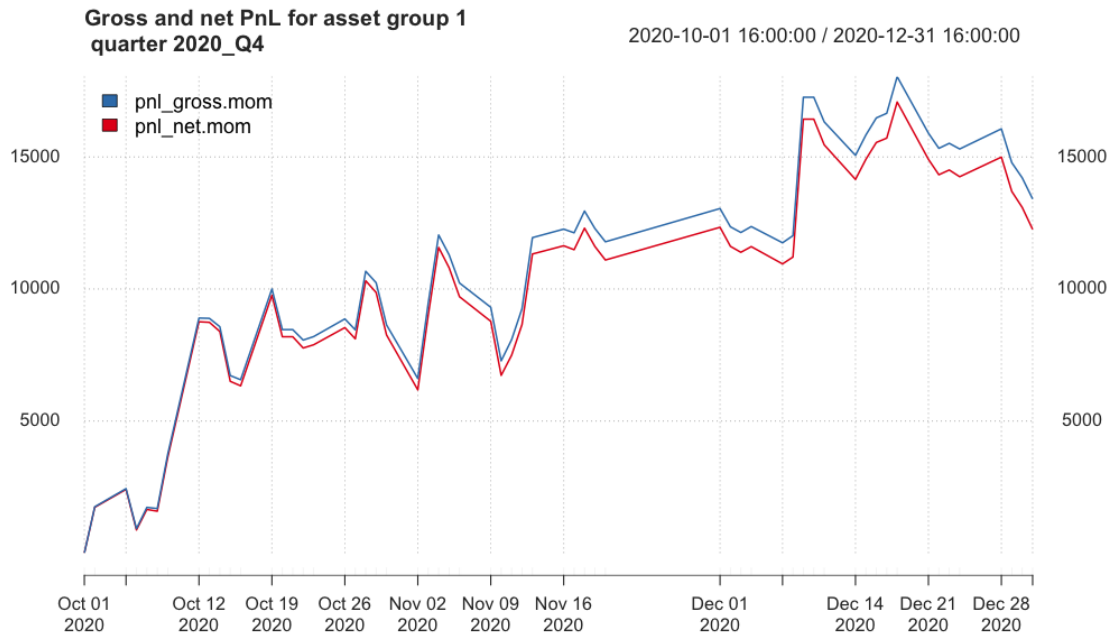
In the second quarter of 2020, the netPnL was close to zero at the end of the quarter. The behavior indicates that a change to the Mean-Reverting Strategy would not improve the outcome. Furthermore, the change to another entry/exit technique or measure of the current could improve the outcome but due to the fact that the COVID-19 pandemic hit the stock market in this period, this is not certain.

## PnL of results for group 1 – quarter 2020Q3



In the third quarter of 2020, the netPnL was substantially negative for the complete quarter. This indicates that a change to the Mean-Reverting Strategy would improve the outcome significantly.

### PnL of results for group 1 – quarter 2020Q4



In the fourth quarter of 2020, the chosen strategy worked out well with a netPnL of about 12,000. However, through an additional filter rule to the end of the quarter, the outcome could again be improved.

## Group 2 – summary of results (including out-of-sample)

### Finally selected strategy for group 2

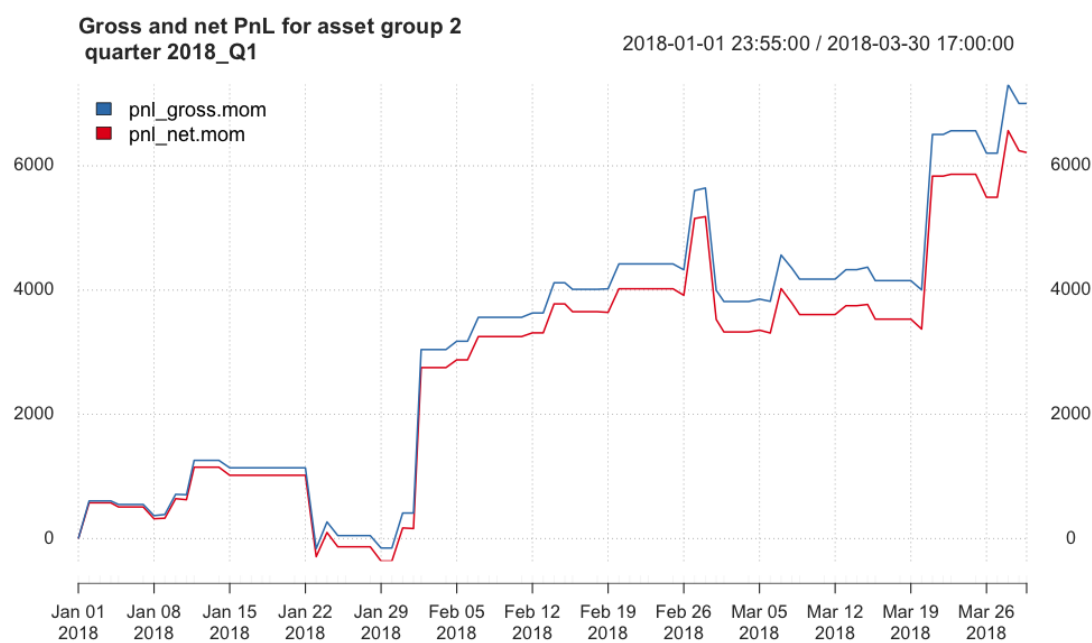
For the assets of group 2 I also applied the Volatility Breakout Model on all assets as a trading strategy. The entry/exit technique of Two Moving Averages was compared to the other two techniques in all cases inferior such that it was no option. The choice between the Pair Trading Strategy and the Volatility Breakout Model was more difficult. The performance of the Pair Trading Strategy was again relatively volatile. It had in some quarter's substantial profits but also losses in other quarter. A problem, in this case, was that the performance of the Volatility Breakout Model was also volatile with a less substantial profit. However, I assumed during the COVID-19 pandemic, which is only partly covered in the sample data, all assets would decline such that the pair trading strategy could not work out. In addition, the Volatility Breakout Model is rather known as a technique for short-term forecasts which could also be an advantage for this situation since situation will change within a short period. For that reason, I have chosen the following measures: AUD: singnalEMA:20, fast EMA: 120, volat.sd.: 120, m: 2; CAD: singnalEMA:30, fast EMA: 120, volat.sd.: 60, m: 2; XAG: singnalEMA:15, fast EMA: 180, volat.sd.: 120, m: 2; XAU: singnalEMA:15, fast EMA: 180, volat.sd.: 120, m: 2. For the Australian Dollar (AUD) and the Canadian Dollar (CAD) the rolling median was also an appropriate measure with slightly higher total profit but also higher volatility. Hence, since the behavior of this approach is already relatively volatile, I decide to use the exponential moving average (EMA) with slightly less but therefore more constant profits. The Momentum Strategy was in most quarters substantially better than the Mean-Reverting Strategy. Hence the total profit of the Momentum Strategy for all assets was higher.

### Summary of results for group 2

quarter	grossSR	netSR	av.ntrades	grossPnL	netPnL	stat
2018_Q1	2.64	2.37	1.61	7004.15	6214.15	3.41
2018_Q2	0.71	0.27	1.46	1179.03	439.03	0.19
2018_Q3	2.18	1.77	1.39	3801.34	3051.34	1.42
2018_Q4	-5.09	-5.45	1.57	-10152.80	-11012.80	-14.27
2019_Q1	2.77	2.42	1.51	5477.46	4717.46	2.98
2019_Q2	-1.94	-2.49	1.69	-2987.25	-3877.25	-4.05
2019_Q3	3.10	2.88	1.59	11865.21	10955.21	5.69
2019_Q4	1.11	0.62	1.52	1817.37	1007.37	0.00
2020_Q1	4.06	3.88	1.62	17635.19	16775.19	9.54
2020_Q2	-0.40	-0.66	1.67	-1392.18	-2292.18	-0.96
2020_Q3	0.35	0.23	2.28	3364.09	2174.09	-0.21
2020_Q4	2.42	2.27	1.21	8627.39	8057.39	3.70

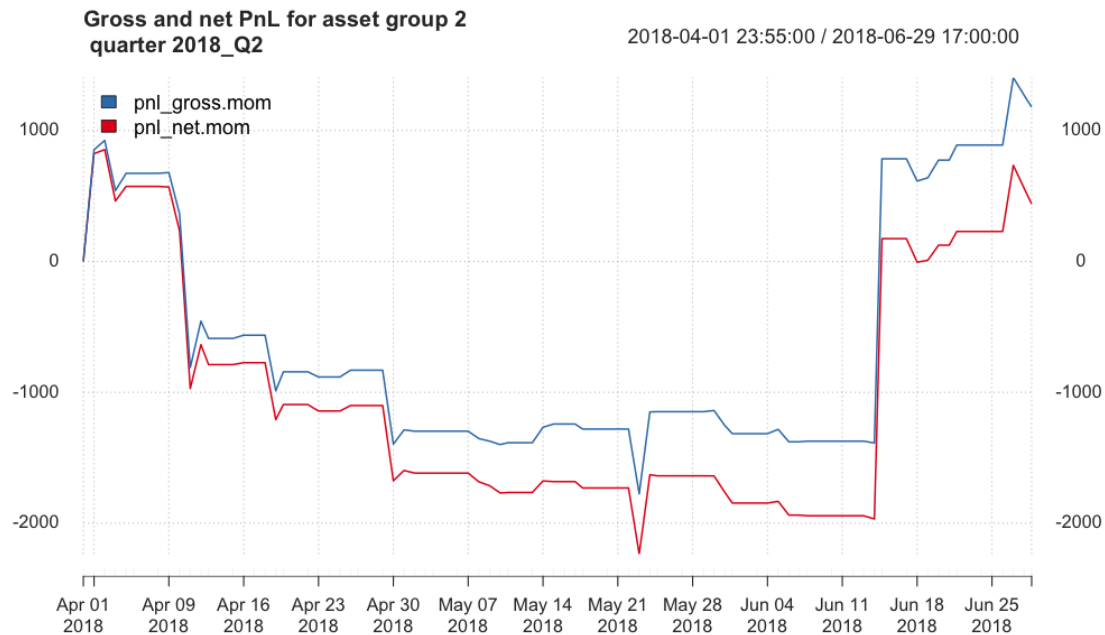
After applying the trading strategy for group 2 the result was not as good as for group 1 but in total still positive. As I describe in the section before hands, the outcomes were more volatile with high positive values in one quarter but also high losses in the other quarter. Comparing the outcomes of the sample data and the out of the sample data the strategy worked out better in the out of the sample data. The assumed the soften of the effect through COVID-19 went not as good as I hoped since the outcome in quarter 2 of 2020 is still negative. However, the outcome could also be substantially more negative. In the end, the chosen strategy generated a total netSR of approx. 8.11, a total netPnL of approx. 36,208.99, and a total stat of 7.44. In the following, I will highlight positive aspects but also improvements of the chosen strategy for group 2. The basis for that will be the inter quarter results of netPnL.

## PnL of results for group 2 – quarter 2018Q1



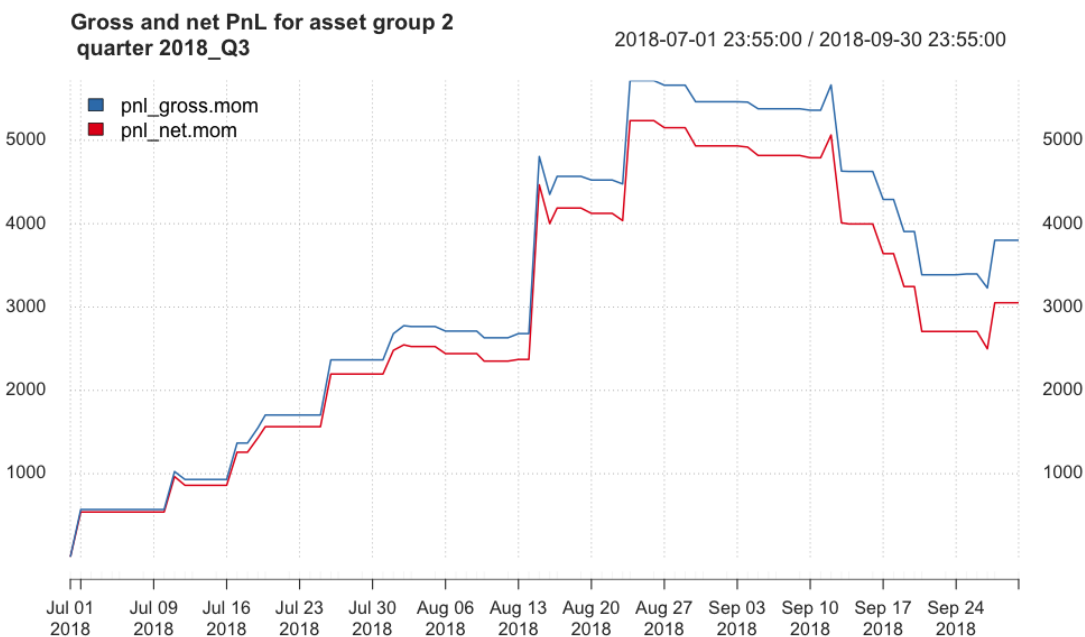
In the first quarter of 2018, after some stagnation at the beginning of the quarter the netPnL increase to approx. 6,000 in the end. The graph indicates that the Momentum Strategy is more suitable than the Mean-Reverting Strategy and the chosen technique and measure worked well.

## PnL of results for group 2 – quarter 2018Q2



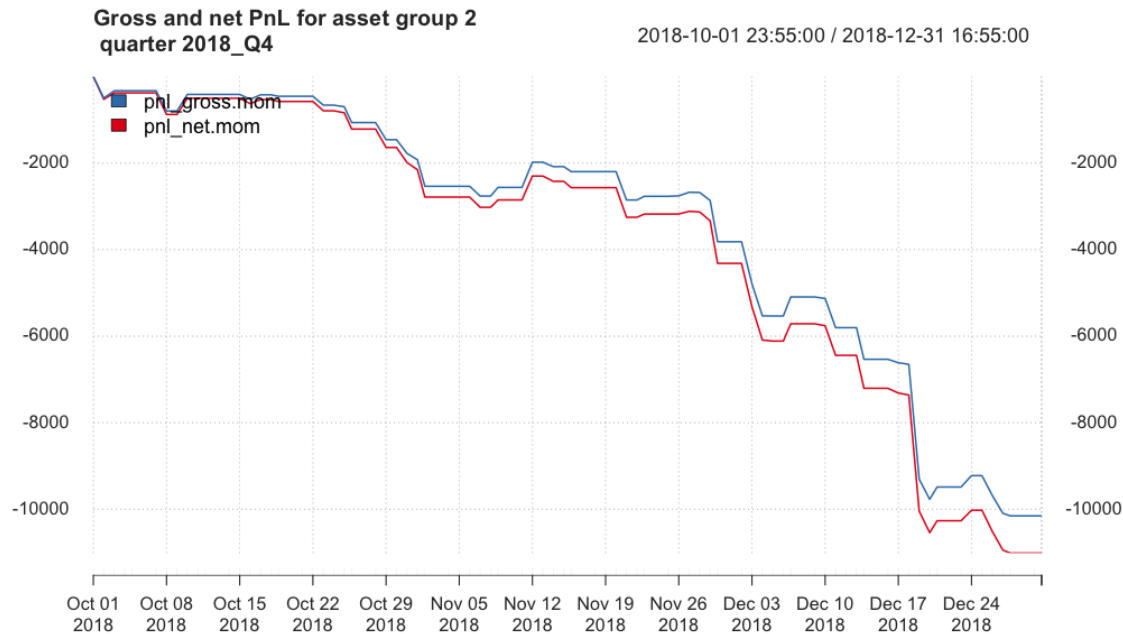
In the second quarter of 2020, the outcome was close to zero. The behavior of the graph suggests that another entry/exit technique or measure of the current technology would be more suitable.

## PnL of results for group 2 – quarter 2018Q3



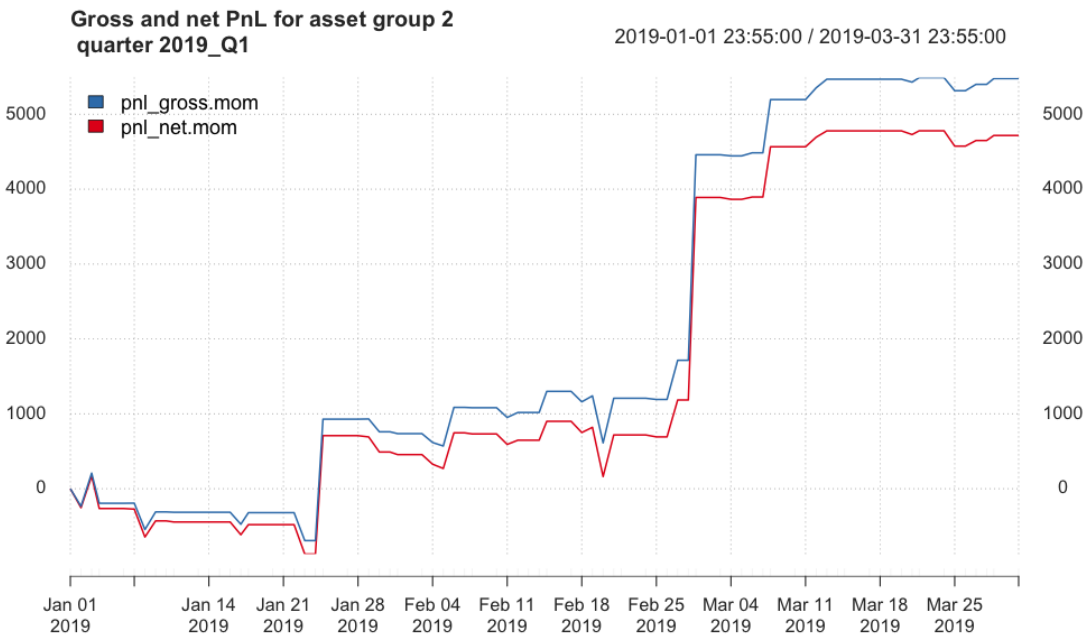
In the third quarter of 2018, the netPnL increased to approx. 5,000 in mid-September but then decreased to approx. 3,000 at the end of the quarter. Here, an additional filter rule for the end of the quarter could improve the outcome.

### PnL of results for group 2 – quarter 2018Q4



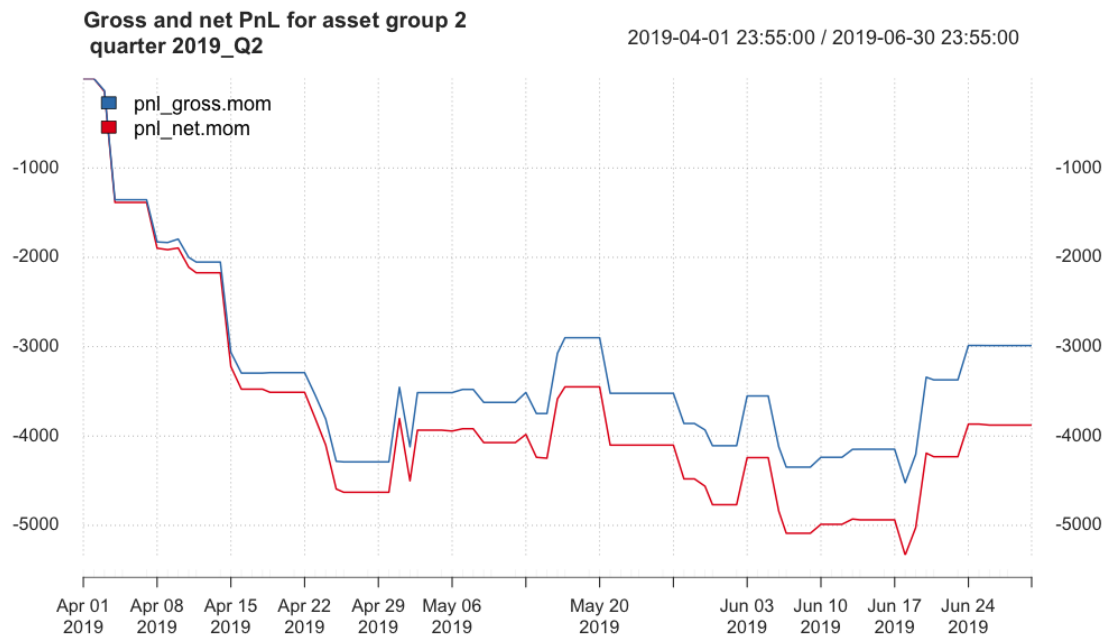
In the fourth quarter of 2018, the netPnL steadily decreased to a negative outcome of approx. -11,000. The behavior of the graph suggests that changes from Momentum Strategy to Mean-Reverting Strategy would result in a substantially better outcome.

## PnL of results for group 2 – quarter 2019Q1



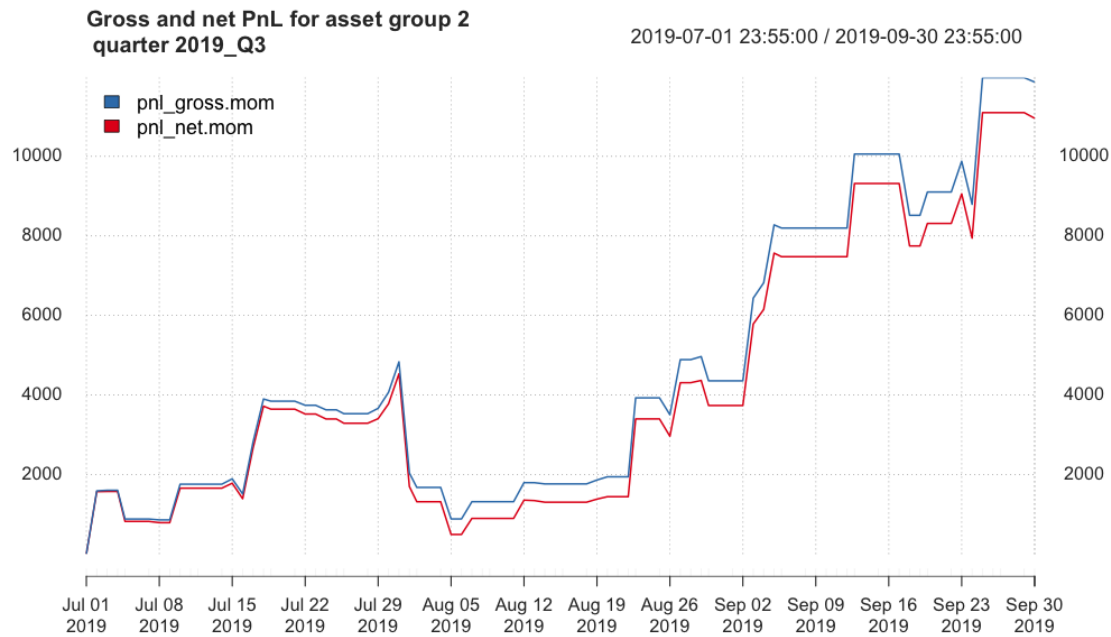
In the first quarter of 2019, the netPnL steadily increased to approx. 5,000. This indicates the chosen trading strategy worked out well.

## PnL of results for group 2 – quarter 2019Q2



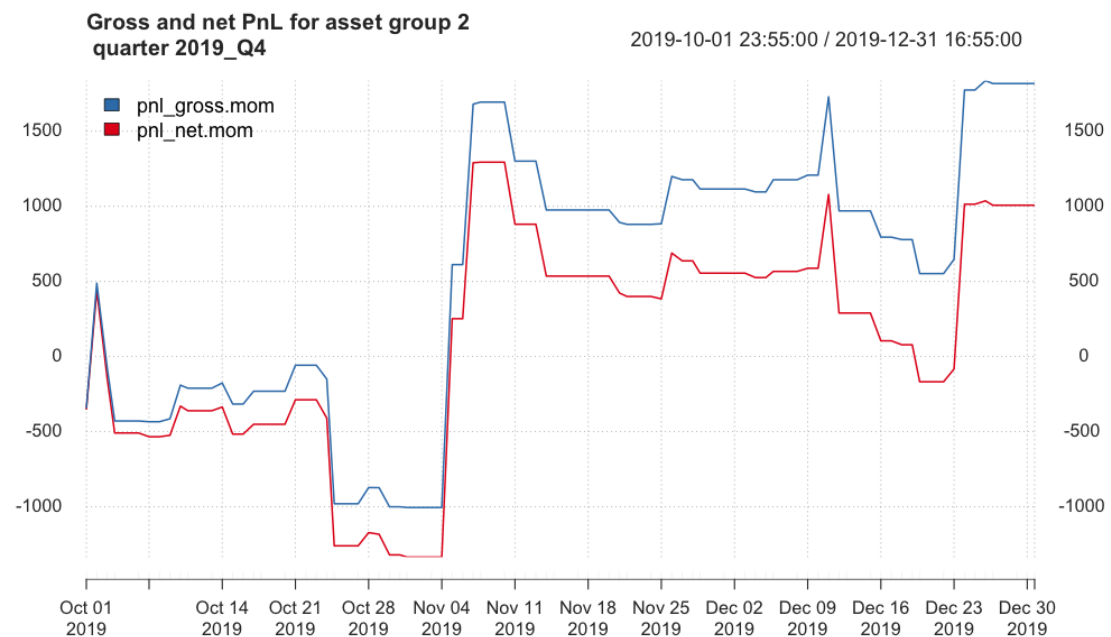
In the second quarter of 2019, the netPnL steadily decreased to approx. -4,000. This suggests that a change from Momentum Strategy to Mean-reverting Strategy would improve the outcome. Additionally, another entry/exit technique could also improve the outcome.

## PnL of results for group 2 – quarter 2019Q3



In the third quarter of 2019, the netPnL decreased to above 10,000 at the end of the quarter. This indicates that the chosen trading strategy worked out well. However, the graph also shows no change of the netPnL at the end of the quarter.

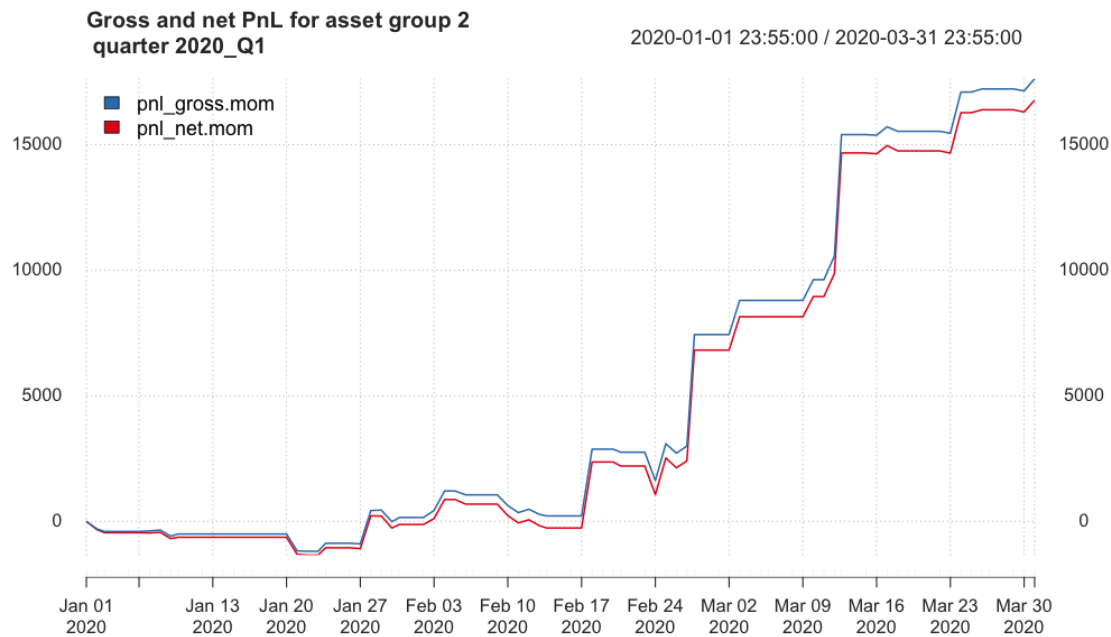
## PnL of results for group 2 – quarter 2019Q4





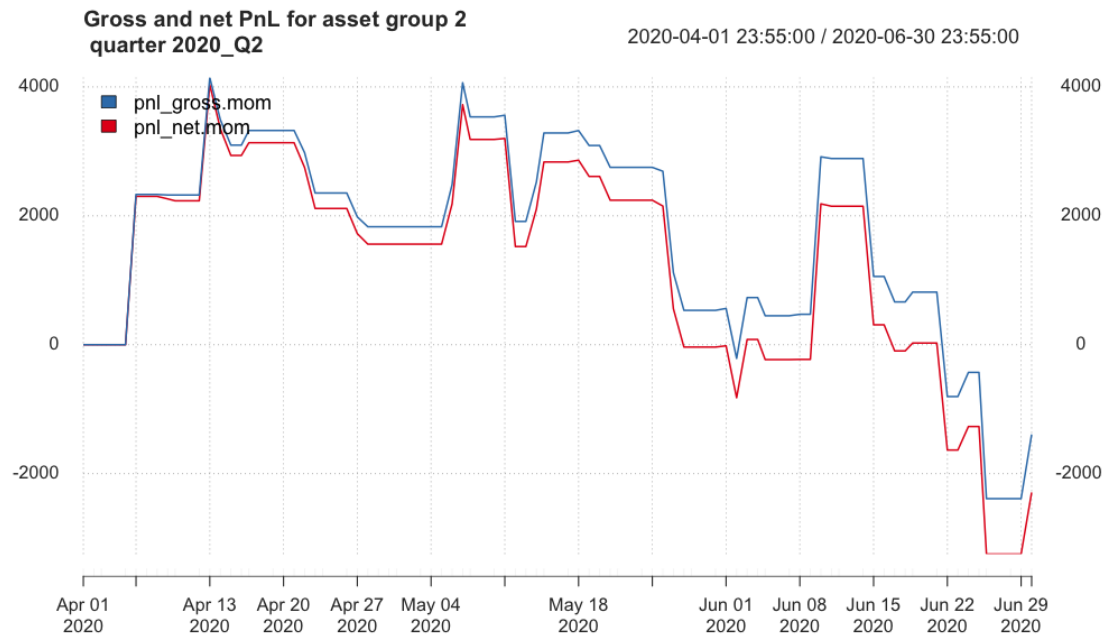
In the fourth quarter of 2019, the behavior of the netPnL was relatively volatile. At first, it decreased to approx. -1,000 then increase to above 1,000 until it decreased again until below zero. At the end of the quarter, the netPnL was approx. 1,000. The spread between the grossPnL and the netPnL indicates an increase in the number of trades. Thus, a change of entry/exit technique or measure of the current technique could improve the outcome.

## PnL of results for group 2 – quarter 2020Q1



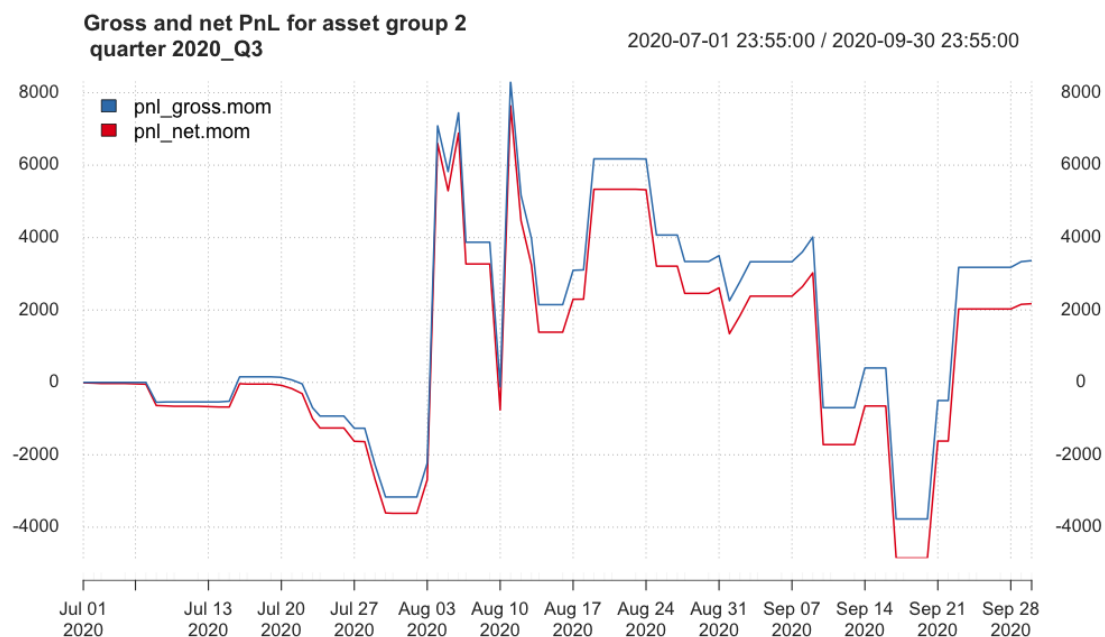
In the first quarter of 2020, the netPnL steadily increased to above 15,000. This result suggests that the chosen trading strategy is well suited for this quarter.

## PnL of results for group 2 – quarter 2020Q2



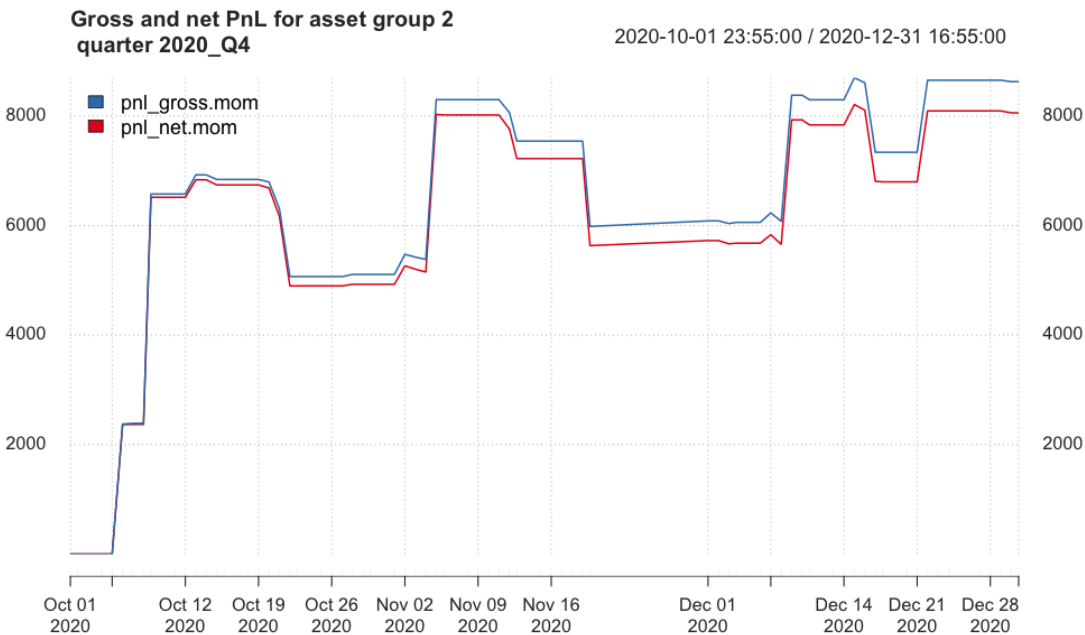
In the second quarter of 2020, the netPnL decreases besides some short outliers to approx. -2,000. This indicates that the Mean-Reverting Strategy would be the more suitable strategy. Additionally, the extent of the outcome suggests that another entry/exit technique or measure of the current technique could improve the outcome which is again not certain since the COVID-19 pandemic hit the stock market in this quarter.

## PnL of results for group 2 – quarter 2020Q3



In the third quarter of 2020, the netPnL behaved very differently over this period. At first, the outcome increased until approx. 8,000 and then decreased to -4,000 after it recovers to approx. 2,000. This indicates that the chosen entry/exit technique or the current measure of the technique is not well suited.

## PnL of results for group 2 – quarter 2020Q4



In the fourth quarter of 2020, the netPnL decreases with some dips over this period. However, at the end of the quarter, the outcome reaches the highest amount of 8,0000 netPnL. This shows again that the chosen strategy as a measure was a good choice.

## Summary and conclusions

In conclusion, for both groups, the chosen entry/exit technique was the Volatility Breakout Model. The Momentum Strategy was the predominant strategy for both groups. However, for group 2 the Mean-Reverting Strategy would be more suitable in particular quarters. The chosen trade strategies for group 1 worked out well also for the out of the sample data. Examining the behavior within the quarters in group 1 there could be done some slight changes to improve the outcome of the strategy. For group 2 the chosen strategy had a relative to group 1 lower outcome. Comparing the outcome of the sample data to the out of sample data, the chosen strategy worked out better. Nevertheless, examining the behavior of the data within the quarter's changes from the Momentum Strategy to the Mean-Reverting Strategy would have a major positive impact on the outcome of group 2. However, implementing an algorithm that would identify the moment of a change of these strategies would exceed the scope of this class. A pattern that is independent of the group is that the outcome substantially changes at the end of several quarters. Thus, the implementation of an additional rule of which stops trading after a certain day at the end of the period could simply

improve the outcome of both groups. In the end, both strategies have a positive outcome which implies that the chosen strategies were at least to some extent appropriate.