

# Homework assignment 1. Programación y modelación financiera (PMF)

Lara Hanna Weitgasser A01759114      Karina Albarrán A01377604  
Christian Contreras A00819400      María Julia Romero A01114404  
Melanie Flores A00820434      Adriana Beatriz Santos Monterroza A00823399

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## **Asset returns**

As we know, a return is the percentage change of an asset price. It turns out that asset returns exhibit more attractive statistical properties than asset prices themselves. In finance, it is very important to know the asset returns because our primary goal of investing in a financial market is to make profits without taking excessive risks. For this analysis the original FANG database will be used which shows the stock prices for Amazon, Facebook, Google and Netflix from 2013-01-02 to 2016-12-30. This database will be compared with the results for the same four companies, however, for the period 2016-12-30 to 2021-07-31.

## **From prices to returns FANG database**

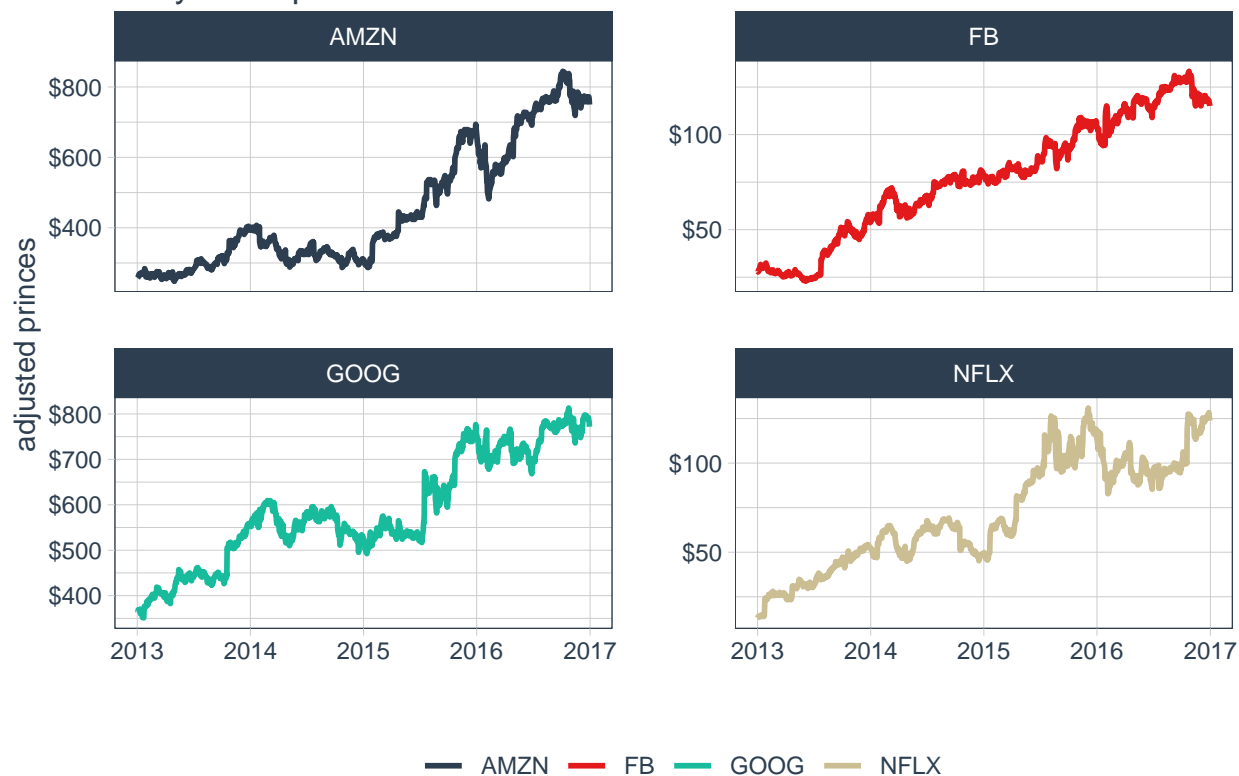
First, a visual representation of the FANG database is needed. In this part daily stock prices per stock are presented.

Daily stock prices from 2013-01-02 to 2016-12-30



It can be seen how stock prices fluctuate in different ranges. Nevertheless, based on the graph on its own, it is not possible to make a decision about the stock to be preferred since one can only observe the fluctuations of the stock prices. It is important to remember to make investment decisions based on prices could be misleading. Besides, each graph must be separated so that price evolution can be clearly observed.

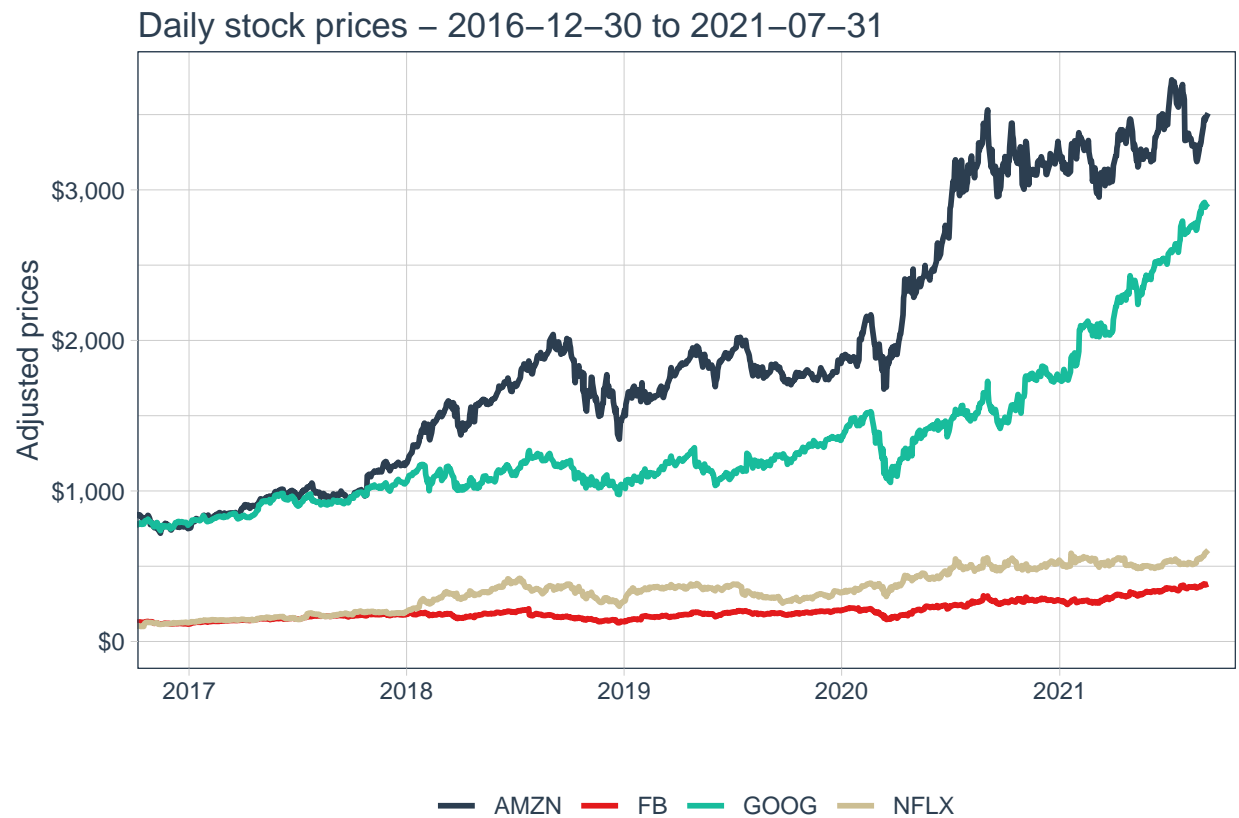
Daily stock prices –from 2013-01-02 to 2016-12-30



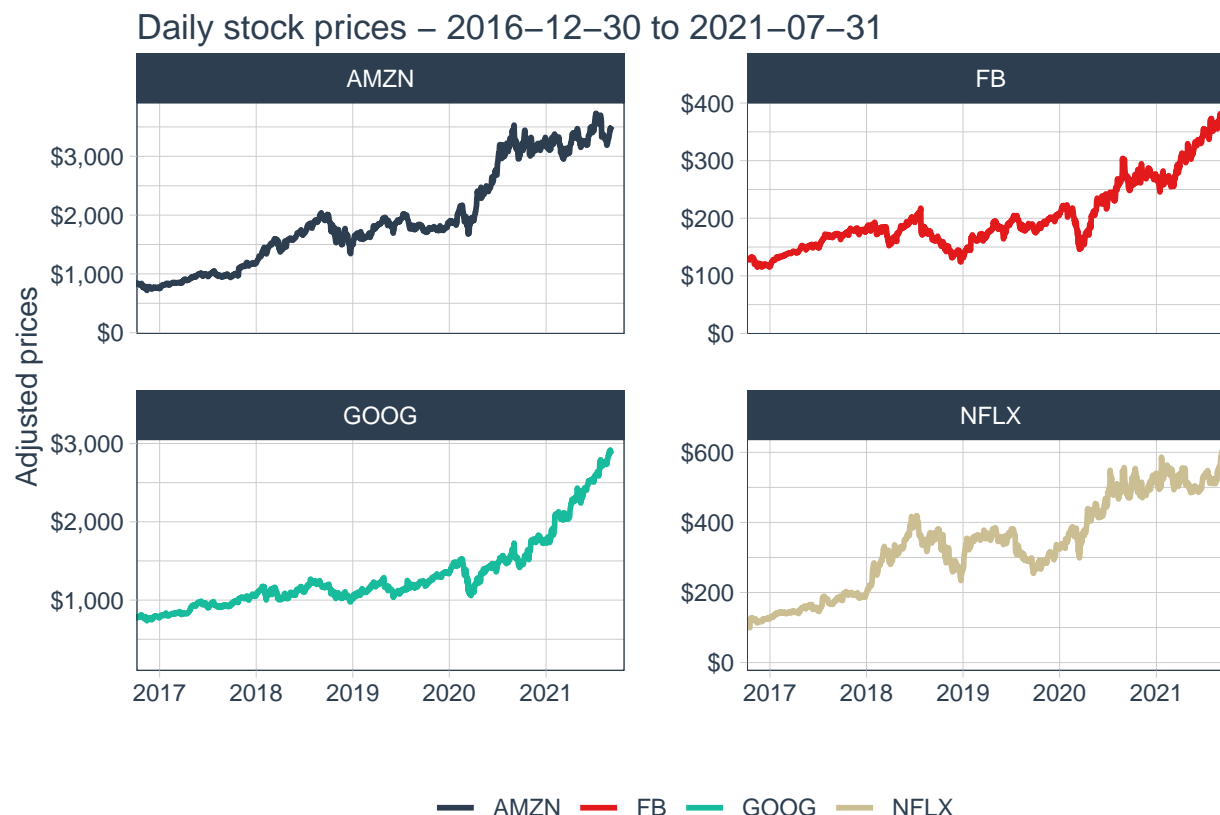
Now that it is more clear one can notice that all stock prices have a positive trend over time, but 2014 was a slightly worse for Amazon, Google and Netflix. In a next step, these results will be compared to the daily stock prices from 2016-12-30 to 2021-07-31.

### From prices to returns from 2016-12-30 to 2021-07-31

At first the data was loaded and plotted for the four companies Amazon, Facebook, Google and Netflix for the time frame 2016-12-30 to 2021-07-31 in order to compare them to the FANG dataset that ends in 2016.



As this plot distorts the perspective on the stock market of the four companies, as in the first step, the next plot shows the four companies separated in order to make comparisons easier and more valuable.



The above plot has the strength of showing the companies separated, however, to make a good comparison, it is important to look at annual returns which will be shown later. It is also important to emphasize, that in a period of 2020 there was a decline in the stock prices of Amazon, Google, Facebook and Netflix. This is because the stock price decreases by the announcement of the pandemic, approximately in March, which is when we can see the decrease in prices. Notwithstanding the pandemic, the four companies recovered.

## Comparison from Prices to Returns

It can be noticed that from 2013-01-02 to 2016-12-30 compared to the new data from 2016-12-30 to 2021-07-31, the prices of all four companies have grown significantly. In both cases, we could say that we prefer Amazon or Google because they have larger price changes compared with Facebook or Netflix, but this would be a mistake. On the other hand, Google in the new data from 2016-12-30 to 2021-07-31 compare to the FANG database had sustained growth, in other words we can say that it had grown without much volatility as Netflix.

As mentioned above, a decision cannot be made based solely on prices, but it can visualize the data to help us to compare the evolution of price per stock.

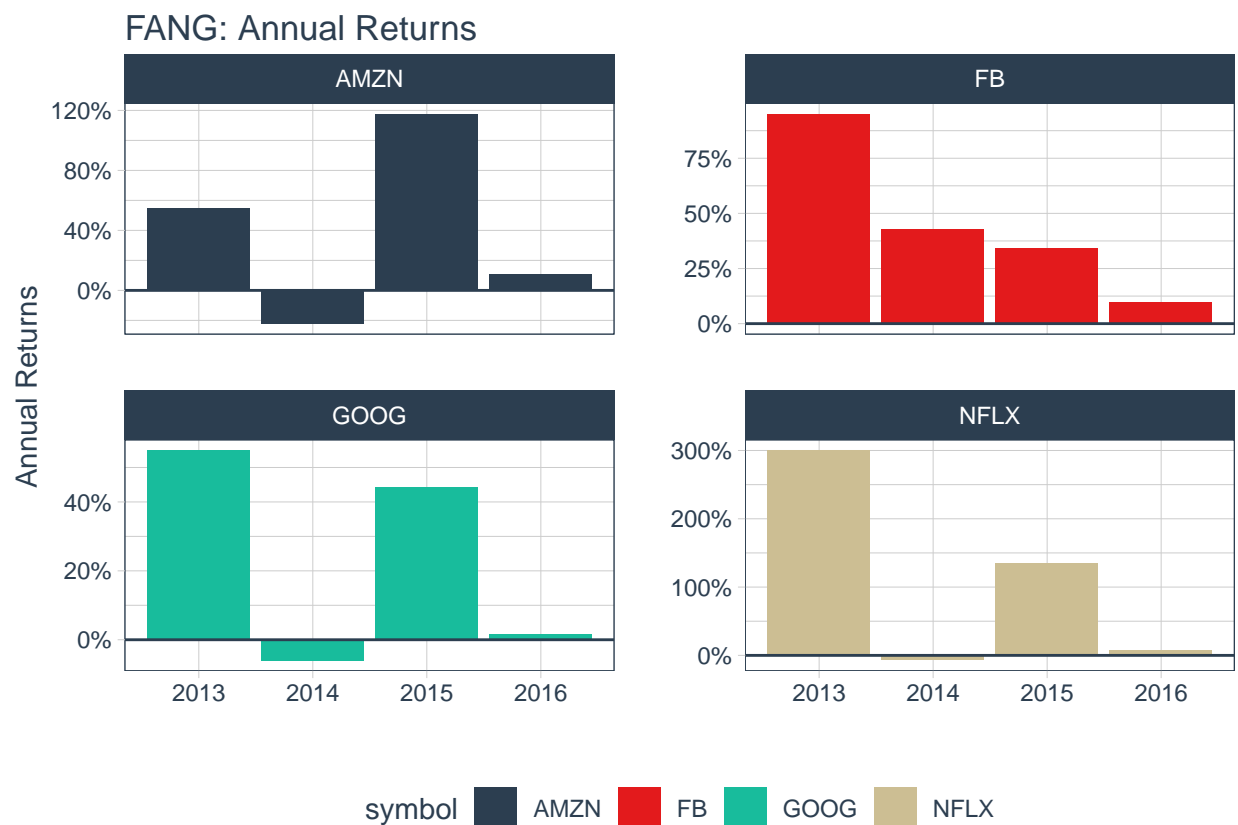
## Yearly Returns

To make the best decision we must analyze the asset returns. Therefore, the adjusted prices were selected and transformed into yearly returns. First, the FANG database will be analyzed.

```
## # A tibble: 16 x 3
## # Groups:   symbol [4]
```

```
##      symbol date      yearly.returns
##      <chr> <date>          <dbl>
##  1 FB      2013-12-31      0.952
##  2 FB      2014-12-31      0.428
##  3 FB      2015-12-31      0.341
##  4 FB      2016-12-30      0.0993
##  5 AMZN     2013-12-31      0.550
##  6 AMZN     2014-12-31     -0.222
##  7 AMZN     2015-12-31      1.18
##  8 AMZN     2016-12-30      0.109
##  9 NFLX     2013-12-31      3.00
## 10 NFLX     2014-12-31     -0.0721
## 11 NFLX     2015-12-31      1.34
## 12 NFLX     2016-12-30      0.0824
## 13 GOOG     2013-12-31      0.550
## 14 GOOG     2014-12-31     -0.0597
## 15 GOOG     2015-12-31      0.442
## 16 GOOG     2016-12-30      0.0171
```

The annual table shows the specific return for each company. In 2013 the highest return for FB and NFLX was registered and in 2015 was for AMZN and GOOG. Due to the fact that we can analyze the exact amount of return, we confirm that NFLX gives the highest return of all companies. The company gives returns of 3 and 1.34 every two years. Additionally, FB was dropping each year due to the fact that 2013 was the IPO and the company was emerging the application for mobile use. Now, the next chunk code shows how to visualize the annual returns in a plot.



The plots help visualize the returns from a broader approach. The worst year for most of the companies was

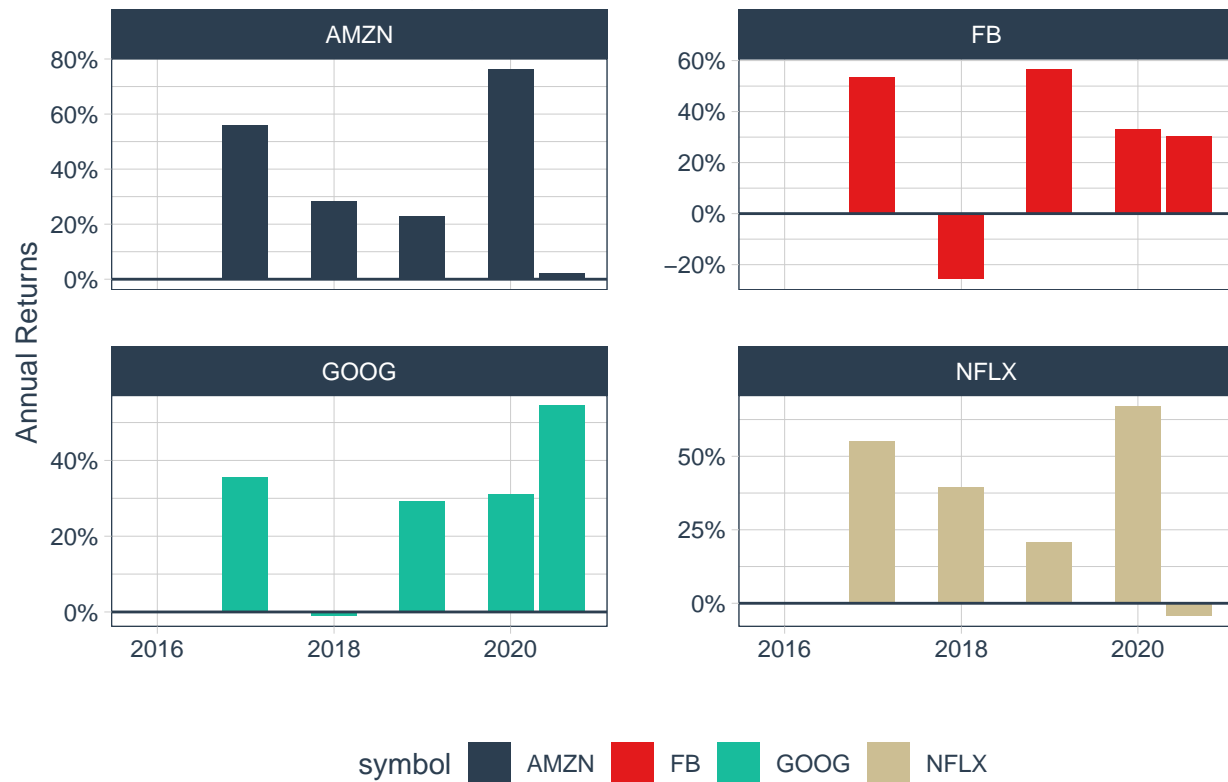
2014, AMZN, GOOG and NFLX. We can deduce this was due to the exaggerated valuation of the FANG which led to a financial bubble. On Facebook's plot, we can clearly see how the returns are decreasing exponentially each year going from 95% in 2013 up to 9% in 2016. Additionally, we can visualize the pattern presented in the remaining companies which consists in increasing and decreasing returns. However the lowest returns are considerably smaller than the highest ones. On one side Amazon starts with a pattern of 54%, -22%, 117% and 10%, having its highest return in 2015. On the other side we have GOOG and NFLX with the same pattern having their highest return in 2013, their lowest and negative return in 2014, followed by a positive yet lower return and ending in 2016 with a positive but incredibly low return.

```
## # A tibble: 24 x 3
## # Groups:   symbol [4]
##   symbol date      yearly.returns
##   <chr> <date>         <dbl>
## 1 AMZN  2016-12-30         0
## 2 AMZN  2017-12-29       0.560
## 3 AMZN  2018-12-31       0.284
## 4 AMZN  2019-12-31       0.230
## 5 AMZN  2020-12-31       0.763
## 6 AMZN  2021-07-30       0.0217
## 7 FB    2016-12-30         0
## 8 FB    2017-12-29       0.534
## 9 FB    2018-12-31      -0.257
## 10 FB   2019-12-31       0.566
## # ... with 14 more rows
```

Comparing returns from 2013 to 2016 against the ones presented from 2017 to 2021, we can see how returns were stabilizing, being significantly lower. NFLX still remains as one of the companies with the highest returns with a 67% in 2020. Nevertheless, the company is the most volatile on the returns given, starting with 55% in 2017, decreasing returns on 2018-2019 up to 20%, increasing them to almost 70% in 2020 and currently having decrease and negative return of -4%. AMZN surprised us during the pandemic being the one who presented the highest return of all in 2020 with 76%. The company was decreasing starting 2017 with 55% up to 23% in 2019. Even though different crisis were presented throughout the years 2017 to 2021, the companies still remained mainly giving positive returns.

Now, the next chunk code shows how to visualize the annual returns from 2017 to 2021 in a plot.

Annual Returns: AMZN, FB, GOOG and NFLX from 2017 to 2021



Here it is easy to visualize that 2018 was not the best year for Google and Facebook. FB annual returns decreased tremendously in 2018 due to the social array problems the company had. Data privacy was hacked that year with a bug software giving access to photos of millions of users. We can see how in 2019 this problems were fixed and public image of the company was fixed, increasing their returns from -25% in 2018 to 56% in 2019. Meaning the company increased 81% on their returns from 2018 to 2019. On the other hand, the year 2020 was the best for Amazon and Netflix, and we could assume that during the pandemic online shopping and movie platforms increased their sales. Both companies follow the same pattern, starting 2017 with 55% both and decreasing it to 20% for 2019, giving their highest peak in 2020 with approximately 20% and currently giving returns lower up to 2% and -4%.

### Comparison of Annual Returns (2013-2016 vs 2017-2021)

Comparing the outcomes from the FANG database the following conclusions can be drawn. First of all, NFLX was the company with the highest return in the period 2013-2016 with 300% at their highest; yet on the period 2017-2021, AMZN became the highest with an 80% of annual return in 2020 compared to NFLX with 60% as their highest in that period. However, the best performing stock of all was NFLX since their returns remain positive for almost all of the years, except in 2014 with -7% and 2021 with -4%, which is significantly better in comparison to GOOG, AMZN and FB negative returns. The worst performing company was FB. During 2013-2016 the company decreased their annual returns from 95% to 9%; and on the next period 2017-2021, the company experienced the lowest annual return of all with a negative return of -25%. As mentioned before, GOOG and AMZN remained on the same pattern which makes them the least volatile companies in the FANG. Their annual returns remained mainly positive for both periods; yet, during 2017-2021 AMZN did not present negative returns being 2% their lowest and GOOG remained on the same range with -1% as their lowest on the same period of time. In addition to, NFLX was the company with the highest yearly cumulative return in USD with over 750 usd in 2016 and over 400 usd in 2020. Following with



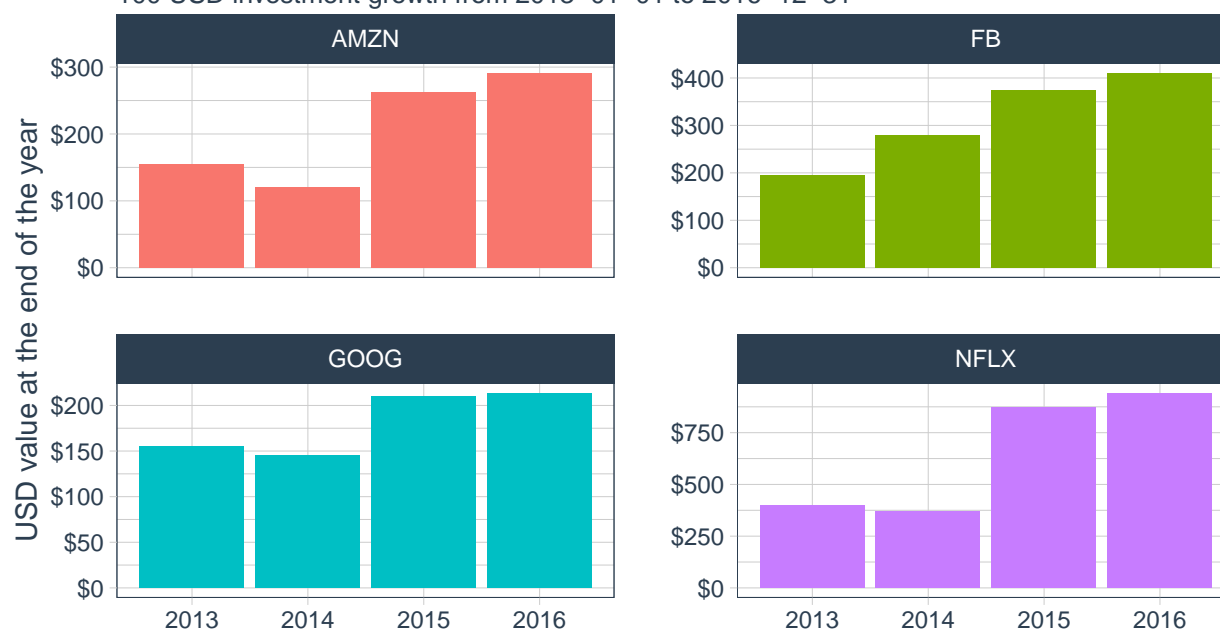
AMZN and FB, which AMZN had the second highest during 2013-2016 and FB during 2017-2021. Leaving AMZN as the least company in investment growth. With that being said, the best option is NFLX. The company performed the best in yearly investment growth and in annual returns.

## Cumulative Returns

The cumulative returns are the total changes in the investment price over a set time. Taking this concept into account, the first analysis will focus on the FANG dataset.

### Yearly cumulative USD returns.

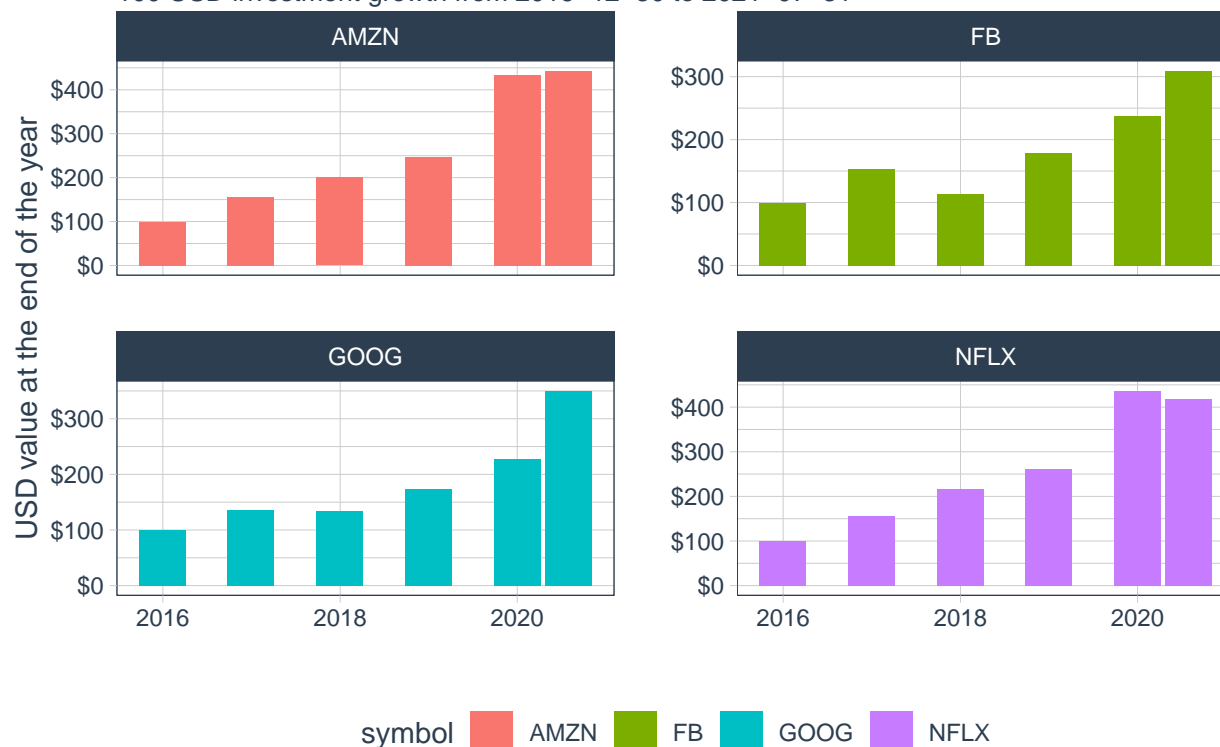
100 USD investment growth from 2013-01-01 to 2016-12-31



symbol AMZN FB GOOG NFLX

## Yearly cumulative USD returns.

100 USD investment growth from 2016-12-30 to 2021-07-31



## Compararison of Yearly Cumulative Returns

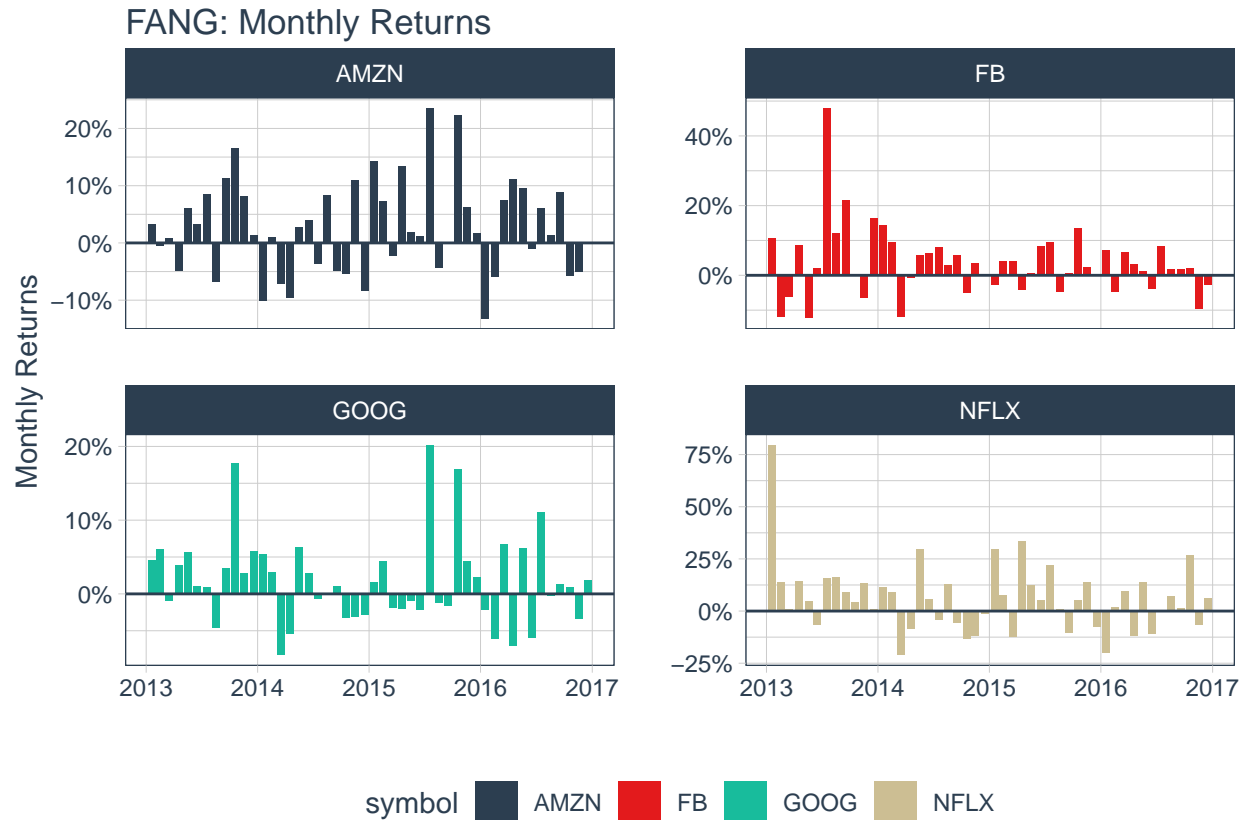
The yearly cumulative return of Netflix has decreased compared to the FANG database from 2013 to 2016. NFLX had their highest peak in 2015 and 2016 with approximately 750 usd; however, from 2016 to 2020 their highest peak was on 2020 with 450 usd in investment growth. FB, AMZN and GOOG graphs remained in the same parameters of growth. FB with a highest peak of 400 usd in 2016 and 300 usd in 2021, GOOG with 200 usd in 2016 and 300 usd in 2021, and AMZN with 300 usd in 2016 and 400 usd in 2021. For their lowest values, the three companies presented 100 usd as their lowest point in both of the periods established (2013-2016 vs 2017-2021).

## Monthly Returns

In order to get a more detailed picture of the four companies compared to yearly, monthly returns will be presented in this chapter. First of all, the monthly returns of Amazon, Facebook, Google and Netflix in the time period of 2013 to 2016 will be regarded.

```
## # A tibble: 192 x 3
## # Groups:   symbol [4]
##   symbol date      monthly.returns
##   <chr> <date>         <dbl>
## 1 FB    2013-01-31      0.106
## 2 FB    2013-02-28     -0.120
## 3 FB    2013-03-28     -0.0613
## 4 FB    2013-04-30      0.0856
```

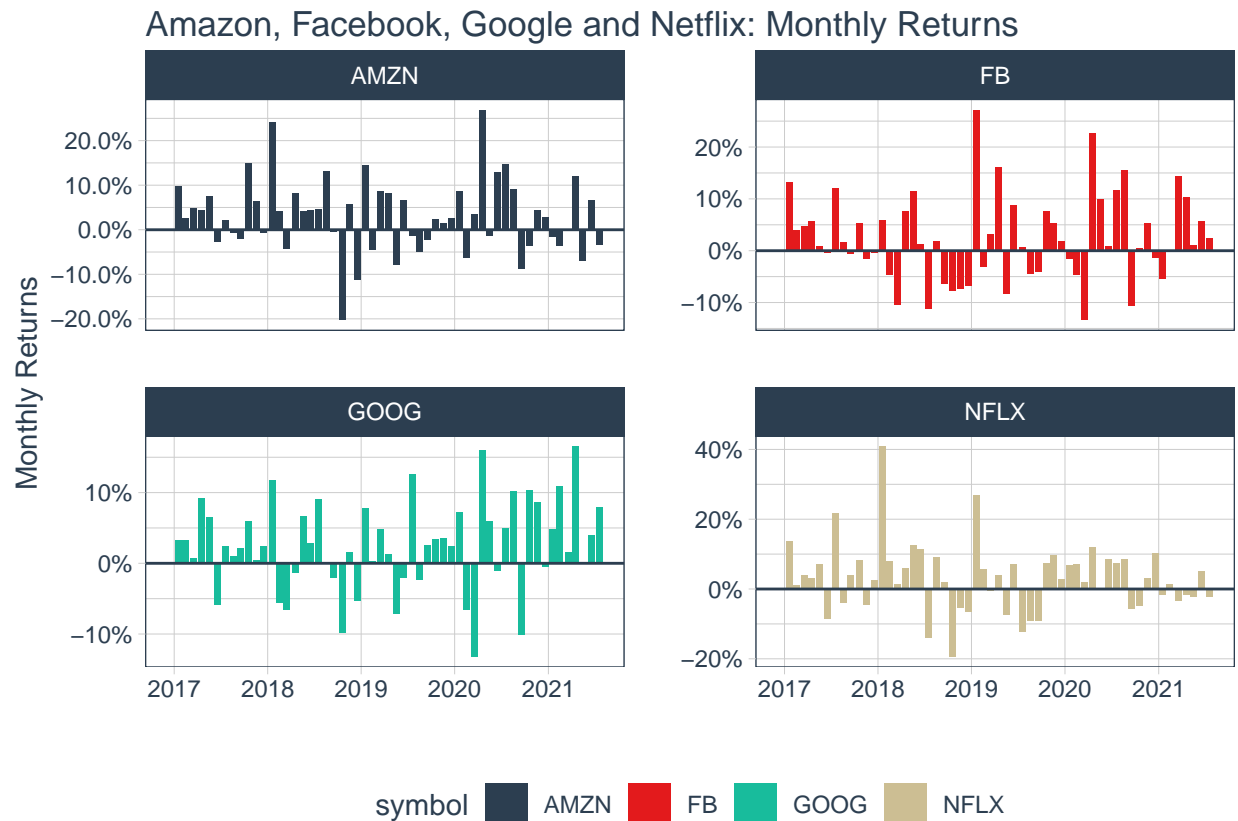
```
## 5 FB      2013-05-31      -0.123
## 6 FB      2013-06-28       0.0218
## 7 FB      2013-07-31       0.479
## 8 FB      2013-08-30       0.122
## 9 FB      2013-09-30       0.217
## 10 FB     2013-10-31      -0.000398
## # ... with 182 more rows
```



The reason of plotting these monthly returns in this manner is to reveal the volatility of the stock returns. It can be noticed that Amazon and Google are rather volatile since at some point they jump from a high positive to a negative return. Netflix reached a maximum negative of -21%. In order to visualize and compare the results with the following period, the graphs for the time frame 2017 to 2021 follow.

```
## # A tibble: 224 x 3
## # Groups:   symbol [4]
##   symbol date      monthly.returns
##   <chr> <date>         <dbl>
## 1 AMZN  2016-12-30         0
## 2 AMZN  2017-01-31      0.0982
## 3 AMZN  2017-02-28      0.0262
## 4 AMZN  2017-03-31      0.0491
## 5 AMZN  2017-04-28      0.0434
## 6 AMZN  2017-05-31      0.0753
## 7 AMZN  2017-06-30     -0.0268
## 8 AMZN  2017-07-31      0.0204
## 9 AMZN  2017-08-31     -0.00727
```

```
## 10 AMZN    2017-09-29    -0.0196
## # ... with 214 more rows
```



As can be concluded from these figures, the stocks of Amazon, Facebook and Google seem to be very volatile with a lot of negative returns. It can also be seen that Amazon and Netflix have the highest negatives with both reaching -20.22% and 19.34%, respectively.

## Comparison of Monthly Returns

The comparison between this two periods, the first one is for 2013-2017 and this is for 2017-2021, we can see how volatility is higher in this last period, it can be for many causes, one of them that is very important is the pandemic factor that came to disturb many business. In that order we can say that in this last four charts we have atypical years, in contrast with the last period that is a more normal and have constant returns; but even though the volatility of this period it still giving returns, for more risk, greater returns.

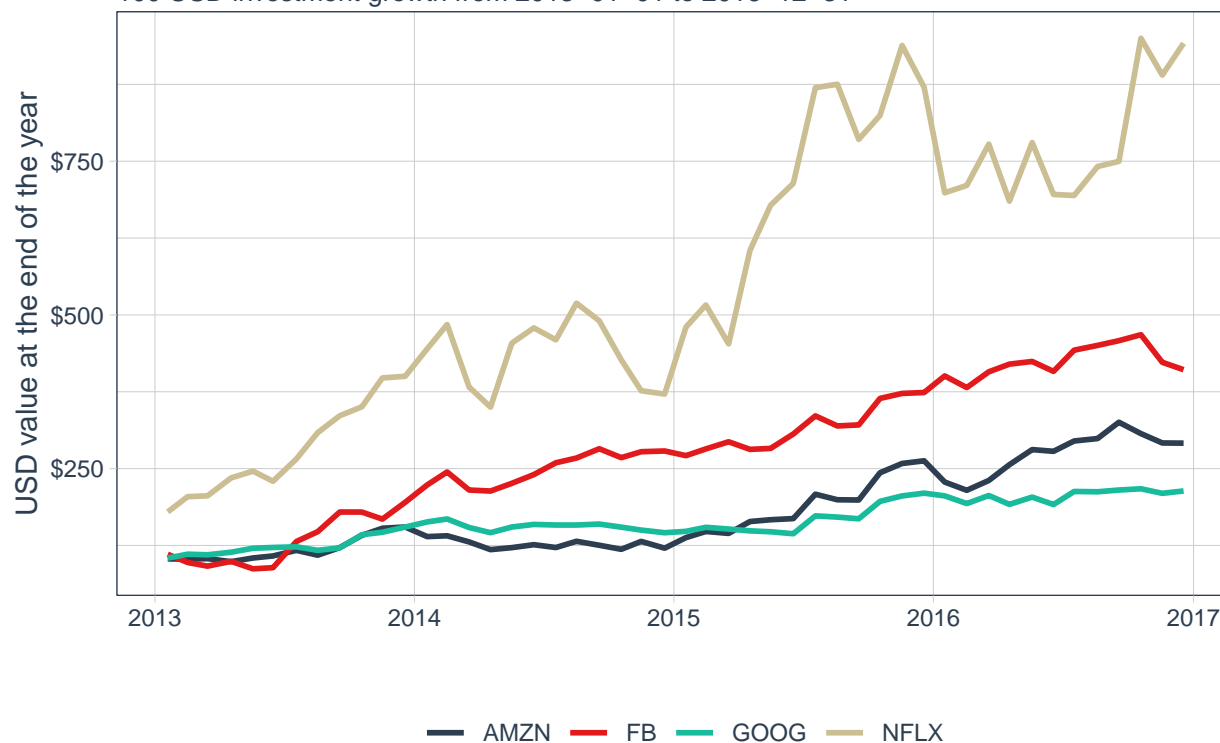
Therefore, cumulative monthly returns will be analyzed in the next chapter.

## Cumulative Monthly Returns

Cumulative monthly returns per stock, under the presumption of investing 100 USD at the beginning of the period, are regarded in the next graphs. First of all, the period between 2013 and 2016 will be visualized.

## Monthly cumulative USD returns.

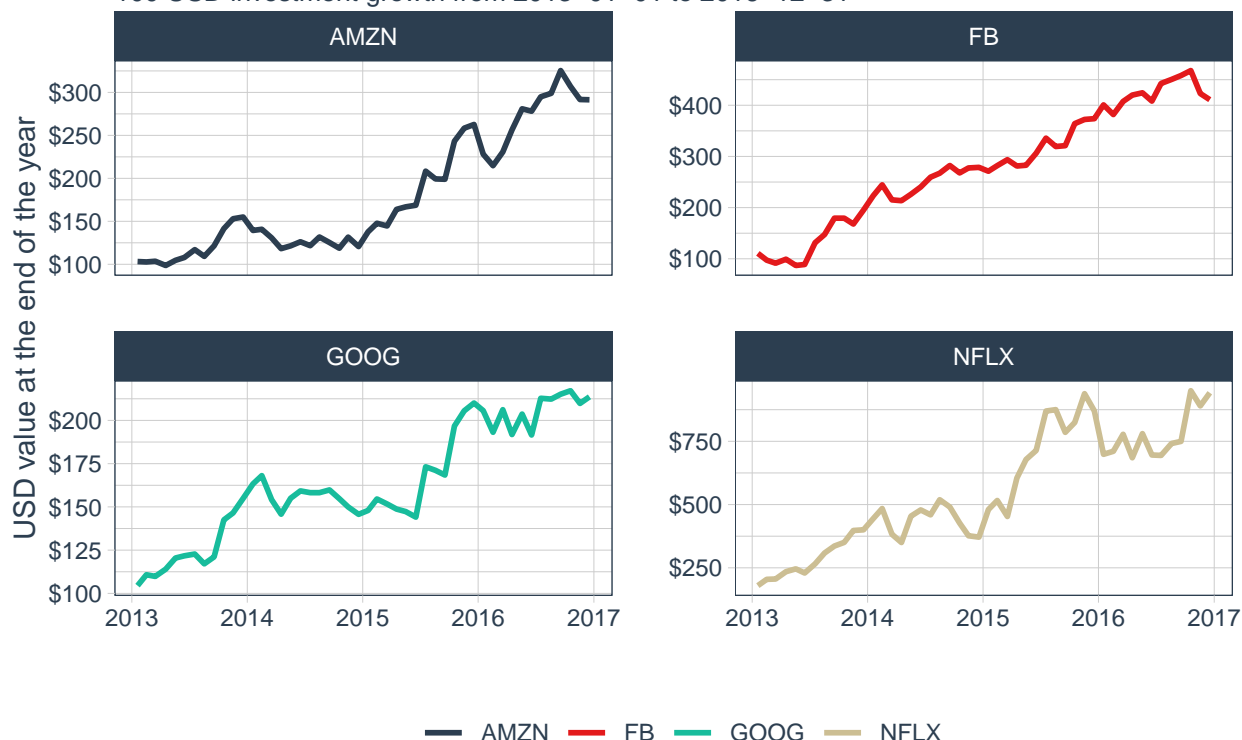
100 USD investment growth from 2013-01-01 to 2016-12-31



The above graph would make one presume that Netflix is the best investment in terms of returns, however, to facilitate the reading of the plot it is better to look at every company separately, therefore, a splitting of the plot in four panels is necessary.

## Monthly cumulative USD returns.

100 USD investment growth from 2013-01-01 to 2016-12-31



As can be seen in the above figures, Facebook has been the most stable in the four years of investigation, however shows a downwards trend in the past months. The stock has increased from 100 USD to 410 USD, while Amazon, the stock that also shows a downward trend in the past months, rose to 291 USD. Netflix gives the highest returns of 942 USD between 2013 and 2016, however, also shows high volatility. Similarly, Google shows volatility but does not give as high of returns as the other three companies, with only 214 USD. As a result, the most stable investment would have been Facebook, but the highest return stemmed from Netflix.

In order to facilitate the comparison of the results to the four and a half years later, plotting of the period 2016-12-30 to 2021-07-31 is imperative.

## Monthly cumulative USD returns.

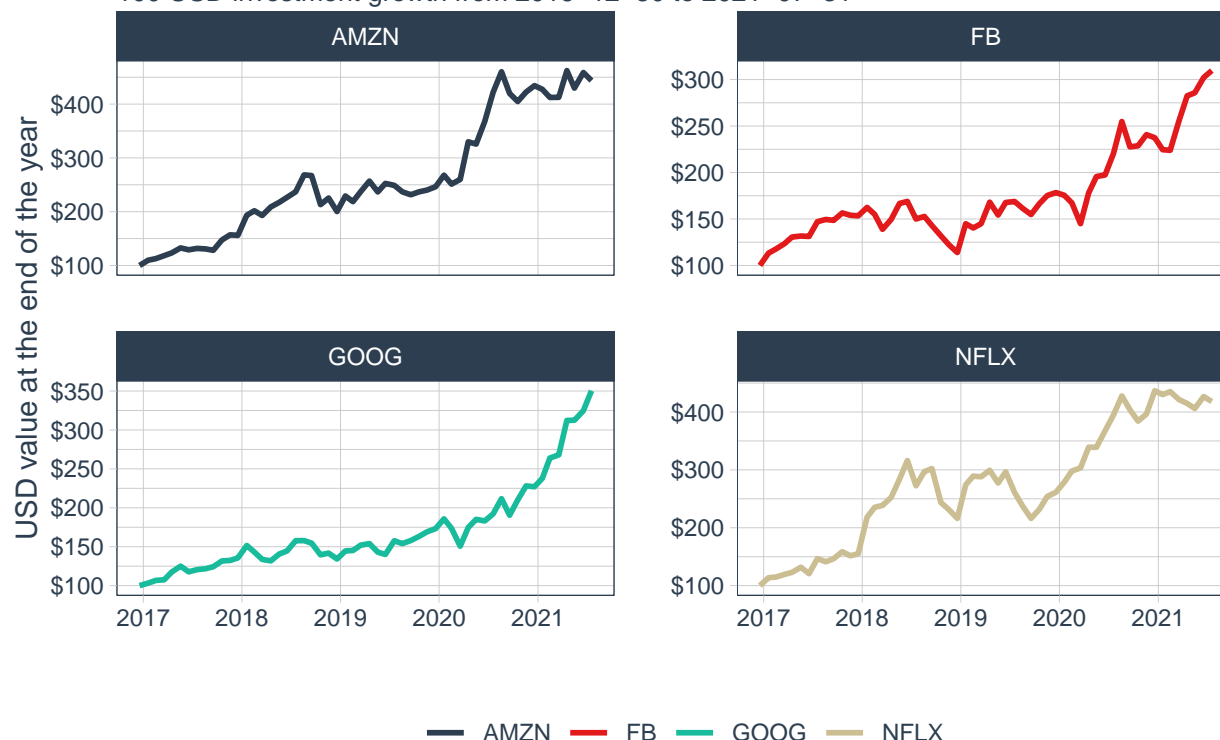
100 USD investment growth from 2016-12-30 to 2021-07-31



This graph already shows a difference to the years 2013 to 2016 with the Netflix stock showing less return and the Amazon having grown in cumulative USD monthly returns. Additionally, Facebook performed worse than the period beforehand, while Google has risen its returns. Once again, splitting the plot in four panels displays a better perspective on the different stocks:

## Monthly cumulative USD returns.

100 USD investment growth from 2016-12-30 to 2021-07-31



On July 30, 2021 the four stocks increased the investment of 100 USD on December 30, 2016 to the following monthly cumulative USD returns: Amazon 444 USD, Facebook 310 USD, Google 351 USD and Netflix 418 USD. In this case, the originally 100 USD invested in Amazon or Netflix during the 4 years would lead to the highest returns of 444 USD and 418 USD, respectively. The most stable stock in the investigated time period is Google, while the other three stocks display more volatility. The least return stems from the investment into Facebook as can be seen in the above figures. Google gives higher returns of 41 USD compared to Facebook while it is roughly 70 USD below Netflix. Interestingly, the two stocks showing the least returns, Facebook and Google, are the ones that have an upward trend in the last months of investigation, while the stocks with the highest returns in the period, Amazon and Netflix, display a downward trend.

## Comparison of Monthly Cumulative USD Returns (2013-2016 vs 2017-2021)

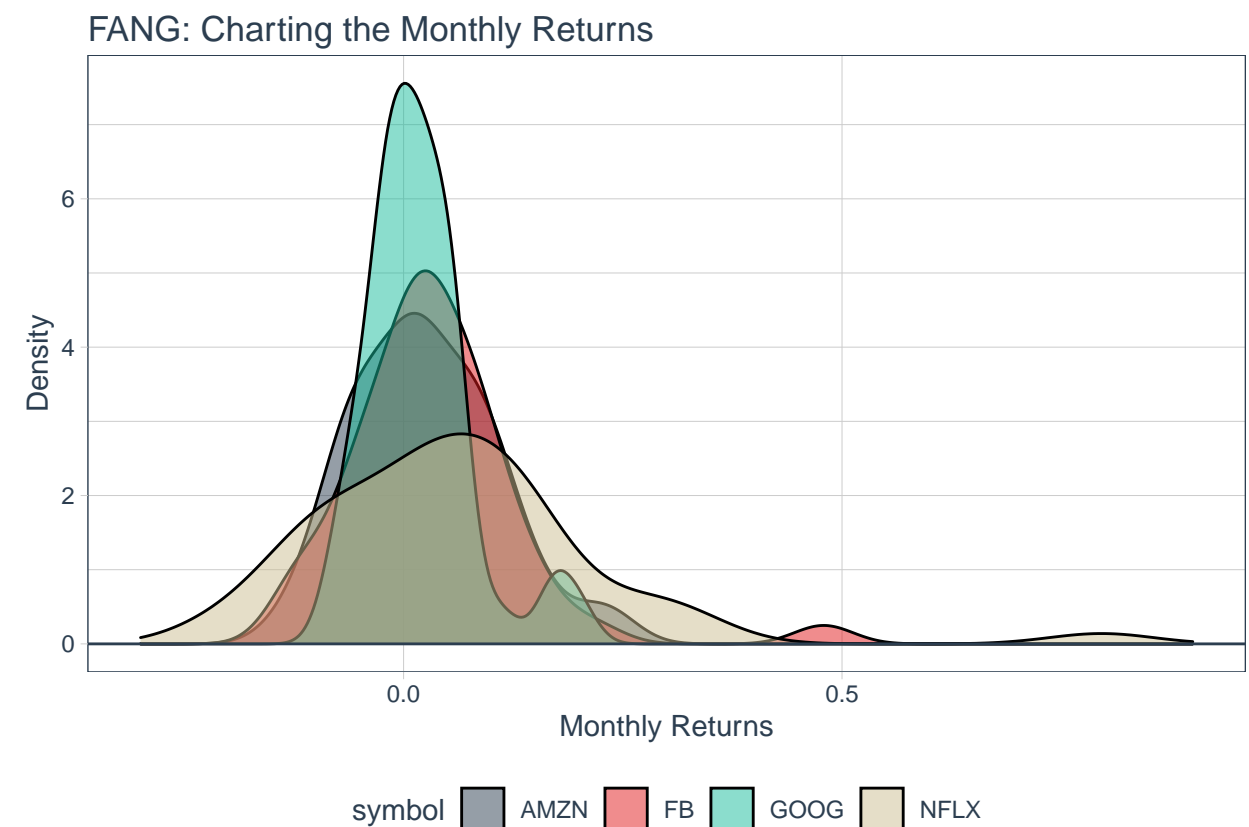
When comparing Amazon, Facebook, Google and Netflix in the period 2013-01-02 to 2016-12-30 to the time frame of 2016-12-30 to 2021-07-31 different outcomes can be observed. First of all, Netflix was the forerunner in the first period of investigation, while in the second time frame the stock was in second place behind Amazon. From 2013 to 2016, Netflix's monthly cumulative USD return was at 942 USD, while in the period to 2021, the returns almost halved to 418 USD. The total return in the whole period for the company was therefore 1,360 USD. Secondly, Amazon, the best performing stock in the period 2017 to 2021 with a cumulative monthly return of 444 USD, was third compared to the other FANG stocks between 2013 and 2016 with a cumulative return of 291 USD on the 100 USD investment. As a result, their total cumulative monthly return was 735 USD. Thirdly, Facebook's stock achieved a comparatively high return of 410 USD in the first period, while the returns dropped by 24% to 310 USD in the following time frame. The total return between 2013 and 2021 is therefore 720 USD. Finally, Google, the company that showed the lowest returns of 214 USD up to 2016, increased the returns to 351 USD with an initial investment of 100 USD in the next four years. The company's total returns for the two periods therefore sum up to 565 USD. As a result, the



highest total monthly cumulative returns over the whole period 2013 to 2021 had Netflix with 1,360 USD, followed by Amazon with 735 USD, Facebook with 720 USD and Google with 565 USD. In terms of volatility, the most stable stock in the first period was Facebook while Google showed the least volatility of the four companies in the last period. Google and Netflix were the stocks that showed an upward trend in the last months of the first period, while Facebook and Google displayed an upward trend in the upcoming months to July 2021. To sum up, based on the total monthly cumulative returns of the two periods combined, Netflix would be the best investment. A counterargument could be the current downward trend of the stock, however, as could be seen from the investigation, this company has a rather volatile history.

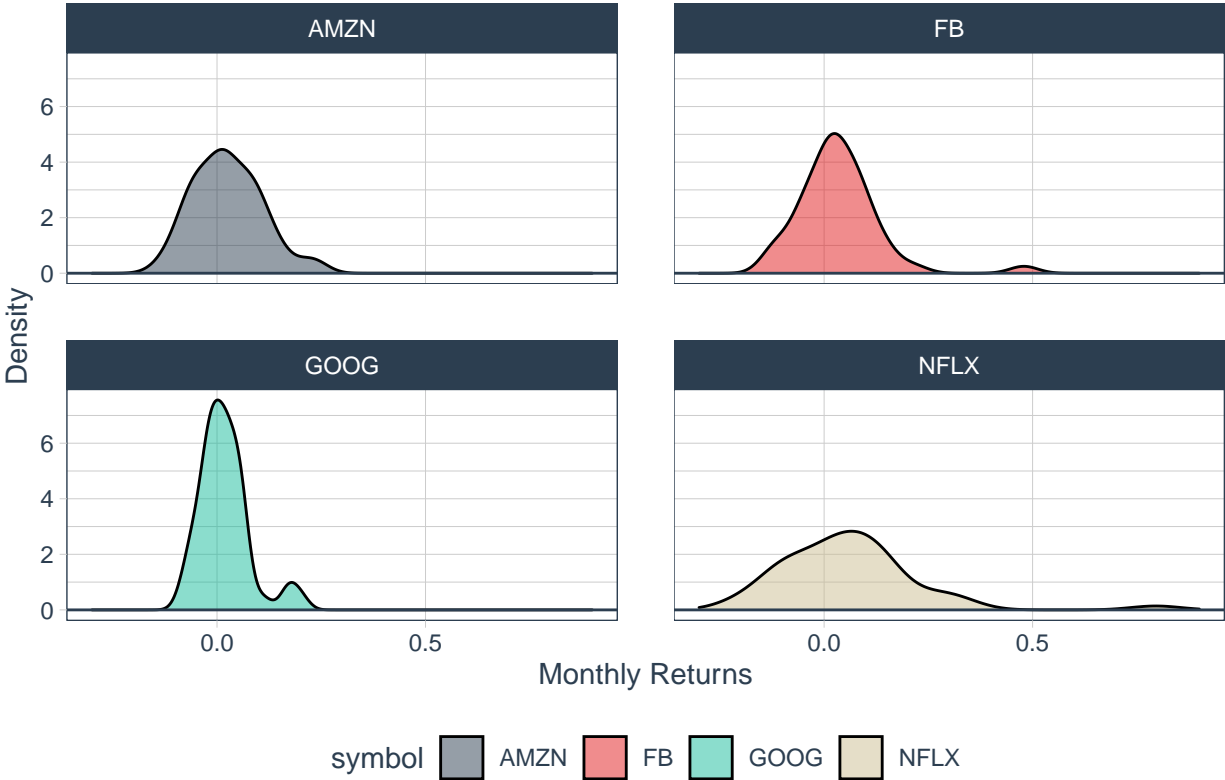
## Distribution of Returns

Another way to see monthly stock returns is through density plots. The density plots can show the distribution of values, which is useful when the objective is to assess the most likely return a stock can have. Therefore, the density plot for the FANG data is visualized first.

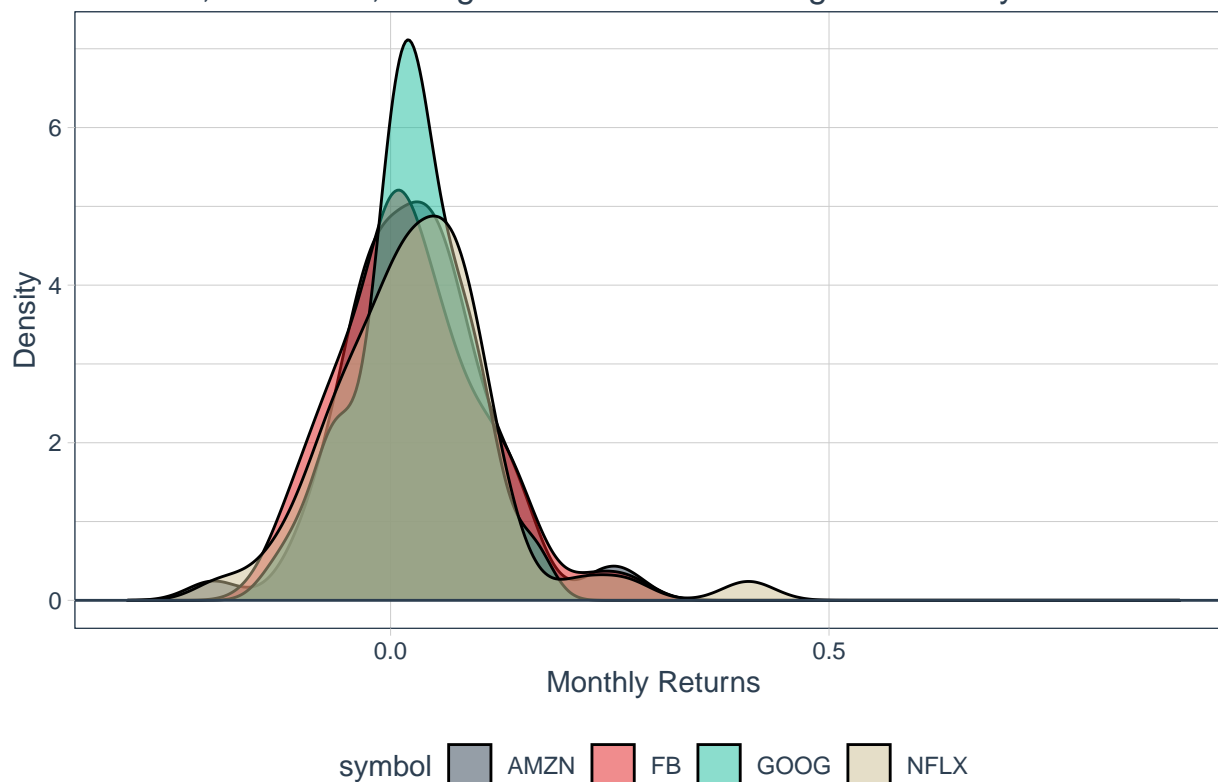


Let's make it clearer

FANG: Charting the Monthly Returns



## Amazon, Facebook, Google and Netflix: Charting the Monthly Returns



With the density graph above, one can get a scope of the average monthly returns on the stocks. It can be appreciated that NFLX had better returns than the other stocks, but is also the stock with more volatility, sometimes with returns around 40%. With these insights it can be confirmed that in general return and risk have a positive correlation (i.e., greater the risk, greater could be the return), but even if this is a generality in the financial markets, there are better ways to measure the relation between risk and return, such as the risk adjusted performance measures. This topic will be tackled later.

## Amazon, Facebook, Google and Netflix: Charting the Monthly Returns



Here each plot will be analyzed in comparison with the FANG chart Monthly Returns. As a first instance it can be said that GOOG is the one that gives more returns in both periods, but if analyzed carefully one can see that the distribution of NFLX is more widely spread in our graphic than the others. In that case it can be mentioned that this stock is riskier than the other three. Furthermore, it can be observed that there is a clear contrast between the two periods that is the way that the density of the stocks is higher than the last period. With all that being said, it can be concluded that GOOG is the safest stock, because it is the most stable that has least movements around the period. At this point it is the investor's call to choose which stock is better for them. If their objective is to get higher returns, they should go for the one that has more risk, but if they feel a little afraid of the risk and want to play it safe, they should go for GOOG because it is the one that has least changes and offers least risk, compared to the other three stocks.

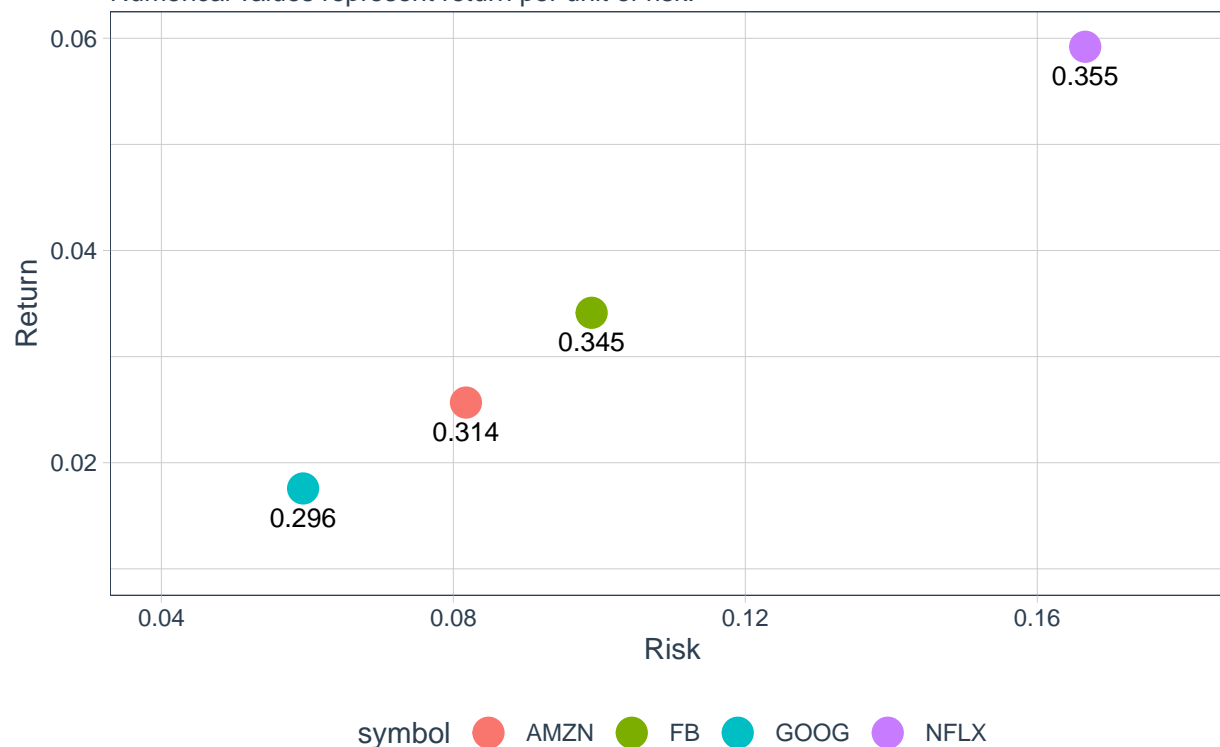
To complete the previous analysis it is important to look into some statistical indicators in order to get to a risk adjusted performance analysis approach.

```
## # A tibble: 4 x 5
##   symbol    mean      sd    sr    iqr
##   <chr>    <dbl>  <dbl> <dbl> <dbl>
## 1 AMZN    0.0257 0.0817 0.314 0.126
## 2 FB      0.0341 0.0989 0.345 0.108
## 3 GOOG    0.0176 0.0594 0.296 0.0646
## 4 NFLX    0.0592 0.167  0.355 0.193
```

It can be observed that in this case the stock with highest mean is NFLX and the lowest is GOOG. So, the expected return of NFLX is the highest. In a next step, the risk of the FANG data in a plot will be visualized.

## The higher the risk, the higher the return (2013–2016)

Numerical values represent return per unit of risk.



Netflix is the stock with the highest return and risk. These results will now be compared with the data from 2016-12-30 to 2021-07-31

```
## # A tibble: 4 x 5
##   symbol    mean      sd    sr    iqr
##   <chr>   <dbl>  <dbl> <dbl> <dbl>
## 1 AMZN    0.0301 0.0818 0.369 0.0973
## 2 FB     0.0236 0.0833 0.284 0.0972
## 3 GOOG    0.0246 0.0631 0.389 0.0718
## 4 NFLX    0.0302 0.0968 0.312 0.0988
```

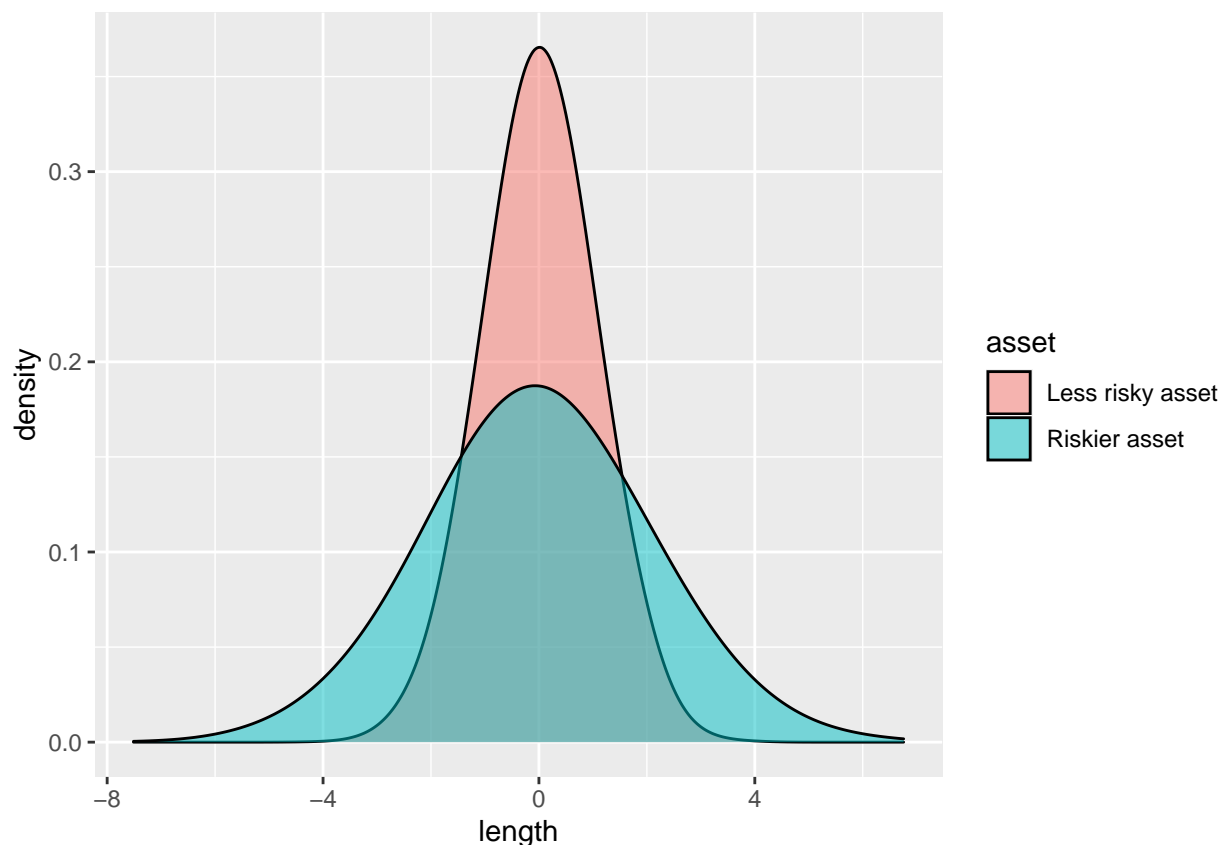
In this case, as in the FANG dataset, the stock with the highest mean is NFLX, as a result, the expected return of NFLX is the highest. On the contrary, in this case the lowest mean is FB, therefore, Facebook's expected return is closest to zero. Nevertheless, the stock with the lowest risk is GOOG, since the standard deviation is the lowest. To make the risk and return visible, the next plot focuses on visualization of it.

## The higher the risk, the higher the return (2017–2021)

Numerical values represent return per unit of risk.



Now that a risk adjusted performance measure such as sharpe ratio has been established, deeper insights can be drawn. In the first period, NFLX outperformed the other stocks quite significantly, which can be seen visually in the graph. The NFLX sharpe ratio is not equidistant between the other ones, this matches with the idea that NFLX had a lot of volatility over the first period, but also delivering high returns according to its level of risk. In the second period, The sharpe ratios has changed, and now the stock delivering better risk adjusted performance is GOOG. If one observes the first period again, it could be noted that if connecting the dots of all stocks, they create a kind of a slope, the interpretation could be that risk and return between all the stocks are proportional between each other. In the second graph the relation between risk and return is not proportional, this means that there are stocks offering better returns in terms of their risk such as GOOG and AMZN. NFLX and AMZN offered almost the same return but NFLX with a greater volatility, and GOOG had offer a better return than FB with less volatility. Now that we have these insights, it is more easy to compare the real performance of the stocks.



## Conclusion

Through the process of the analysis, several new information could be collected about the performance of the stocks over two different periods. It can be implied that the best decision would have been to invest from 2013 to 2016 in the NFLX stock, while during 2017 to 2021, the best decision would have been to invest in AMZN. As mentioned beforehand, in the financial markets there is a relation between risk and return. While risk is measured in terms of volatility which is the standard deviation of the returns, the returns are measured in terms of the relative changes in the stock prices over time. As can be observed in the graph above, a riskier asset will give an investor better chances of having higher returns, but, also more probabilities of losing money, while a less risky asset may provide you with smaller returns but also with less probability of losing money. Every investor should know their risk aversion and in order to that, take their investment decisions based on financial analysis. The conclusion is simple, if you want to earn big, you need to be willing to also lose sometimes, but if you make a deep analysis that provides you with useful information, you can decrease those probabilities of losing and increase the ones of winning.