A Machine Learning Stock Forecasting Project

(R Programming Language)

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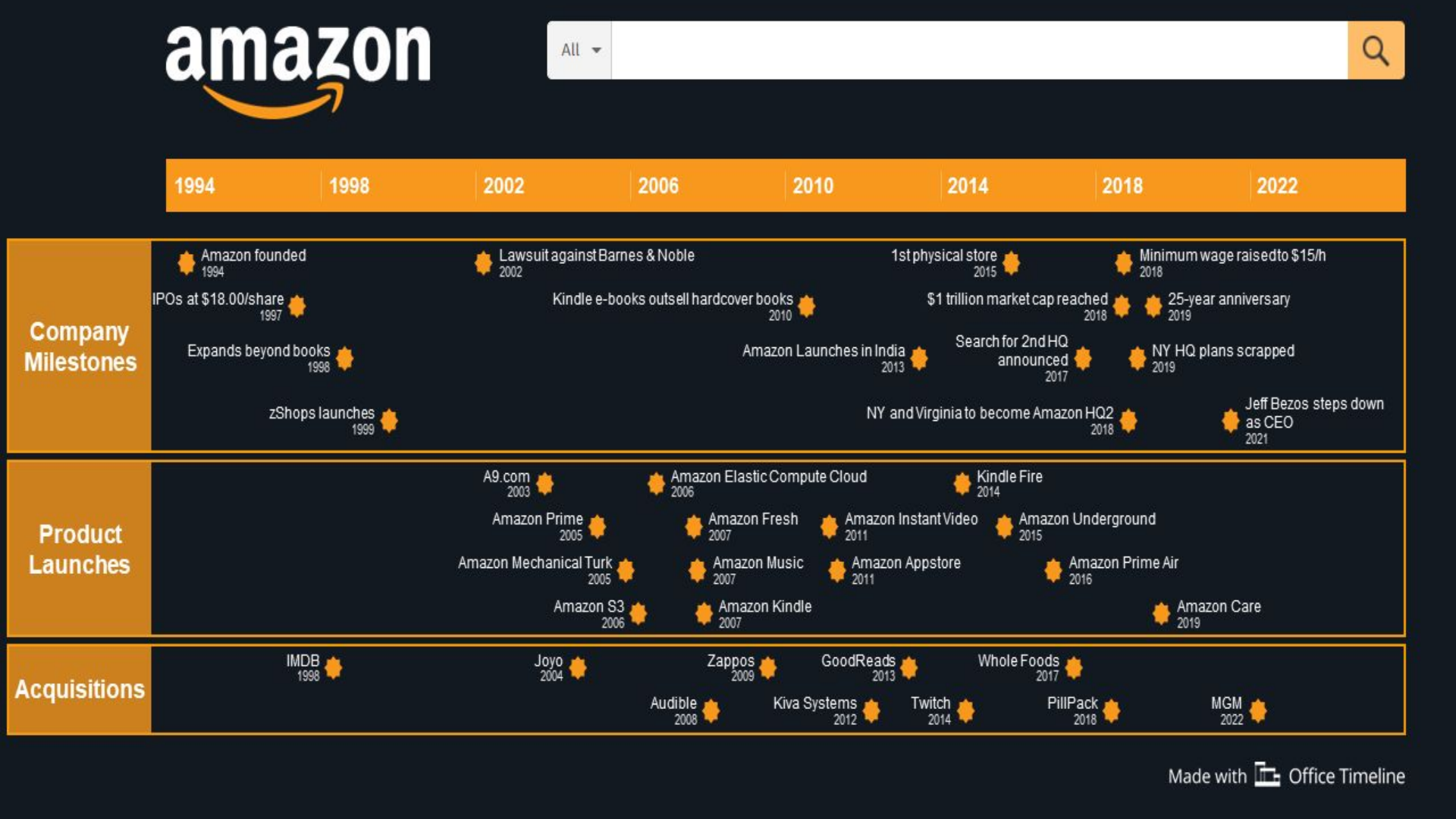
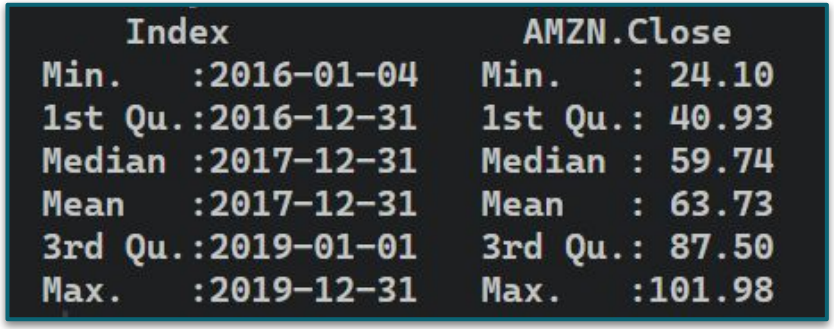
Tech Talent & Strategy, Data Science | February-May '23 Cohort | Instructor: Preston Menke


amazon
All
1994
1998
2002
2006
2010
2014
2018
2022
Company Milestones
Amazon founded 1994
IPOs at $18.00/share 1997
Expands beyond books 1998
zShops launches 1999
Lawsuit against Barnes & Noble 2002
Kindle e-books outsell hardcover books 2010
Amazon Launches in India 2013
1st physical store 2015
Search for 2nd HQ announced 2017
$1 trillion market cap reached 2018
NY and Virginia to become Amazon HQ2 2018
Minimum wage raised to $15/h 2018
NY HQ plans scrapped 2019
25-year anniversary 2019
Jeff Bezos steps down as CEO 2021
Product Launches
A9.com 2003
Amazon Prime 2005
Amazon Mechanical Turk 2005
Amazon S3 2006
Amazon Elastic Compute Cloud 2006
Amazon Fresh 2007
Amazon Music 2007
Amazon Kindle 2007
Amazon Instant Video 2011
Amazon Appstore 2011
Kindle Fire 2014
Amazon Underground 2015
Amazon Prime Air 2016
Amazon Care 2019
Acquisitions
IMDB 1998
Joyo 2004
Audible 2008
Zappos 2009
Kiva Systems 2012
GoodReads 2013
Twitch 2014
Whole Foods 2017
PillPack 2018
MGM 2022
Made with Office Timeline

About the Data

- Stock data from 01-01-2016 to 01-01-2020
- Only the closing stock price will be used
- Used to create a model that predicts 90 days (3 months) into 2020
- Supervised Machine Learning method is the **ARIMA model**, which will be used for forecasting stock prices
- Unsupervised method is **K-Means clustering**, will be used for competitors stock performance

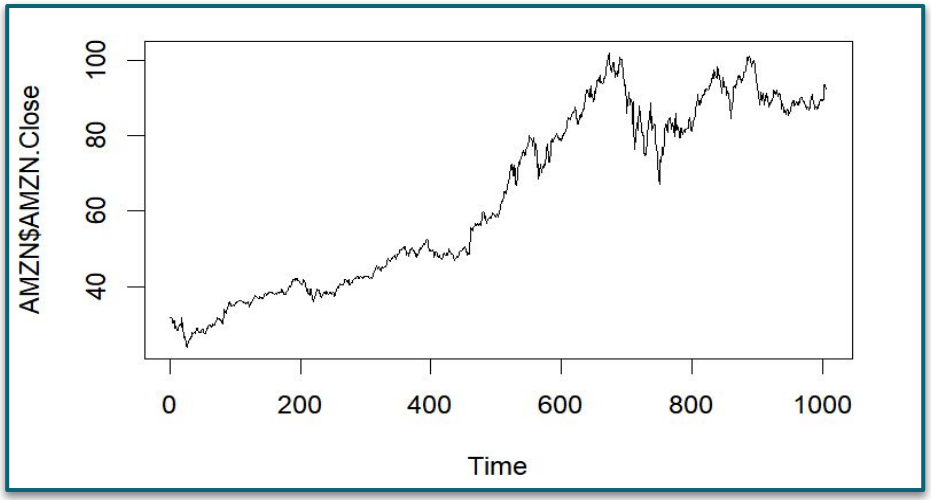


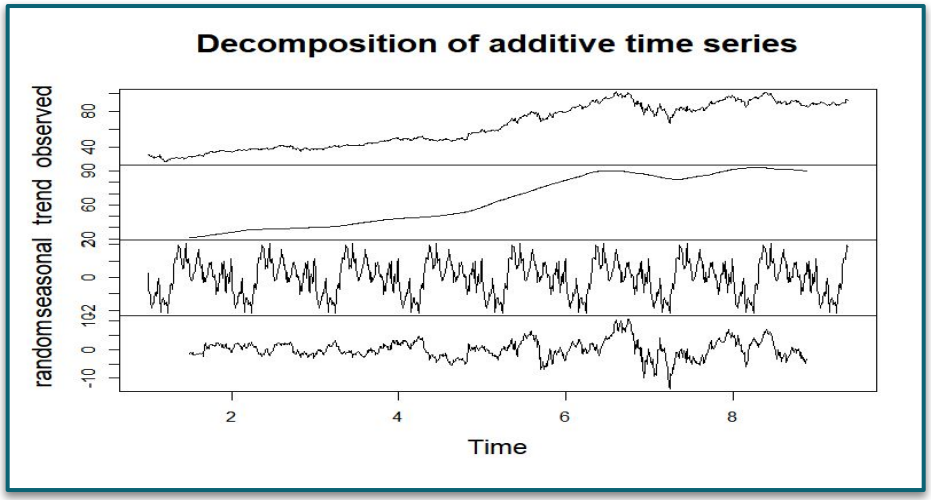
Index		AMZN.Close	
Min.	:2016-01-04	Min.	: 24.10
1st Qu.	:2016-12-31	1st Qu.	: 40.93
Median	:2017-12-31	Median	: 59.74
Mean	:2017-12-31	Mean	: 63.73
3rd Qu.	:2019-01-01	3rd Qu.	: 87.50
Max.	:2019-12-31	Max.	:101.98

Descriptive statistics for Amazon's closing stock price from 2016-01-01-01 to 2020-01-01

Amazon Stock Data 2016-2019

- Plotting the data reveals that the data is not stationary
- The time series graph can be broken down to see its individual components: random, seasonal, trend, and observed
- Time series models, like ARIMA, assume mean and variance are consistent
    - For better accuracy, the data gathered needs to be made stationary





Stationary Data

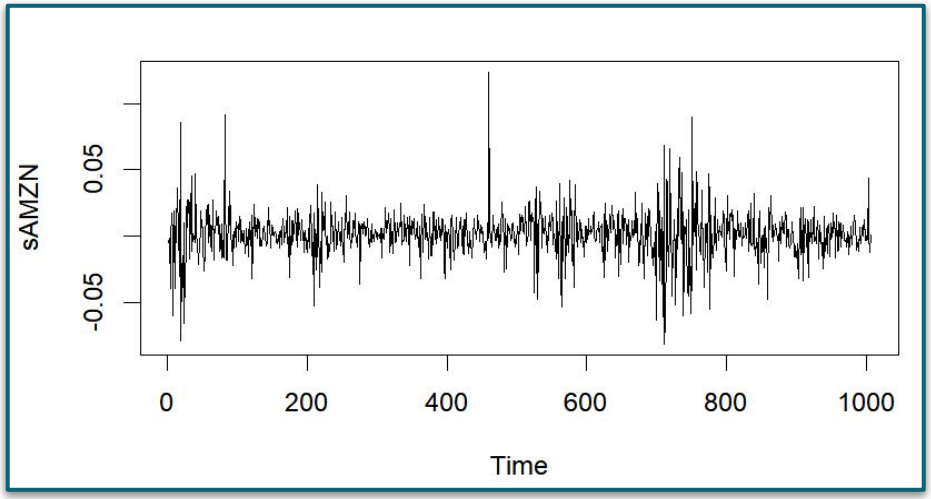
- Stationary = mean and variance do not vary across time
- Augmented Dickey-Fuller test confirms data is not stationary as is
  - P-value is much greater than 0.05
- Differencing can remove the effect of trend or seasonality, making the data stationary
  - P-value is below 0.05 and DF is a higher negative value
  - Plotting will show that the data is now stationary

```
        Augmented Dickey-Fuller Test

data:  AMZN$AMZN.Close
Dickey-Fuller = -1.823, Lag order = 10, p-value = 0.6532
alternative hypothesis: stationary
```

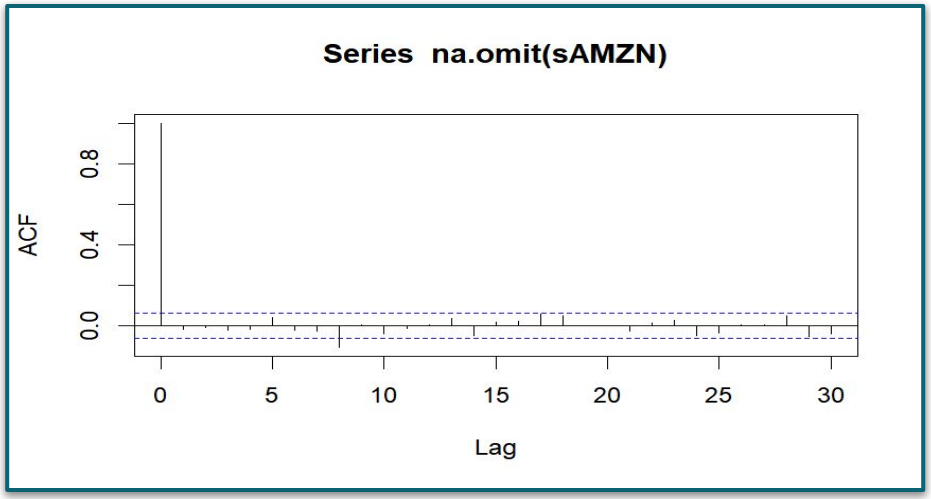
```
        Augmented Dickey-Fuller Test

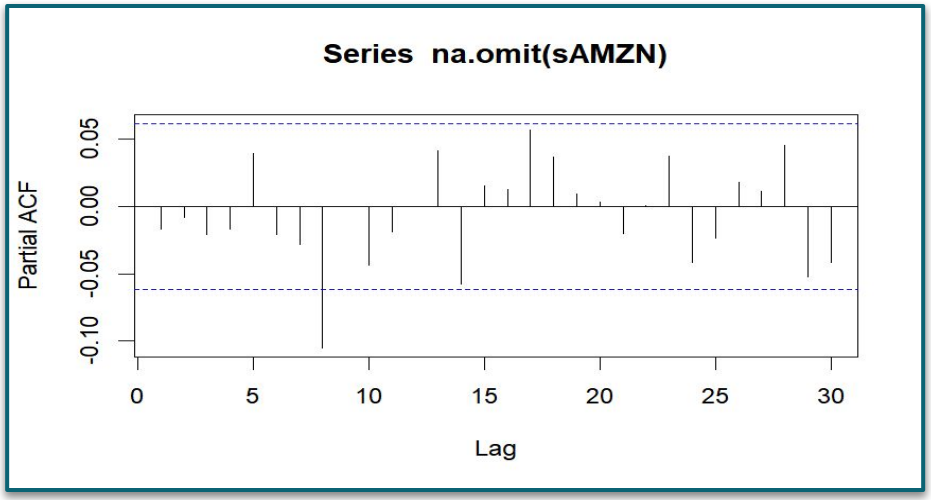
data:  as.numeric(na.omit(sAMZN))
Dickey-Fuller = -11.299, Lag order = 10, p-value = 0.01
alternative hypothesis: stationary
```



Autocorrelation Analysis

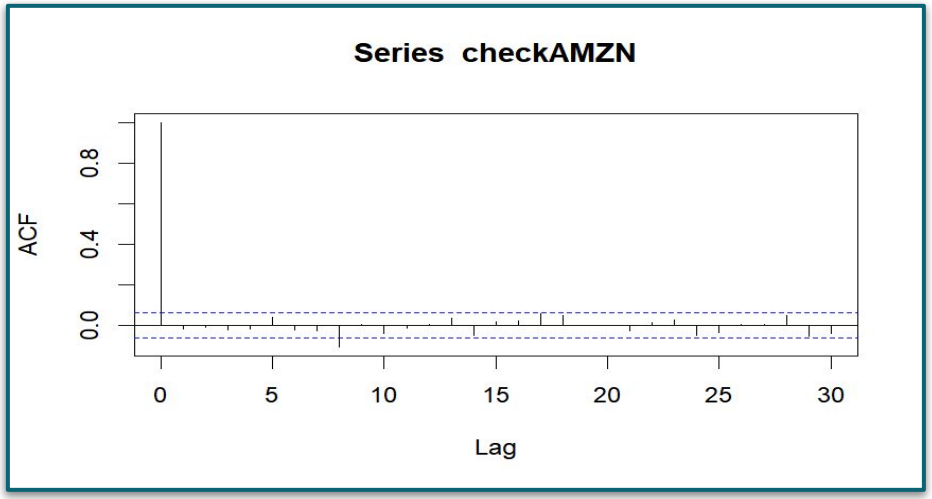
- Autocorrelation analysis to detect patterns and check for randomness
  - One significant non-zero autocorrelation = not random
  - Only one of the values is outside of the bounds for the PACF
    - White Noise = uncorrelated random variables with constant mean and variance
      - can't obtain parameters from the ACF and PACF = likely use ARIMA (0,0,0)

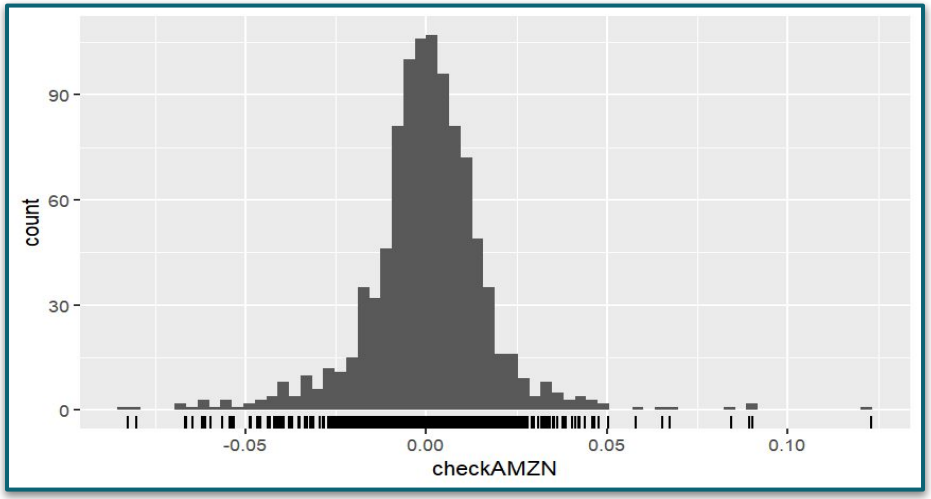


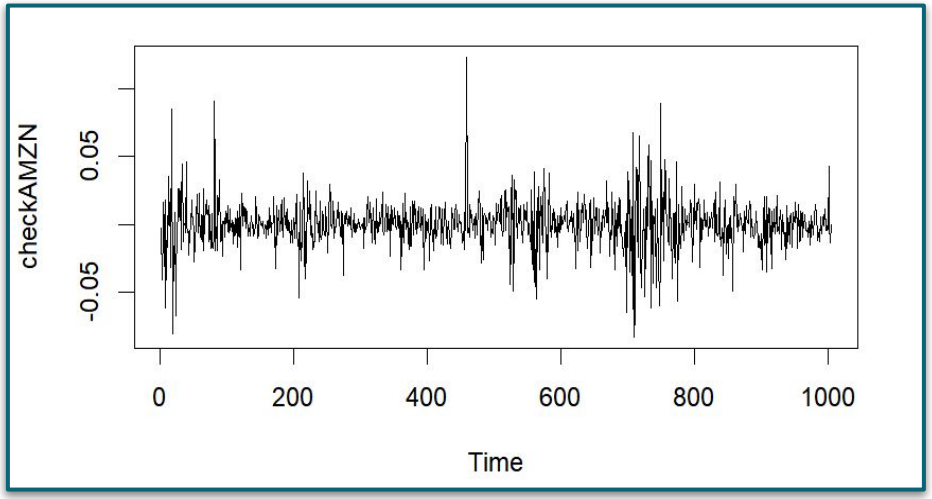


Diagnostic Check

- To confirm that ARIMA (0,0,0) is best fit, residual are:
  - Not correlated/are independent
  - Have zero mean
  - Normally distributed

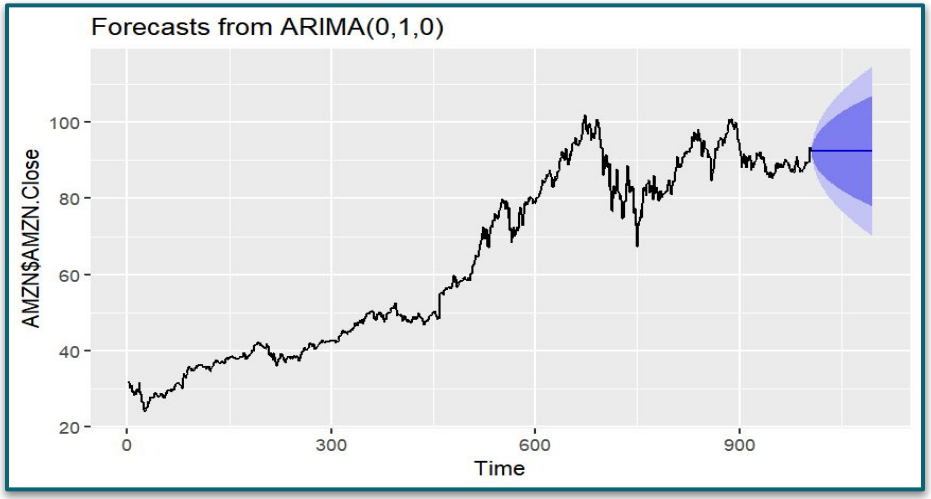


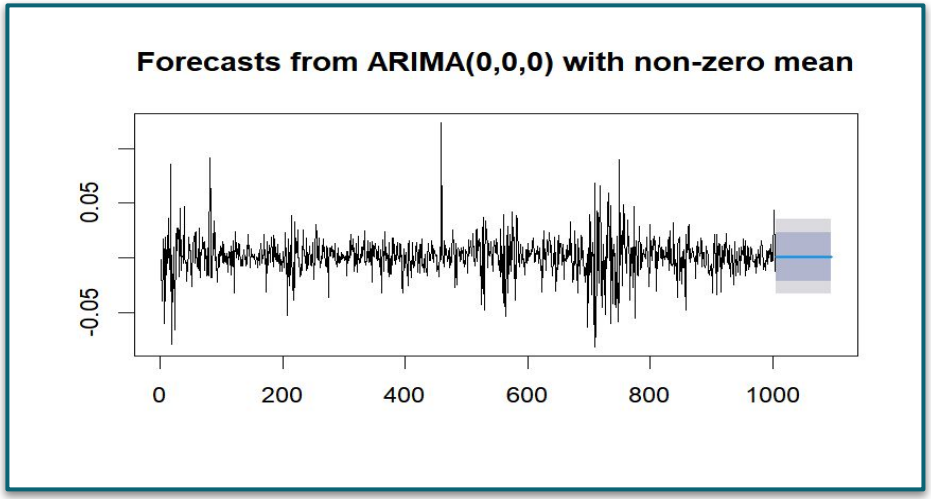




Forecasting 90 Days(3 Months)

- Forecasting with the original data, which is not stationary, can be observed in the left graph
- The stationary data forecasting can be observed on the right graph
- The lighter areas represent high and low at 95% confidence that the true population forecast is somewhere between these values
- The darker areas represent high and low at 80% confidence





Checking for Accuracy

Model has high accuracy!

- Comparing predicted with actual data = values are similar
  - tail values can be compared to what the model would predict for these same values
- Looking at the MAPE value
  - Because there are 0 values, MAPE comes out to infinity, so we look at Mean Absolute Error
- Looking at the MAE value
  - Low value represents high accuracy of the model

```
> forecastAMZN
     Point Forecast       Lo 80     Hi 80       Lo 95      Hi 95
1001    0.001032292 -0.02139021 0.0234548 -0.03325997 0.03532456
1002    0.001032292 -0.02139021 0.0234548 -0.03325997 0.03532456
1003    0.001032292 -0.02139021 0.0234548 -0.03325997 0.03532456
1004    0.001032292 -0.02139021 0.0234548 -0.03325997 0.03532456
1005    0.001032292 -0.02139021 0.0234548 -0.03325997 0.03532456
> tail(sAMZN)
            AMZN.Close
2019-12-23  0.0036318473
2019-12-24 -0.0021160007
2019-12-26  0.0435062436
2019-12-27  0.0005509959
2019-12-30 -0.0123283321
2019-12-31  0.0005142526
> #comparing the forecast to the actual we can see that the values are very similar
> #or by using accuracy function
> accuracy(modelAMZN)
                      ME       RMSE        MAE  MPE MAPE      MASE        ACF1
Training set -4.919185e-15 0.01749637 0.01178156 -Inf  Inf 0.6962565 -0.01669486
```

The Competition

“Our current and potential competitors include:
(1) physical, e-commerce, and omnichannel **retailers**, publishers, vendors, distributors, manufacturers, and producers of the products we offer and sell to consumers and businesses;
(2) publishers, producers, and distributors of physical, digital, and interactive **media of all types** and all distribution channels;
(3) **web search engines**, comparison shopping websites, social networks, web portals, and other online and app-based means of discovering, using, or acquiring goods and services, either directly or in collaboration with other retailers;
(4) companies that provide e-commerce services, including website development and hosting, **omnichannel sales**, inventory, and supply chain management, advertising, fulfillment, customer service, and payment processing;
(5) companies that provide **fulfillment and logistics services** for themselves or for third parties, whether online or offline;
(6) companies that provide **information technology services or products**, including on-premises or cloud-based infrastructure and other services;
(7) companies that design, manufacture, market, or sell **consumer electronics**, telecommunication, and electronic devices; and
(8) companies that sell **grocery products** online and in physical stores. “

-Amazon.com, Inc. 2020 Form 10k

Chosen Companies	Google = GOOG	Microsoft = MSFT
Walmart = WMT	Salesforce = CRM	APPLE = APPL
Netflix = NFLX	UPS = UPS	Costco = COST

The Competition


```
     Index               AMZN.Close        WMT.Close        NFLX.Close
 Min.   :2016-01-04   Min.   : 24.10   Min.   : 60.84   Min.   : 82.79
 1st Qu.:2016-12-31   1st Qu.: 40.93   1st Qu.: 71.75   1st Qu.:127.71
 Median :2017-12-31   Median : 59.74   Median : 86.25   Median :201.88
 Mean   :2017-12-31   Mean   : 63.73   Mean   : 87.32   Mean   :228.87
 3rd Qu.:2019-01-01   3rd Qu.: 87.50   3rd Qu.: 98.75   3rd Qu.:326.44
 Max.   :2019-12-31   Max.   :101.98   Max.   :121.28   Max.   :418.97
   GOOG.Close       CRM.Close        UPS.Close        MSFT.Close
 Min.   :33.41   Min.   : 54.05   Min.   : 88.7   Min.   : 48.43
 1st Qu.:39.90   1st Qu.: 81.47   1st Qu.:105.7   1st Qu.: 62.69
 Median :51.42   Median :107.00   Median :110.0   Median : 86.15
 Mean   :49.58   Mean   :113.04   Mean   :110.5   Mean   : 89.67
 3rd Qu.:57.31   3rd Qu.:147.57   3rd Qu.:116.3   3rd Qu.:110.06
 Max.   :68.06   Max.   :166.95   Max.   :134.1   Max.   :158.96
   AAPL.Close       COST.Close
 Min.   :22.59   Min.   :141.3
 1st Qu.:29.39   1st Qu.:159.3
 Median :41.31   Median :185.3
 Mean   :40.78   Mean   :198.2
 3rd Qu.:48.13   3rd Qu.:229.7
 Max.   :73.41   Max.   :305.2
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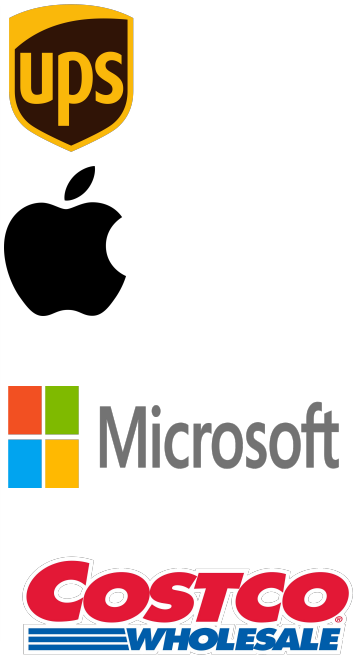
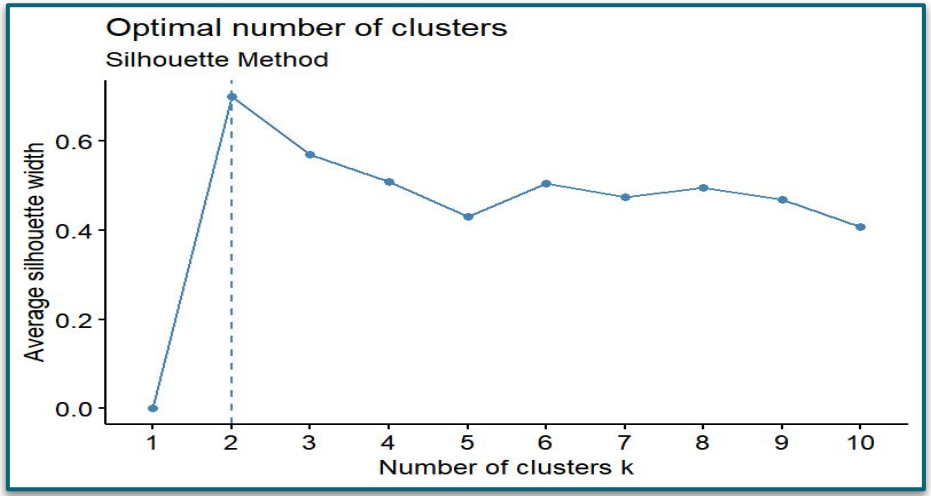


Descriptive statistics for each company's closing stock price from 2016-01-01-01 to 2020-01-01

Clustering Stock Data

- The companies can be split into clusters based on stock performance
- Optimal number of clusters = 2, according the the Silhouette Method
- Being able to cluster in this way may be helpful to investors to begin to decide how to diversify portfolio

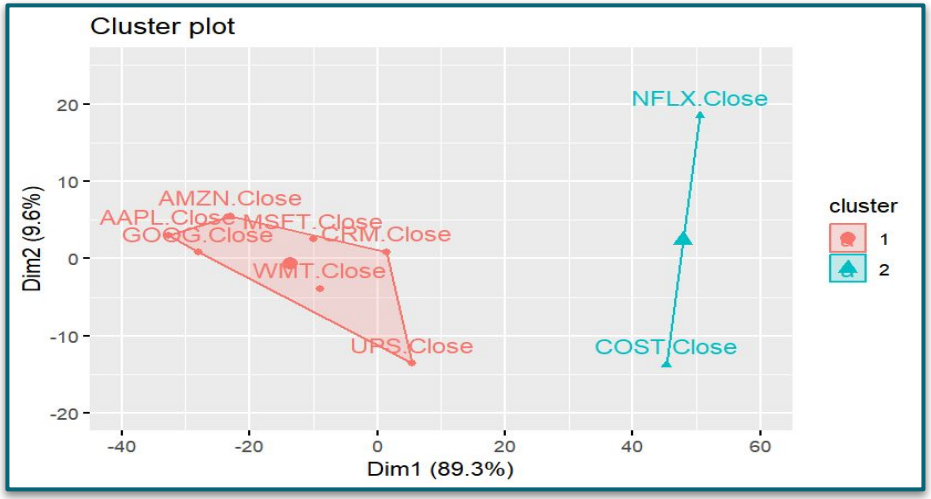


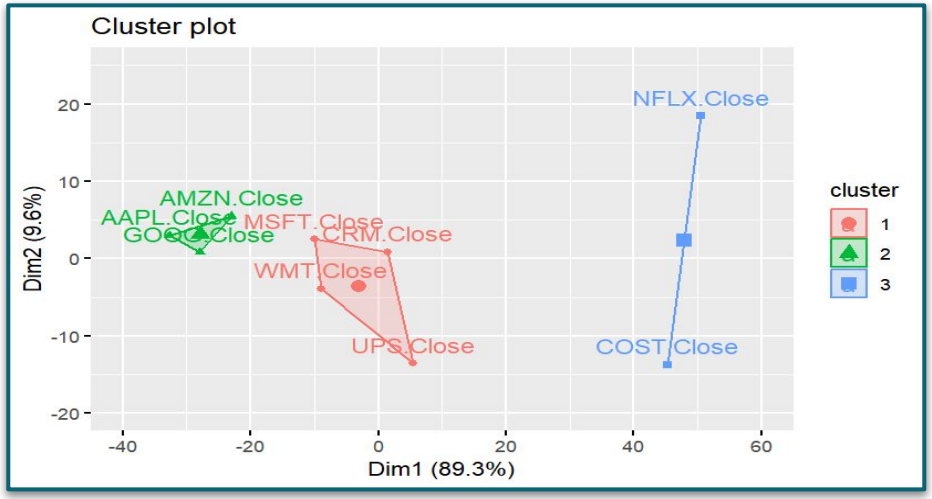

```
K-means clustering with 2 clusters of sizes 517, 489

Cluster means:
  AMZN.Close WMT.Close NFLX.Close GOOG.Close CRM.Close UPS.Close MSFT.Close AAPL.Close
1   42.26040   74.9776   135.8261   42.00021  83.11195  109.4391   64.28074   32.20812
2   86.42803  100.3784   327.2315   57.60102 144.67256  111.6004  116.51534   49.83387
  COST.Close
1   161.6548
2   236.8639
```

Top Competition

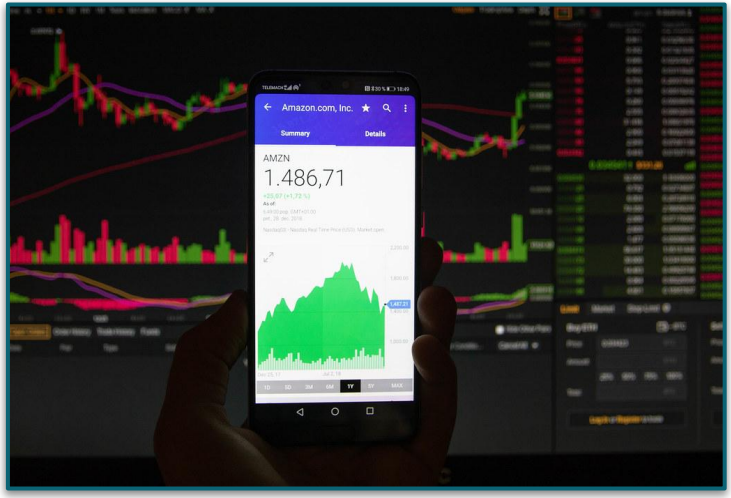
- Two clusters(optimal):
  - All companies but Netflix and Costco are comparable to AMZN stock
- Three clusters:
  - Only Google and Apple stocks are comparable to Amazon





Some Takeaways

- Seasonality and other factors can influence the performance of a stock
- Time series machine learning models may be less accurate when these factors are not taken into account
- ML models can provide high accuracy predictions when data is stationary
- K-means is a useful initial approach to investors who want to know how to best diversify their portfolio



Resources

- https://d18rn0p25nwr6d.cloudfront.net/CIK-0001018724/4d39f579-19d8-4119-b087-ee618abf82d6.pdf
- https://youtube.com/playlist?list=PLzAfHlPtM1I537hUVaqNDUBffDINzEmva
- https://medium.com/@aaronyen/https-medium-com-aaronyen-arimaproject-ab892486dc84
- https://bozliu.medium.com/financial-data-forecasting-using-r-7a55f2a1599
- https://towardsdatascience.com/interpreting-acf-and-pacf-plots-for-time-series-forecasting-af0d6db4061c
- https://www.geeksforgeeks.org/supervised-and-unsupervised-clustering-in-r-programming/
- https://www.youtube.com/watch?v=5mlth-yM2NE&t=337s
- https://towardsdatascience.com/machine-learning-for-stock-clustering-using-k-means-algorithm-126bc1ace4e1
- https://otexts.com/fpp2/index.html