**MSDM5053 Project (Fall 2021)**

**Technical Analysis on HSBC Holdings (0005.HK)**

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1. **Introduction**

HSBC, The Hongkong and Shanghai Banking Corporation Limited, is the largest bank in Hong Kong. It is one of the only three commercial banks in Hong Kong which can issue banknotes for the [Hong Kong dollar](https://en.wikipedia.org/wiki/Hong_Kong_dollar). The stock of HSBC (HSBC Holdings, 0005.hk), used to be Hong Kong people’s favorite stock in the 1990s. People loved it because many people became rich after investing the HSBC stock. Besides, it had a stable dividend return and people believed their money would be safe for buying HSBC. There was a proverb in Chinese: “有買貴，冇買錯” meaning that the decision of buying the stock would not be wrong, though it might be a bit expensive. From the graph of daily historical stock price, there was an upward trend since it first listed in 1980 until 2008 when there was a global financial crisis. Since then, HSBC was no longer the favorite. We believe some Hong Kong people are still loving it, but more are hating it.

1. **Objective**

In the project, we are going to apply some techniques of modeling time series to analyze the stock price of HSBC Holdings, 0005.hk. We will first try to find adequate models for different price series. Then we will suggest some trading strategies and test for their performance. At the end of this report, we will share some insights we have observed throughout the project.

1. **Data**

The historical stock price of 0005.hk were obtained from Yahoo! Finance’s API via Python. The data downloaded with specific time horizon (daily, weekly, monthly) consists of the following fields:

1. Open – Opening price ()
2. High – Highest price ()
3. Low – Lowest price ()
4. Close – Closing price ()
5. Volume – Trading Volume
6. Dividends – dividend
7. Stock Splits

In this project, we will focus on the daily series of High, Low and Close. The oldest data available was from 03 January 2000. The data were separated into two parts with the training part consisting data from year 2000 to year 2015 while the remaining from year 2016 onwards will be used for testing.

1. **Model Fitting**

In this section, we are fitting different models for daily High, Low and Close series separately with the training data and determine the model to be used for prediction in the testing dataset. 5% significant level is used for type-I error.

* 1. **Daily High Series**
     1. **Stationarity checking**

From the graph of over time, it is clear that series is not stationary.

Applying Augmented Dickey-Fuller test (ADF Test) on the differenced log series, , is rejected implies that is stationary.

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* + 1. **Serial Dependence**

Applying Ljung-Box test (LB Test) on , is rejected indicating that there is serial dependence for .

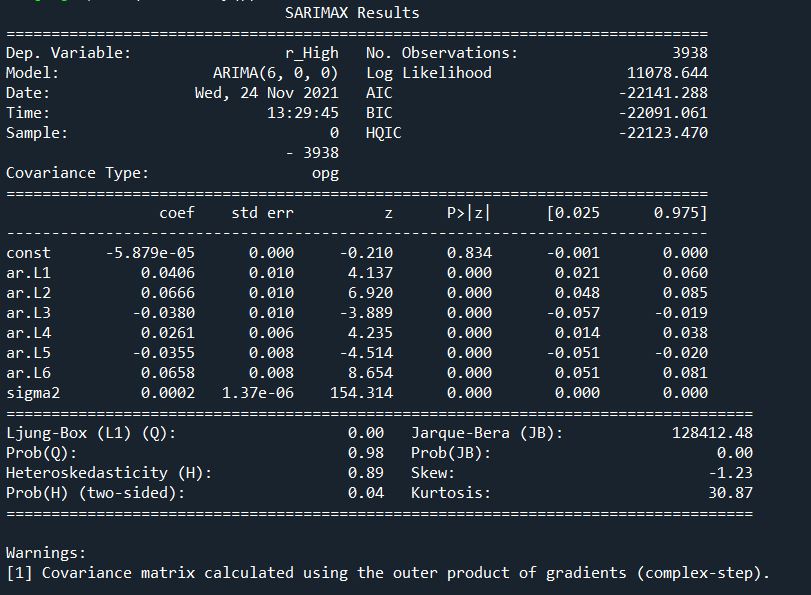


* + 1. **ARMA model**

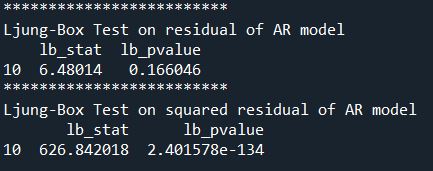
ACF and PACF shows that for .

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ARMA model with different orders were fitted and AR(6) model was chosen. Result shows that all are significant.

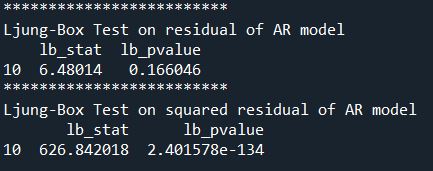


Applying LB Test on the residual of the fitted model, is not rejected indicating that the model is adequate.

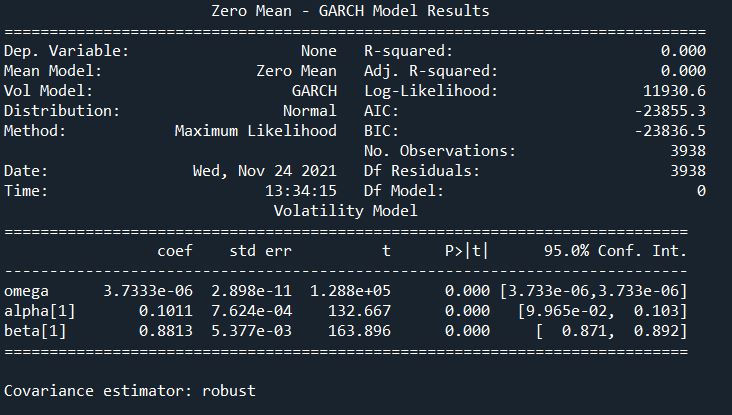


* + 1. **GARCH model**

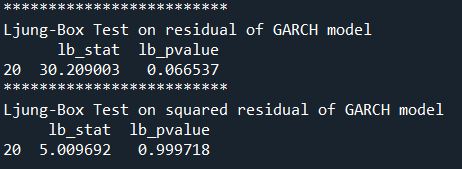
Applying LB Test on the squared residual of the fitted model, is rejected indicating that there is ARCH effect.



GARCH(1,1) model with Gaussian innovations was fitted on the residual of the AR(6) model.



Applying LB Test on both the standardized residual and squared residual of the fitted GARCH(1,1) model, is not rejected and we conclude that the model is adequate.



* 1. **Daily Low Series**
     1. **Stationarity checking**

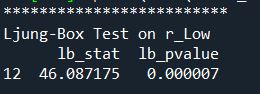
From the graph of over time, it is clear that series is not stationary.

Applying ADF Test on the differenced log series, , is rejected implies that is stationary.

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* + 1. **Serial Dependence**

Applying LB Test on , is rejected which indicating that there is serial dependence for .

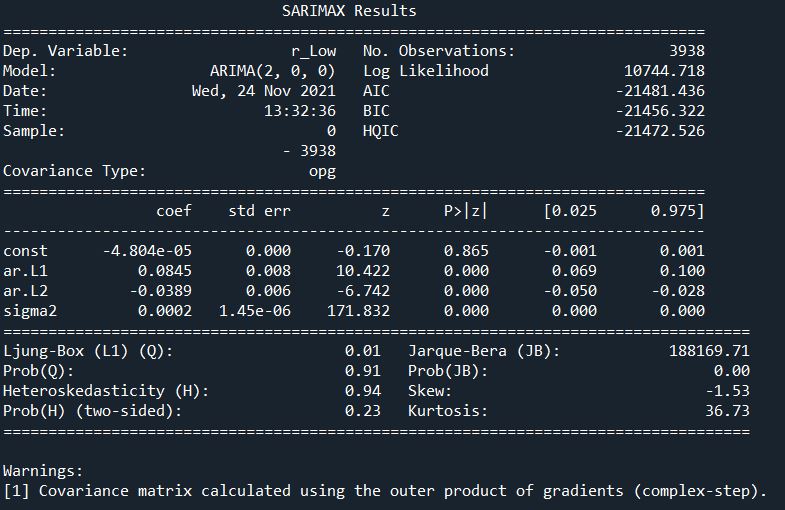


* + 1. **ARMA model**

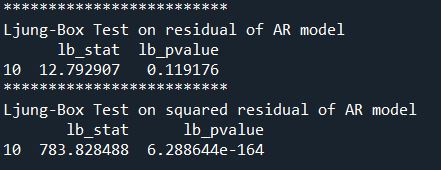
ACF and PACF shows that for .

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ARMA model with different orders were fitted and AR(2) model was chosen. Result shows that both are significant.

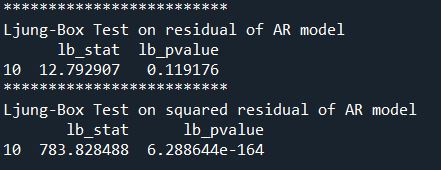


Applying LB Test on the residual of the fitted model, is not rejected indicating that the model is adequate.

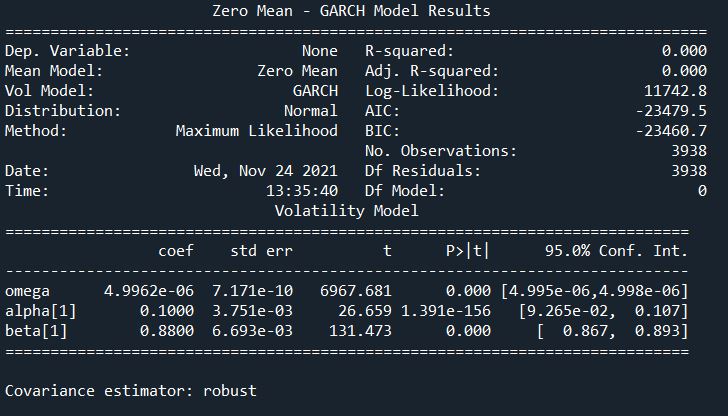


* + 1. **GARCH model**

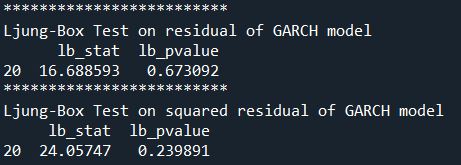
Applying LB Test on the squared residual of the fitted model, is rejected indicating that there is ARCH effect.



GARCH(1,1) model with Gaussian innovations was fitted on the residual of the AR(2) model.



Applying LB Test on both the standardized residual and squared residual of the fitted GARCH(1,1) model, is not rejected and we conclude that the model is adequate.



* 1. **Daily Close Series**
     1. **Stationarity checking**

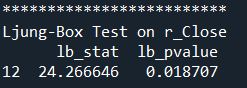
From the graph of over time, it is clear that series is not stationary.

Applying ADF Test on the differenced log series, , is rejected implies that is stationary.

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* + 1. **Serial Dependence**

Applying LB Test on , is rejected which indicating that there is serial dependence for .

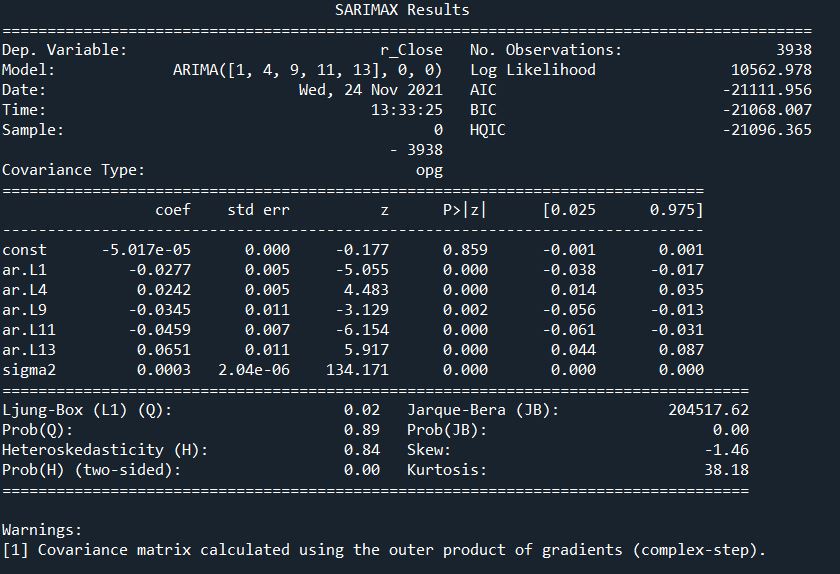


* + 1. **ARMA model**

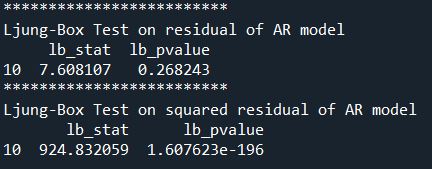
ACF and PACF shows that for some .

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ARMA model with different orders were fitted and AR model with lag-1, 4, 9 and 11 was chosen. Result shows that all are significant.

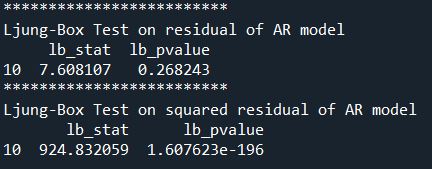


Applying LB Test on the residual of the fitted model, is not rejected indicating that the model is adequate.

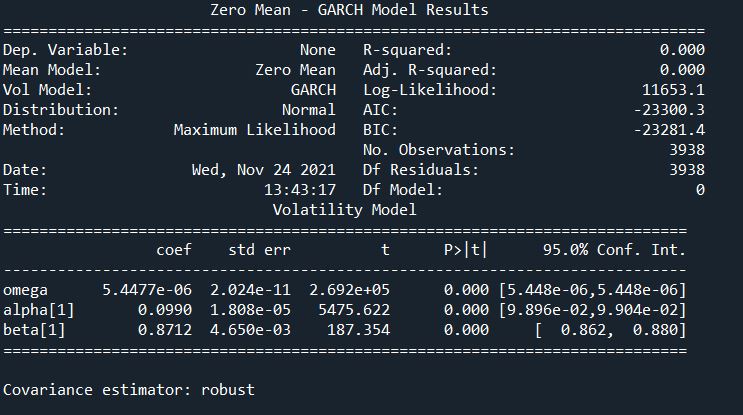


* + 1. **GARCH model**

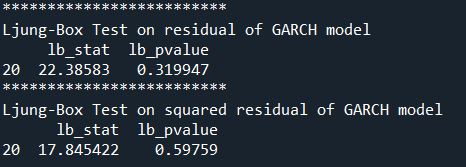
Applying LB Test on the squared residual of the fitted model, is rejected indicating that there is ARCH effect.



GARCH(1,1) model with Gaussian innovations was fitted on the residual of the AR model.



Applying LB Test on both the standardized residual and squared residual of the fitted GARCH(1,1) model, is not rejected and we conclude that the model is adequate.

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1. **Predictions**

Having determined the adequate models for , and , we now make 1-step ahead predictions on the testing period.

Steps of make prediction at day t:

1. Fit the defined ARMA model with data from 03 January 2000 to day .
2. Get the 1-step ahead forecast for the returns: .
3. Fit GARCH(1,1) model with the residual of the ARMA model.
4. Get the 1-step ahead forecast for the standard deviations: .
5. The 1-step ahead prediction for stock prices () are given by:

for c = high, low or close.

1. The 95% prediction intervals are given by:

for c = high, low or close.

The percentage of actual prices lying within the prediction intervals aligned with the confidence interval chosen:

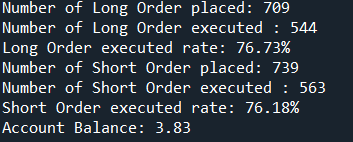
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| --- | --- | --- | --- |
| Series | High | Low | Close |
| % | 93.37% | 94.4% | 93.72% |

1. **Strategy**

In this section, we are proposing several “Buy Low Sell High” trading strategy which are intuitively feasible. The performance of each strategy will be tested with the actual data since Year 2016 with the assumption of no transaction cost.

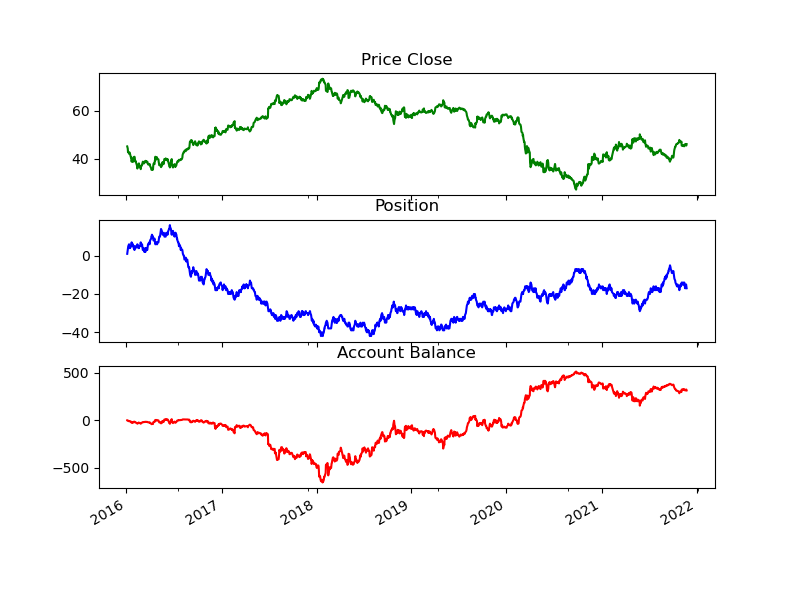
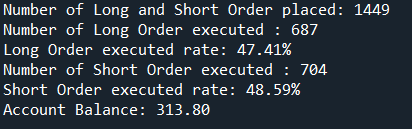
* 1. **Trading with** 
     1. **Description**
* After the market closed on day , will be predicted.
* If , then we place an order to long with price .
* If , then we place an order to short with price .
* On day t:
  + The long order will be successful if with ;
  + The short order will be successful if with .
* Both the short and long orders are of the same volume = 1 in the test.
* Positon will be +1 if the long order is executed and -1 if the short order is executed.
  + 1. **Performance on test data**

The result is not promising. The final account balance is just as the initial level. The account balance from 2016 to 2018 has a downward trend and gradually climbs upward since 2018, which is in the opposite direction of the stock price change. The position is also in the opposite direction of the stock price.



* 1. **Trading with and** 
     1. **Description**
* After the market closed on day , and will be predicted.
* A short order will be placed with price and a long order will be placed with price .
* On day t:
  + The long order will be successful if with ;
  + The short order will be successful if with .
* Both the short and long orders are of the same volume = 1 in the test.
* Positon will be +1 if the long order is executed and -1 if the short order is executed.
  + 1. **Performance on test data**

Though the latest account balance is positive, the performance is not promising as well. Profit will be made if both the buy and sell orders could be executed at the same day. However, we can see that during the Close Price increasing period (Mid 2016 to Start 2018), the number of short order executed exceeds the number of long order executed which resulted in a negative account balance in the start of Year 2018.



* 1. **Trading with the 95% prediction intervals of and – version 1**
     1. **Description**

This is similar to strategy as described in 6.2 but orders will be placed only when the prediction intervals of and do not overlap. The price of short order to be placed is the minimum of the interval and the price of long order to be placed is the maximum of the interval as illustrated below.

95% Interval

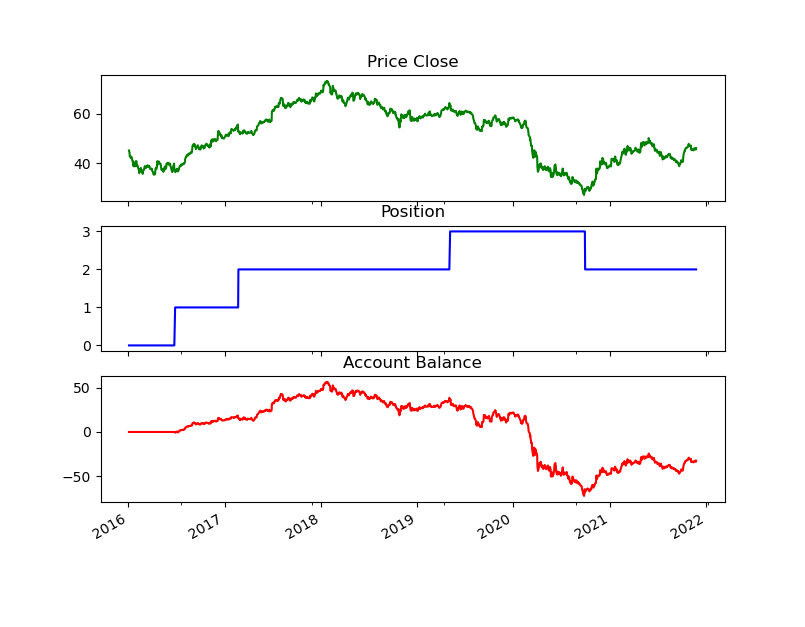
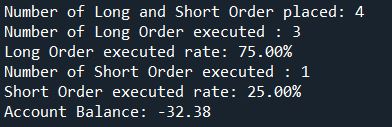
95% Interval

Short at min( Interval)

Long at max( Interval)

* + 1. **Performance on test data**

This strategy aims to increase the chance of executing the short and long orders in the same date. However, it is not useful at all as the chance of having separated prediction intervals of High and Low are very small. Among the horizon of the test data, the prediction intervals of and did not overlap only in 4 days and the chance of short and long orders executed in the same day has not been increased.

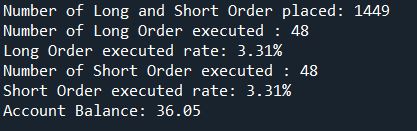


* 1. **Trading with the 95% prediction intervals of and – version 2**
     1. **Description**

This is similar to strategy as described in 6.2 that a pair of short and long orders will be placed after the market closed at day . The price of short order to be placed will be the maximum of the interval and the price of long order to be placed will be the minimum of the interval.

* + 1. **Performance on test data**

The percentage of order executed is expected to be low as the order prices are set at the outer boundary of the prediction level. It aims to reduce the number of transaction and at the same time make the transaction at a more competitive price. However, result shows that the transaction price is not as competitive as what is expected.

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1. **Conclusion**

In this project, we are able to fit adequate models for both High, Low and Close series with data from Year 2000 to 2015. Four strategy has been tested with data from Year 2016 onwards but none of them shows promising results. Some potential reasons are summarized below:

1. Use of point estimate for decision making is not reliable

Point estimate is only the expected value. Even for the true model, we will have about 50% chance that the order could not be executed.

1. The prediction intervals are reliable but not useful.

Using prediction interval should be more appropriate. However, the intervals are so wide that it is not useful.

1. The order of dependency may change in long term

The order of ARMA model chosen was fixed for the testing data. It is not surprise that the order of dependence may change over time such that the model chosen became inadequate.

1. Data is limited

Model built with single time series may not explain the series well.

The key of our trading strategy to have profit is to have accurate prediction. To have accurate prediction, we need a good model. The good model not only can provide reliable prediction intervals, it should provide narrow intervals so that our orders could be executed in pairs.