FAANG Analysis

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Abstract

It would be important to dive into FAANG since they stand as the top 5 technology companies in America. In this paper, statistical analysis will be used to evaluate FAANG. The analysis will begin with evaluating on different risks of FAANG. Next, Capital Asset Pricing Model (CAPM) and Fama-French Model will be used to estimate the excess return that FAANG could bring compare to the market. Finally, time series analysis will be used to forecast the FAANG.

1 Introduction

FAANG stands for the most well known American technoloy companies, which are Facebook (FB), Amazon (AMZN), Apple (AAPL), Netflix (NFLX); and Alphabet (GOOG). Generally, analyst use fundamental, and technical analysis to evaluate stock companies. However, in this report, neither one will be presented. Instead, statistical models will be used to analyze FAANG. In addition, data range of 2012-05-18 to 2020-10-09 will be used in this report.

(a) (b)

Figure 1: (a) Price trends of each FAANG (b) Cumulative return on each FAANG.

From the data, it can be tell that: Facebook has grown 6.86 times higher, Amazon has grown 14.83 times higher, Apple has grown 7.05 times higher, Netflix has grown 51.77 times higher, and Google has grown 4.92 times higher. Until October 2020, the growth of FAANG can be rank from high to low as following: Netflix>Amazon>Apple>Facebook>Google. However, knowing the growth is not that useful. The return that FAANG can bring and the future of FAANG is what that really matters. Therefore, this report will be using different statistical methods to answer the questions.

2 Risks of FAANG

Risks can alter an investor's willingness toward an stock due to many reasons, such as budget. Therefore, before dive in further, risks of FAANG should be discussed. There will be 5 methods used for evaluating the risks[1]:

1. Standard Deviation (STD):
   STD is one of the most well known statistical measurement - it tells the distribution of the data. However, it is not that useful since it considered upside variation, where upward movement should be considered as gain instead of risk.
2. Downside Deviation:
   Downside deviation is similar to the concept of STD. However, downside deviation evaluates only the distributions that are below the Minimum Acceptable Rate of Return (MARR), where MARR can be Risk free return, zero, or average return.

[1]The risks that have been evaluated is the rate of return of FAANG

3. Value at Risk (VaR):
Generally speaking: VaR = The expected maximum loss under a level of confidence.

$$Pr\{X < -VaR(\alpha, \Delta t)\} = \alpha\% \tag{1}$$

ex) Under 95% confidence, the maximum loss of next month will be 10%.
However, it should be note that the maximum loss is indeed greater than the VaR value.

4. Expected Shortfall (ES):
Expected Shortfall is simply an extension of VaR: It takes the average value under VaR (or literally the expected shortfall).

$$ES = E[X|_{X \leq -VaR}] \tag{2}$$

5. Maximum Drawdown (MDD):
Maximum Drawdown is the highest drawdown during (0,T). For example, when an investor buys a stock at price X at t=0 but the price begins to drop afterward. At time t, price once reached its lowest at price Y and never goes back to price X. The MDD will then be X-Y, or the maximum loss. In addition, MDD is especially useful when evaluating chasing stocks.

Risk	FB	AMZN	AAPL	NFLX	GOOGL
STD	0.02356	0.019097	0.017917	0.030264	0.015897
Downside Deviation	0.01607	0.01319	0.01288	0.01943	0.01104
VaR	-0.03755	-0.02997	-0.02839	-0.04746	-0.02526
ES	-0.05614	-0.04551	-0.04504	-0.07194	-0.03954
MDD	0.479	0.341	0.438	0.442	0.309

Table 1: Risks Table of FAANG

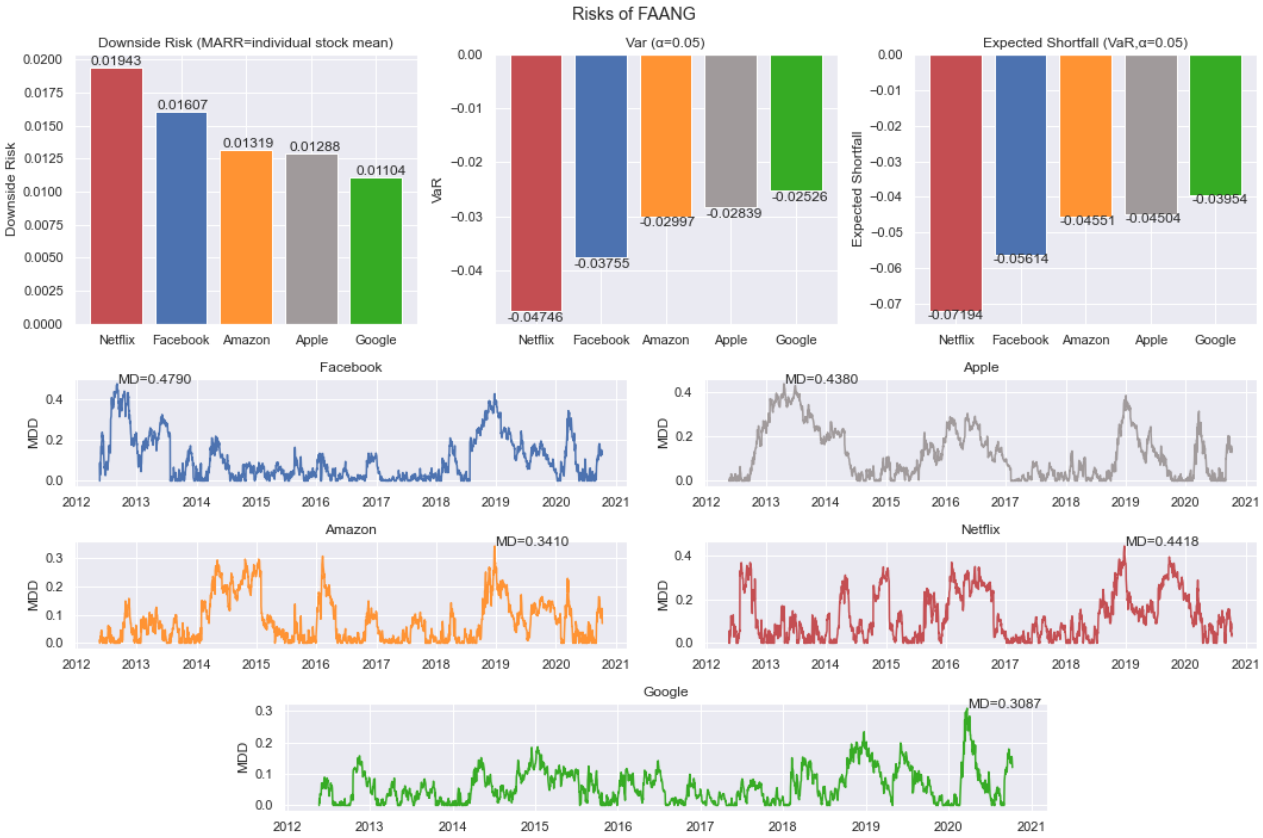


Figure 2: FAANG Risks

First, by looking at the STD of each stock, we made a hypothesis that the risk of Netflix > Facebook > Amazon > Apple > Google. To support the hypothesis, Downside Deviation, Value at Risk (VaR), Expected Shortfall (ES), and Maximum Drawdown (MDD) were examined. By looking at the graphs, it can tell that the Downside Risk, VaR, and ES have all given out same conclusion as the hypothesis: risk of Netflix > Facebook > Amazon > Apple > Google. On the other hand, when MDD is examined, it turns out that the MDD from high to low is not the same: Facebook > Netflix > Apple > Amazon > Google. This gives us an understanding that, when extreme event happens, Facebook could bring a greater loss to investor (even though Netflix has the highest risks in general).

3 Capital Asset Pricing Model (CAPM)

Risks can be categorized as systematic, and unsystematic risk. Systematic risk is the one that can affect the entire market, which is beyond the control of an individual and can't be diversified. For example, macroeconomic risks such as inflation, political crisis, and natural disasters are consider as unsystematic risks. On the other hand, systematic risk is the risk that can be prevented, or can be diversified through asset allocation. For example, risks that only affect individual firm or sector, such as failure of product development, and the drop of real estates during recession, respectively.

Since systematic risk can't be diversified, it is required for a risk premium. Therefore, there should be a relation between the risk premium and the return of the market. CAPM is the model that build under this relation.

Commonly seen CAPM:

$$E(R_i) = R_f + \beta \times [E(R_m) - R_f] \tag{3}$$

where:

$E(R_i)$ = Expected return of asset i
R_f = Risk free rate
$E(R_m)$ = Expected return of market
$E(R_m) - R_f$ = the market risk premium
β = the volatility of the asset with respect to the market

In 1968, Michael Jensen raised Jensen's Alpha[2] to evaluate the performance of mutual fund manager:

$$\alpha_i = R_i - E[R_i] \tag{4}$$

$$\rightarrow \alpha_i = R_i - [R_f + \beta_i(E(R_m) - R_f)] \tag{5}$$

$$\Rightarrow R_i - R_f = \alpha_i + \beta_i(E(R_m) - R_f) \tag{6}$$

α can be interpret as the abnormal return that an asset make compare to the expected return computed by CAPM. Therefore, by evaluating an asset with CAPM and Jensen's alpha, one could have an idea of the expect and abnormal return that an asset could bring.

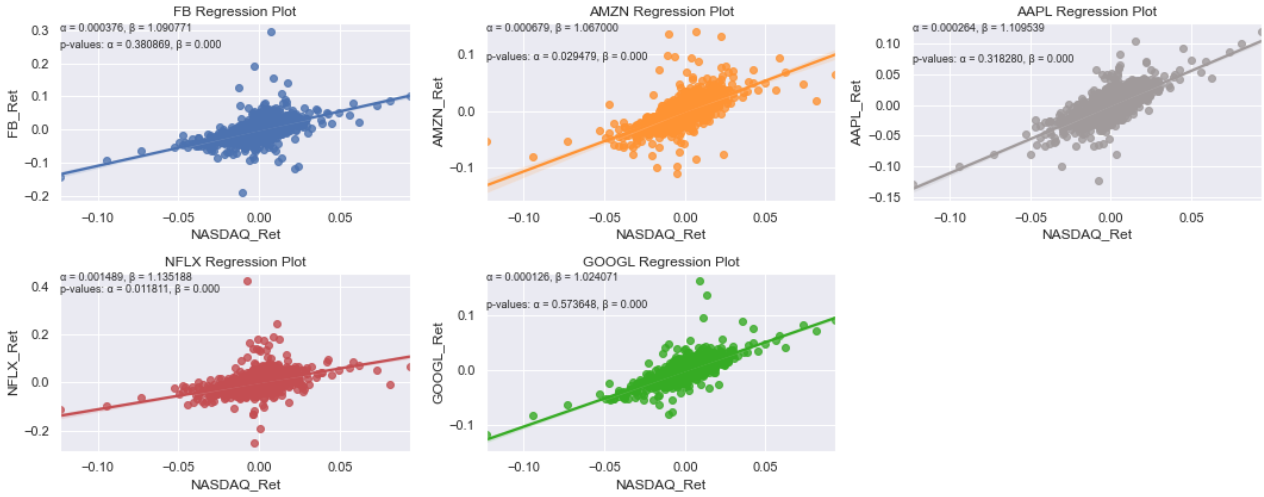


Figure 3: FAANG CAPM[3]

- Facebook

$$R_{FB} - R_f = 0.000376 + 1.090771(R_{NASDAQ} - R_f) \tag{7}$$

α_{FB} have a p-value[4] of 0.38 and β_{FB} have a p-value of 0. As a result, under 95% level of confidence, there is no excess return for Facebook. In addition, the β for Facebook is 1.09, which tells that Facebook moves with the NASDAQ market.

- Amazon

$$R_{AMZN} - R_f = 0.000679 + 1.067(R_{NASDAQ} - R_f) \tag{8}$$

α_{AMZN} have a p-value of 0.029 and β_{FB} have a p-value of 0. As a result, under 95% level of confidence, there is an excess return of 0.068% for Amazon. In addition, the β for Amazon is 1.067, which tells that Amazon moves with the NASDAQ market.

[2] Jensen Michael C. "The Performance of Mutual Funds in the Period 1945-1964." The Journal of Finance 23.2 (1968): 389-416

[3] The market is chosen to be the NASDAQ and risk free rate is the 1 Year Treasury Rate at 2020/10/9: 0.15%

[4] When null hypothesis is true, p-value is the maximum probability that an observed result(or more extreme) happens.

- Apple

$$R_{AAPL} - R_f = 0.000264 + 1.109539(R_{NASDAQ} - R_f) \tag{9}$$

α_{AAPL} have a p-value of 0.32 and β_{AAPL} have a p-value of 0. As a result, under 95% level of confidence, there is no excess return for Apple. In addition, the β for Apple is 1.109, which tells that Apple moves with the NASDAQ market.

- Netflix

$$R_{NFLX} - R_f = 0.001489 + 1.135188(R_{NASDAQ} - R_f) \tag{10}$$

α_{NFLX} have a p-value of 0.012 and β_{NFLX} have a p-value of 0. As a result, under 95% level of confidence, there is an excess return of 0.15% for Netflix. In addition, the β for Netflix is 1.135, which tells that Netflix moves with the NASDAQ market.

- Google

$$R_{GOOGL} - R_f = 0.000126 + 1.024071(R_{NASDAQ} - R_f) \tag{11}$$

α_{GOOGL} have a p-value of 0.57 and β_{FB} have a p-value of 0. As a result, under 95% level of confidence, there is no excess return for Google. In addition, the β for Google is 1.024, which tells that Google moves with the NASDAQ market.

4 Fama-French Three Factor Model

Even though CAPM gives an nice relation between risk premium and expected return of an asset, but risk-premium by itself can't explain the expected return completely. In 1993, Fama and French adds market equity and book-to-market-equity ratio (B/M) as additional two factors for the explanation of expected return. The reason for market equity as a factor can refer to the research of Banz's in 1981, where he found out that a firm with smaller market equity will have better performance than the market, and the reason for book-to-market-equity ratio as a factor can refer to the research of Stattman, where he found out that firm with higher B/M ratio tends to have higher peroformance than the market.

The Fama-French Three Factor Model[5]:

$$E(R_{it}) - R_{ft} = \beta_i[E(R_{mt} - R_{ft})] + s_i E[SMB_t] + h_i E[HML_t] \tag{12}$$

where:

SMB_t = the excess return of small firms (the return of small firms - the return of large firms)
s_i = the corresponding movement of asset i with respect to the SMB factor
HML_t = the excess return of High B/M ratio (the return of high B/M ratio firms - the return of low B/M ratio firms)
h_i = the corresponding movement of asset i with respect to the HML factor

Like Jensen's Alpha, its also useful to write as:

$$E(R_{it}) - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + s_i SMB_t + h_i HML_t \tag{13}$$

1. FB:

$$R_{FB} - R_f = 0.000569 + 1.093153(R_{NASDAQ} - R_f) - 0.000410SMB - 0.002983HML \tag{14}$$

   - α=0.000569, β=1.093153, SMB coef.=-0.000410, HML coef.=-0.002983
   - Corresponding p-value: α=0.193163, β=0.000000, SMB coef.=0.614319, HML coef.=0.000004

2. AMZN:

$$R_{AMZN} - R_f = 0.000753 + 1.069962(R_{NASDAQ} - R_f) - 0.002449SMB - 0.005416HML \tag{15}$$

   - α=0.000753, β=1.069962, SMB coef.=-0.002449, HML coef.=-0.005416
   - Corresponding p-value: α=0.014592, β=0.000000, SMB coef.=0.000020, HML coef.=0.000000

3. AAPL:

$$R_{AAPL} - R_f = 0.000494 + 1.111724(R_{NASDAQ} - R_f) - 0.003837SMB - 0.001192HML \tag{16}$$

   - α=0.000494, β=1.111724, SMB coef.=-0.003837, HML coef.=-0.001192
   - Corresponding p-value: α=0.061862, β=0.000000, SMB coef.=0.000000, HML coef.=0.002337

4. NFLX:

$$R_{NFLX} - R_f = 0.001685 + 1.109416(R_{NASDAQ} - R_f) + 0.001501SMB - 0.005936HML \tag{17}$$

   - α=0.001685, β=1.109416, SMB coef.=0.001501, HML coef.=-0.005936
   - Corresponding p-value: α=0.004992, β=0.000000, SMB coef.=0.178676, HML coef.=0.000000

5. GOOGL:

$$R_{GOOGL} - R_f = 0.000207 + 1.044771(R_{NASDAQ} - R_f) - 0.002353SMB - 0.001649HML \tag{18}$$

[5]Note that the SMB and HML factors can be obtained from the data companies.

- α=0.000207, β=1.044771, SMB coef.=-0.002353, HML coef.=-0.001649
- Corresponding p-value: α=0.359083, β=0.000000, SMB coef.=0.000000, HML coef.=0.000000

In conclusion, it can be seen that, under 95% confidence, Amazon and Netflix will have excess return. Moreover, all of the FAANG are moving positively with the NASDAQ market. In addition, since FAANG stocks were all base on technology[6], they all have low BM; therefore, they move in an inverse direction with the HML factor. Also, the SMB also affects Amazon, Apple, and Google in an negative way, since they were all large firms. Possible reason that the SMB didn't explain well on Facebook and Netflix may be caused by the big drops during 2019[7], where other three firms didn't plunged severely in 2019.

5 Stock Price Forecast

In previous sections, expected return of a stock have been discussed by using CAPM and Fama-French model. However, the models can only give the investors a point estimate, which is not quite enough. In this section, the stock price of FAANG will be forecasted through ARIMA model, so that the investors could have a general idea on how the stock will progress with time.

The first thing that should be done before a time series analysis begin is to check the stationary of the data. Generally speaking, stationary means that a data have same statistical properties over time. If the data is non-stationary, such as trends, then the data can't be used for prediction since it will present false relationship between variables. In addition, Argumented Dickey–Fuller (ADF) test will be used to check for the stationary of the data:

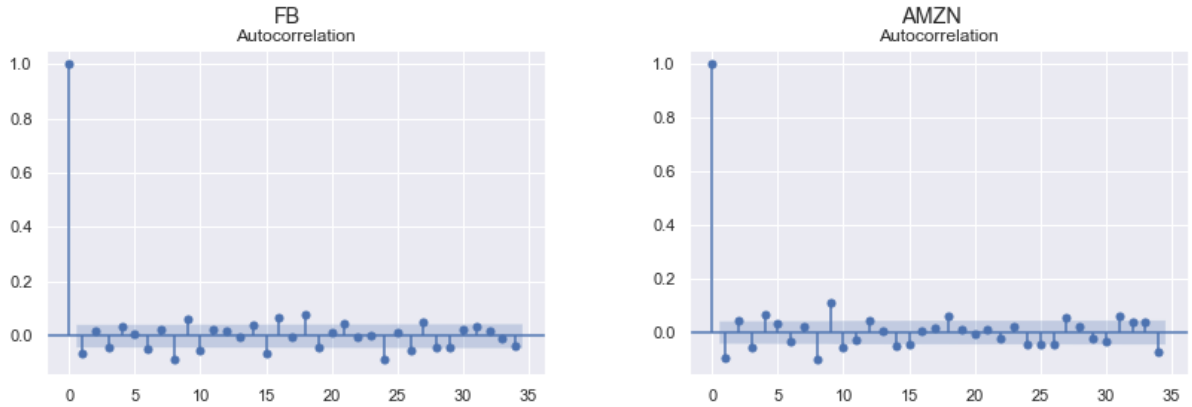
$$H_0 : \gamma = 0 \text{ (Process has unit root, or non-stationary)}$$
$$H_1 : \gamma \neq 0 \text{ (Process has no unit root, or stationary)}$$

Reject null hypothesis if p-value < 0.05; otherwise, fail to reject null hypothesis.

	p-value of ADF test	Stationary?
FB	0.962	Non-Stationary
AMZN	1.000	Non-Stationary
AAPL	1.000	Non-Stationary
NFLX	0.993	Non-Stationary
GOOGL	0.903	Non-Stationary

Table 2: Table of FAANG ADF p-value

The ADF test has shown that all the FAANG stocks are non-stationary. In addition, notice that looking visually at the price history, it can easily tell that there's a trend exist. Therefore, the next thing to do is to transform the data from non-stationary into stationary. The process will begin with taking log on the data, so the magnitude of the value and the influence of trend can be reduced. Then, the data will be take n-step differencing with itself to create a stationary data. Last, check the Auto Correlation Function (ACF) plot of the new data to verify that it is indeed stationary.



[6]Technology sectors are usually growth stocks, which usually have lower BM

[7]Can be check by looking back to the trend figure at Introduction.

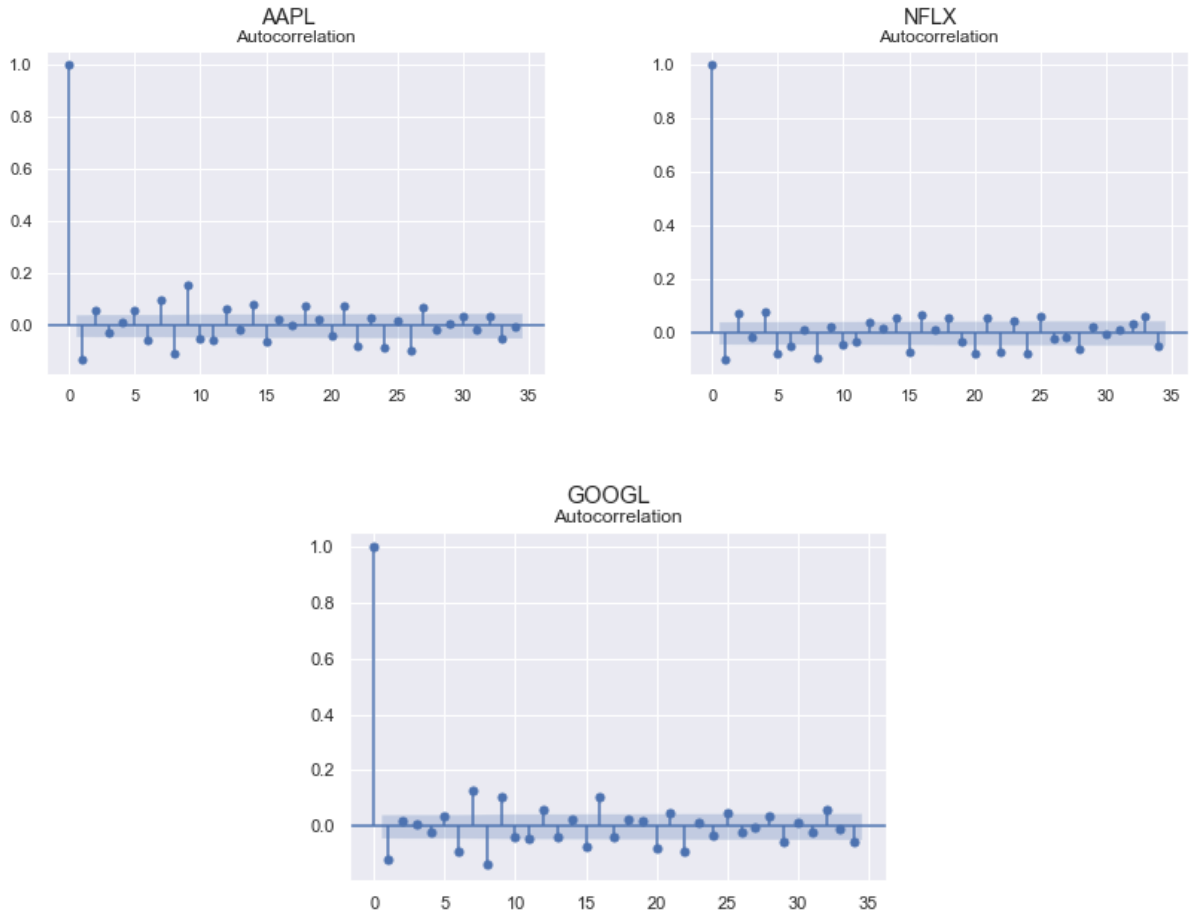


Figure 4: FAANG ACF Plots

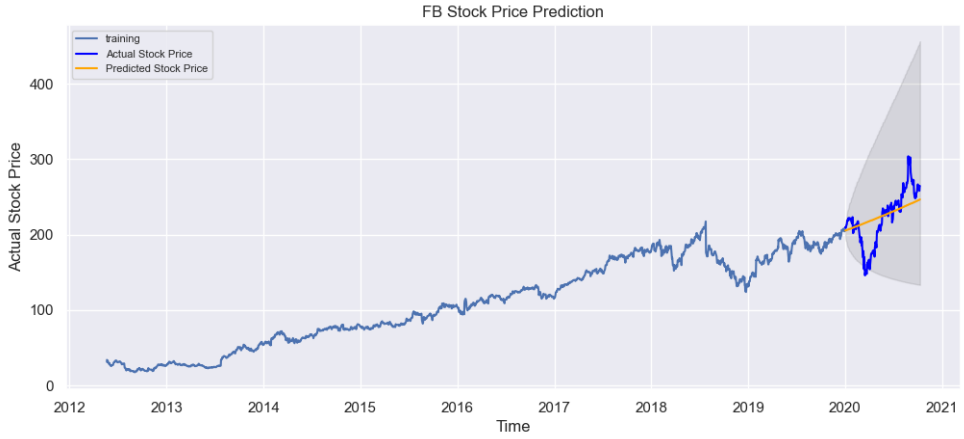
Since the data has been transformed to stationary, the data can now be used for the modeling. To forecast the stock price, Autoregressive Integrated Moving Average (ARIMA) model will be used. The ARIMA model can be decomposed into three parts:

1. Autoregressive:
   Takes the past values as the explanatory variables and the current value as the dependent valuable.
   $$x_t = \alpha + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \cdots + \beta_p x_{t-p} + \epsilon_t \tag{19}$$
2. Integrated:
   The differencing part of the data (The process of making data stationary)
3. Moving Average:
   Takes the error term of each term ϵ_t as the explanatory variables and the current value as the dependent valuable.
   $$x_t = \mu + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \cdots + \theta_q \epsilon_{t-q} \tag{20}$$

where:

α = intercept term
β = coefficient of lag t that the model estimates (with respect to itself)
$E(x_t) = \mu$
$\{\epsilon_t\}$ = white noise
θ = coefficient of lag t that the model estimates (with respect to the white noise)

Result: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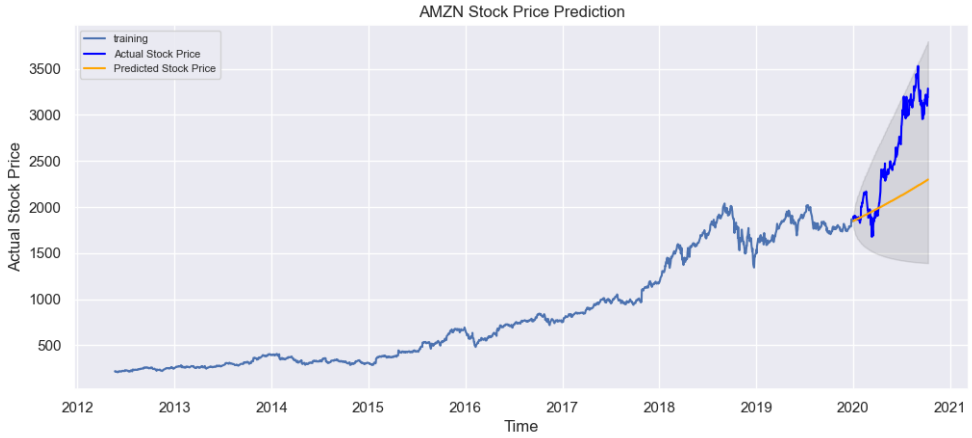
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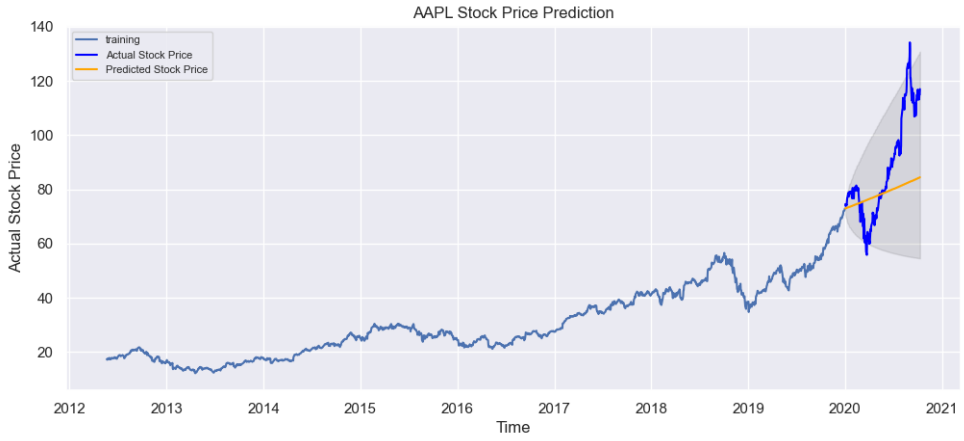
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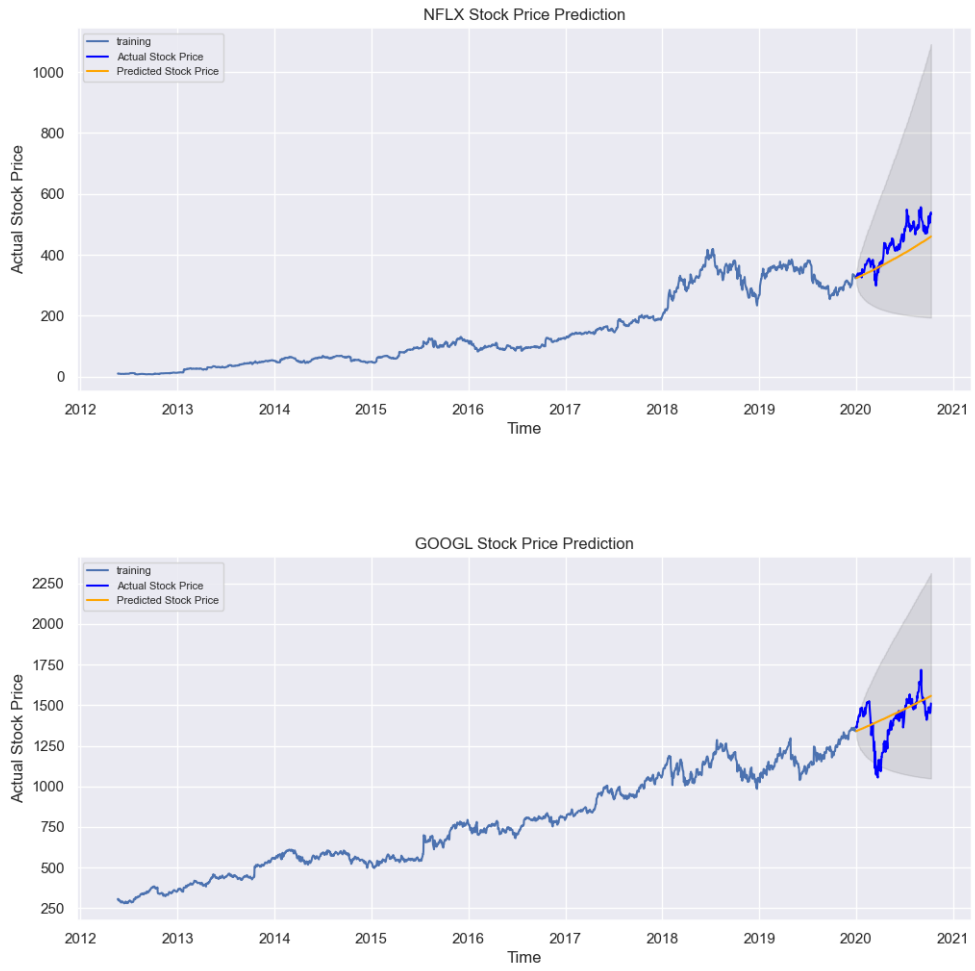


Figure 5: FAANG Stock Forecast (Gray area represents the 95% confidence interval)

By using ARIMA, the general progression of the stock can be tell. However, some models have forecast nicely while others does not. Therefore, the next step is to evaluate the model. One way is to calculate the Mean Absolute Percentage Error (MAPE) of the forecast, which represents the percentage error that the model makes.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}|\frac{A_t - F_t}{A_t}| \tag{21}$$

While MAPE tells us the performance of the forecast, it fail to tell the completeness of the model. The completeness of the model can be check with the residual. If there are correlation between the residues, that means that there are still information left over that haven't been discovered. To check for the residuals, Ljung-Box test will be used:

H_0 : Residuals are white noise

H_1 : Correlation exists between residuals

Reject null hypothesis if p-value < 0.05; otherwise, fail to reject null hypothesis.

	MAPE	p-value of Ljung-Box test	Residue White Noise?	Model Usable?
FB	0.104	0.434	Residue Is White Noise	Yes
AMZN	0.171	0.000	Residue Is Not a White Noise	No
AAPL	0.144	0.000	Residue Is Not a White Noise	No
NFLX	0.0973	0.888	Residue Is White Noise	Yes
GOOGL	0.0695	0.089	Residue Is White Noise	Yes

Table 3: Table of FAANG Model Evaluations

The result has shown that the model have done a pretty nice job on Facebook, Netflix, and Google. However, when the model is used on Amazon and Apple, it turns out that the model has made pretty big mistakes. By evaluating on the residuals, it shows that the residuals aren't white noise; therefore, there's still something missing in the model.

One possible reason is the ARCH effect, where the volatility are not constant over time (homoskedasticity); instead, it's changing over time (heteroskedasticity). Volatility is important since it may be a representation of risk. Investors will want to trade stocks while the volatility of an asset is low. Therefore, the analysis on volatility is also an important part. Here, GARCH[8] model will be used to evaluate the volatility of the daily return of Amazon and Apple.

The concept of GARCH is similar to the ARMA, where GARCH regress with ϵ (AR part) and σ (MA part):

$$\epsilon_t = \sigma_t u_t \tag{22}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \tag{23}$$

where:

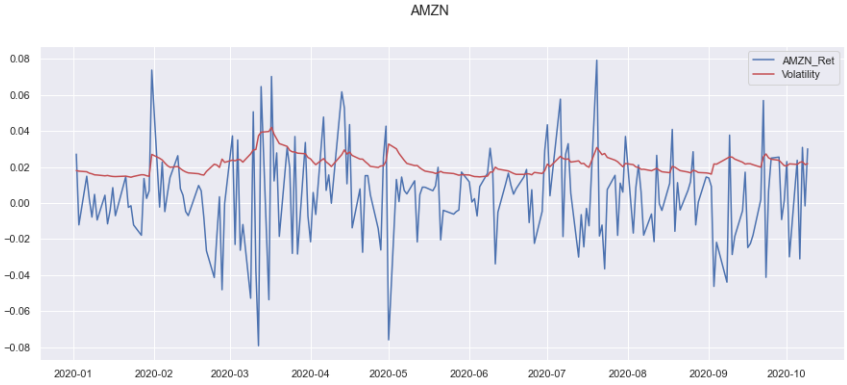
ϵ_t = residual
u_t = iid N(0,1)
σ^2 = variance of the data

- Amazon:

$$r_t = 0.00176 + \epsilon_t \tag{24}$$

where:

$\epsilon_t = \sigma_t * u_t$
$\sigma_t^2 = 0.0000337 + 0.1\epsilon_{t-1}^2 + 0.8\sigma_{t-1}^2$

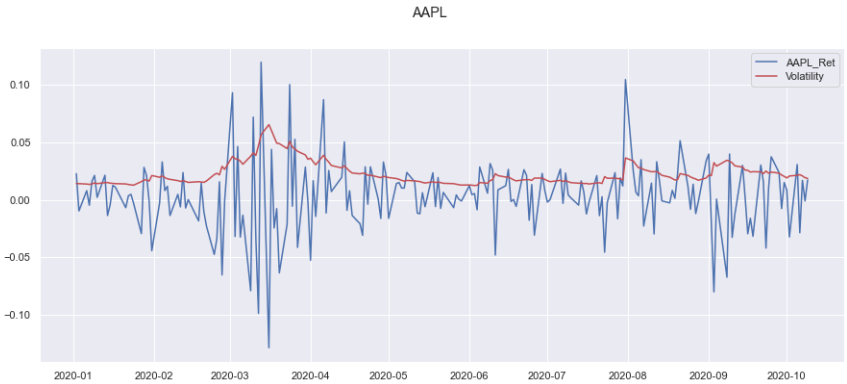


- Apple:

$$r_t = 0.00149 + \epsilon_t \tag{25}$$

where:

$\epsilon_t = \sigma_t * u_t$
$\sigma_t^2 = 0.0000253 + 0.1\epsilon_{t-1}^2 + 0.8\sigma_{t-1}^2$



[8]Note that GARCH only captures the statistic characteristic of a time series but not used for interpret the cause of the characteristic.

6 Conclusion

From the analysis of the FAANG risks, the general risks of the FAANG stock can be rank from high to low as Netflix $>$ Facebook $>$ Amazon $>$ Apple $>$ Google. However, investors should note that the ranking of maximum possible loss of the asset aren't the same, where Facebook $>$ Netflix $>$ Apple $>$ Amazon $>$ Google.

Next, from the CAPM and Fama-French model, the relation between the individual asset and different factors (Market, Small Firms, Book-Market Ratio) has been carry out. Moreover, both models have given out same conclusion: under 95% confidence, Amazon and Netflix brings excess return.

However, knows the asset that can bring excess return isn't enough. By forecasting, the investors can get a bigger picture of the asset they are going to invest on. By the ARIMA model, it shows that all FAANG stocks have a upward trend in the future. Yet, note that there are still errors exist in the forecasts of Amazon and Apple. The GARCH model captures the error, which is the volatility clustering. By analyzing the volatility, investors can decide when to invest on the asset; for example, conservative investor might join when the volatility is low and stable.