Project Report

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1. Instrument and Strategy

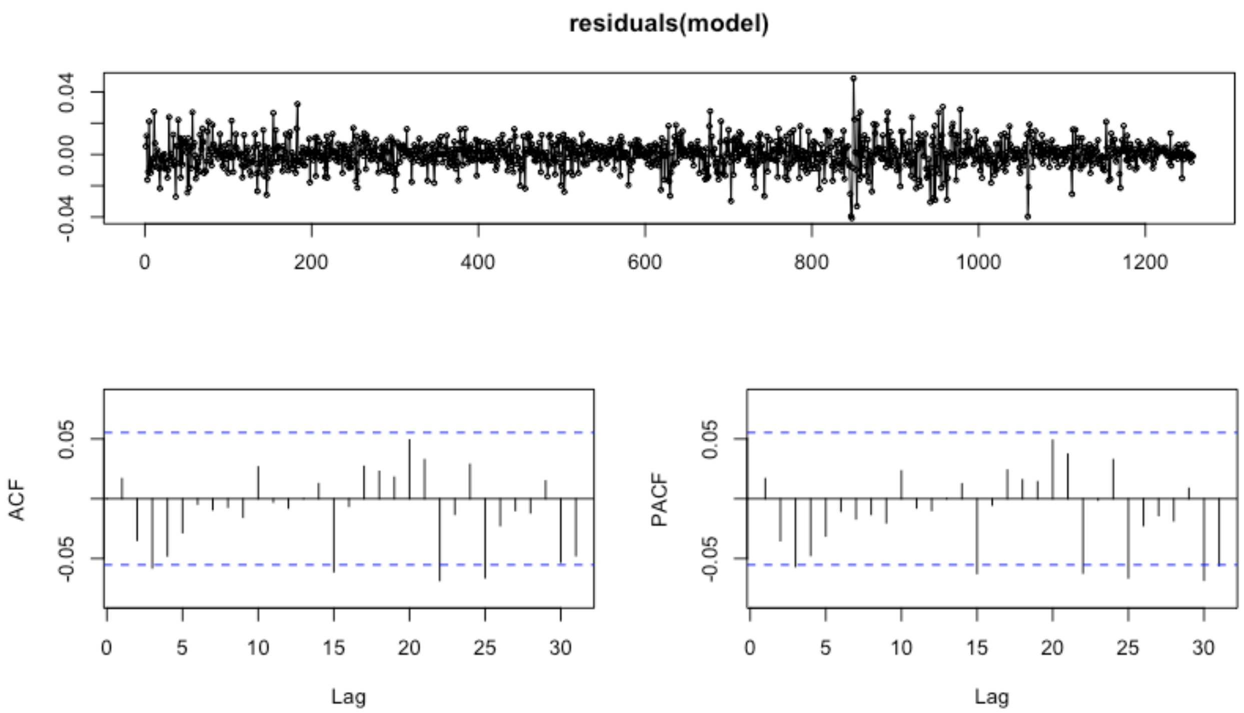
The instrument I have chosen is XLK, an ETF for technology sector. The time period I used is 5 years, from 2014-04-10 to 2017-04-07. It includes the 2018 financial crises, which is a very unique opportunity to the test how robust the strategy is.

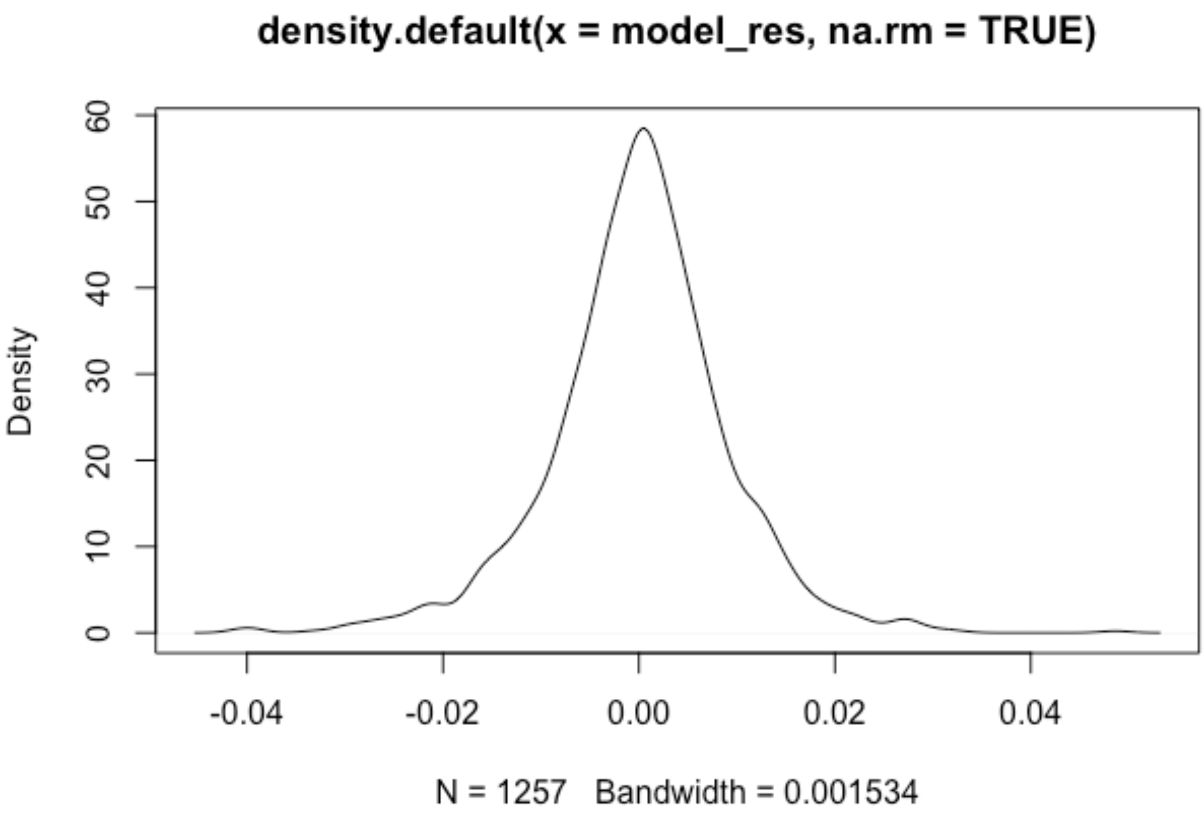
The trading strategy is based on the idea of mean reverting. I have calculated the exponential weighted moving average (EWMA) as the trading signal, and compare the close price with the EWMA signal. If the adjusted close price is higher than the signal, I short one unit of ETF; if the price goes lower than the signal, I long one unit of ETF. However, I have done some improvements to this strategy.

There are two arguments when calculating the EWMA, look back window length and lambda which represents how fast the weight of previous price decays. I improve the EWMA signal by choosing lambda dynamically according to the result of back testing. More specifically, when I look back at time t, I calculate the Sharpe Ratio and choose the lambda which gives me the highest Sharpe Ratio and use this lambda do calculate EWMA after time t.

2. Beck test

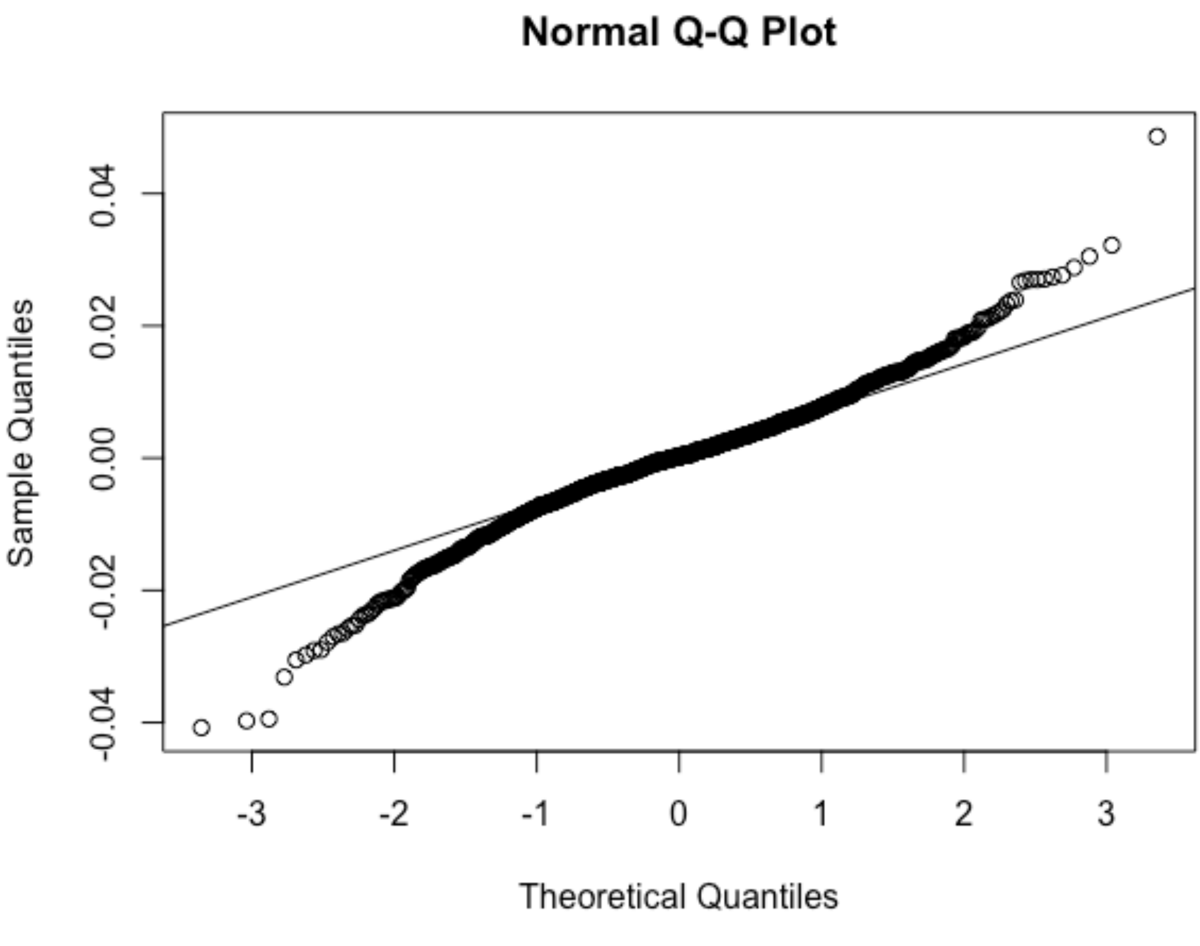
After implementing the trading strategy, it comes to the part of back testing. In this part, I have used a R package called “boot” which provides a bootstrap framework. But before we goes to the bootstrap part, I want to discuss the time series modelling part. Because I choose to bootstrap residuals of the times series model, I tried to choose a good model. After calculated the log daily return of the XLK, I have tested the stationarity of the new time series (log daily return). The Augmented Dickey-Fuller test gives a p-value less than 0.01, which means the times series is stationary. Then, I used auto.ARIMA function in R, which gives me the best ARIMA model based on AIC criteria (Akaike Information Criterion). The residuals, ACF and PACF graphs of the best ARIMA model is as the following.





From these three graphs, we can see that there are maybe some pattern in p=3 or q=3. But even if I choose q=3 for the order argument of ARIMA, we will see the residuals are still not normally distributed. If we plot the density of the residuals, the distribution is as the following.

We can see the distribution of the residuals seems like a normal distribution. So in order to see in more detail, I also drew the Q-Q plot of the residuals, which is as following.



In the Q-Q plot we can see even if the distribution looks like a normal distribution, it actually has fat tails compared to normal distributed random variables. So if we do some test like The Anderson-Darling test or Shapiro-Wilk test, they all give us a very small p-value. Because the null hypotheses of these tests are normally distributed, a very small p-value will reject the null hypotheses which means that the residuals are not normally distributed. However, we can still assume we can use this model to do bootstrap for the time series. So for simplicity, I just choose the AR(1) model.

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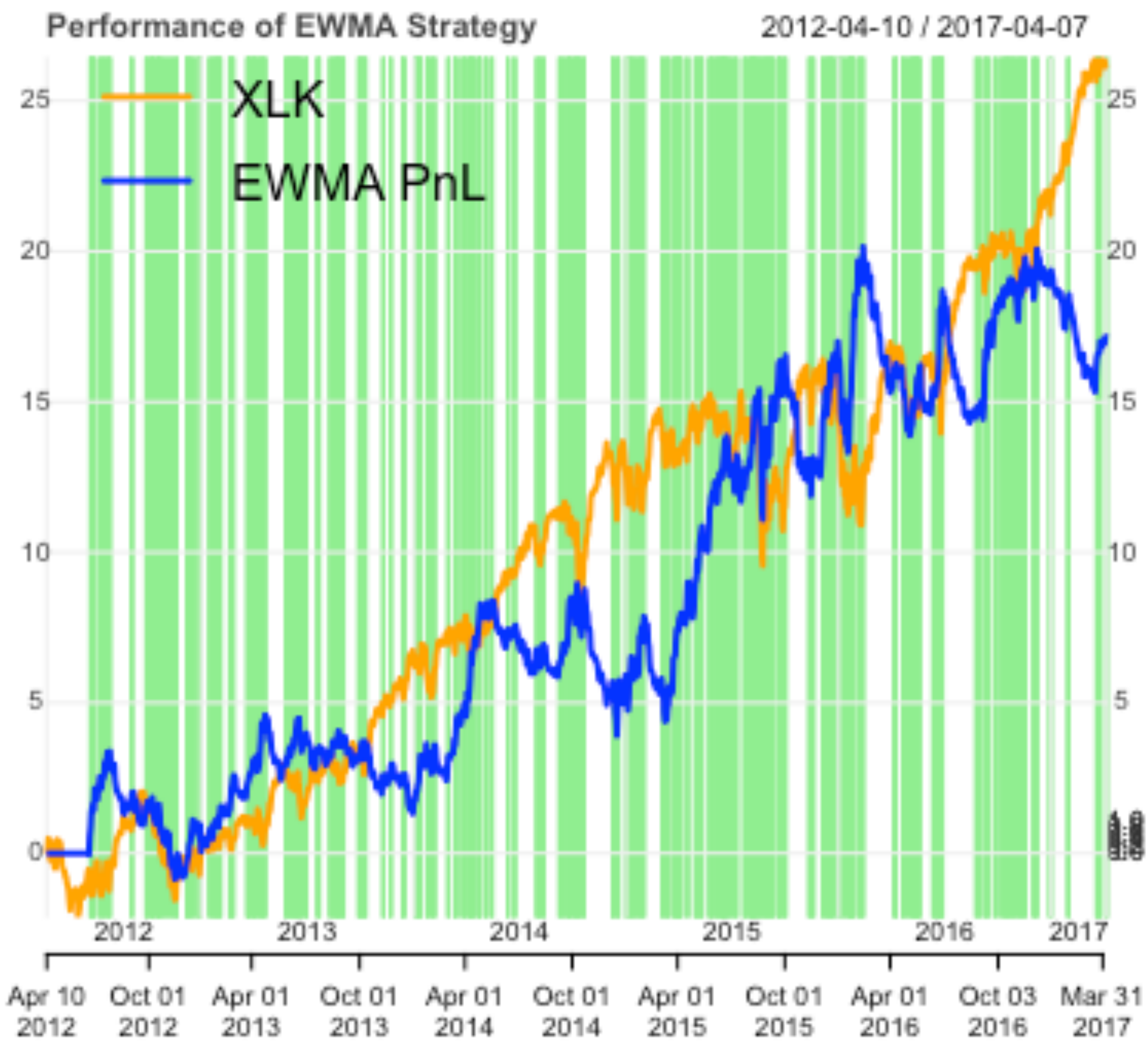
3. Bootstrap results

I have done 1000 times of bootstrap and the result is as the following.

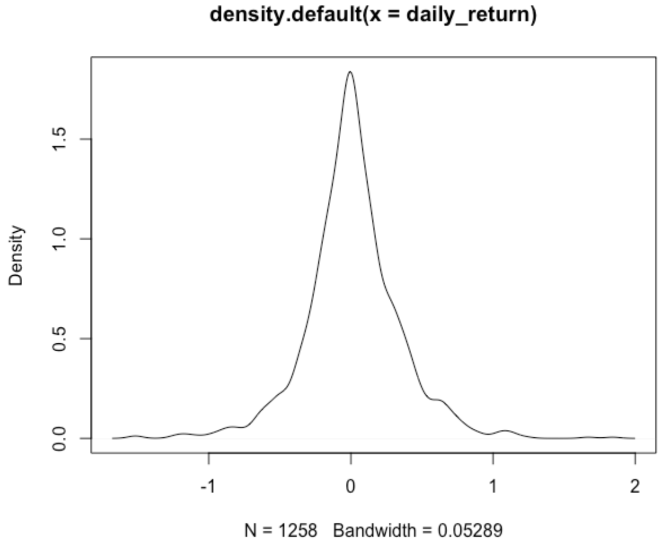
	tradeNum	total_return	winning_rate	max_drawdown	sharpe_ratio
Empirical	234	0.6352441991573199	0.6324786324786325	-0.16233981751398746	0.6641036907209302
Average	241.511	0.1348806540552425	0.6017969591181141	-0.4558688033834125	0.156091720975707

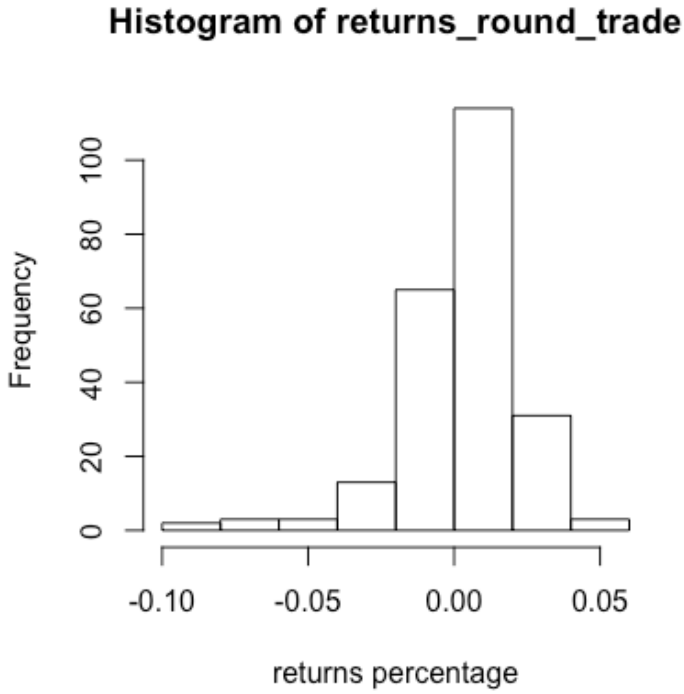
Note: If you want to see that percentage number, you have to time 100 to the number. E.g. on average, total return is 13.49%.

For empirical results, the cumulative pal is as the following.



The yellow line is the price of XLK. I have shifted the beginning of it to 0 so that we can compare it with cumulative PnL easily. The blue line is the cumulative PnL of the EWMA strategy. The green shade background represents long positions, and the white background represents short positions. In Empirical, the total return rate is 63.52% with maximum drawdown of -16.23% which happens during the financial crises of 2008. The portfolio has negative value compared to the beginning point. But on average, the total return rate has declined to 13.49% while the maximum drawdown has increased tup to -45.59%. Even though in empirical it seems a good strategy, on average, it's performance is not acceptable.
If we look at the density of daily PnL, it looks like that they are normally distributed.





4. Possible ways for improving PnL

According to the discuss above, there are several ways to improve this strategy. First of all, using another trading signal will make a huge difference to the PnL. Maybe it's a good idea to choose trading signals according to optimised back-testing results. Secondly, instead of mean revert, we can combine trading strategy and mean reverting strategy together. For example, using some machine learning techniques like boost or bagging to make weak classifiers stronger (long or short can be viewed as two classes). Finally, maybe finding a better model for the time series will gives us a more precise bootstrap result compared to the ARIMA model.