

PROJECT REPORT - Lisa Wagner

GitHub URL:

Lisa's GitHub Repository for UCDPA Data Analytics Training Assignment
(https://github.com/WagnerLD/UCDPA_LisaWagner.git)

Abstract

This project's purpose is to demonstrate a specific set of competencies learned in the UCDPA Fidelity International - Data Analytics Training course. Given I had no prior experience in data science, coding (I knew Python to be a snake and Jupyter as the 5th planet from the sun) or statistics, the learning curve was steep. As a result, I have chosen straightforward datasets, and in some cases individual datasets to demonstrate a lone competency. The intention is to build a strong foundation, before moving on to more complex datasets and problems, including refining my code writing skills to be succinct and easier to understand.

Introduction

The two main datasets used through the project are "Wine Quality" and "Data Science Salaries", both chosen as I find the topics interesting and could think of various problem statements to investigate in the data. 1. Wine Quality - the data is all numeric and had 11 features from which to predict the quality, this dataset was used for the Machine Learning competencies. 2. Data Science Salaries - originally I was interested in what salary ranges exist for various qualities (title, year of experience, employee location), but in the end, the dataset chosen was more suitable for importing and data cleaning competencies. 3. Other datasets: a. Stock prices - demonstrate use of API, data merging and presenting charts on financial data b. Tweets - demonstrate Regex to extract a pattern in data from text

Datasets

Description and source for each data set used is below (also repeated at the beginning of the notebook section where the dataset is used)

1. Wine Quality

Source: UCI Machine Learning Repository

<https://archive.ics.uci.edu/ml/datasets/Wine+Quality>

Reason for choosing:

- a. the website and dataset was suggested in more than search for "good datasets for beginners to learn Machine Learning"
- b. the website itself appeared safe and the data was explained

2. Data Science Salaries

Source: Kaggle.com

<https://www.kaggle.com/datasets/ruchi798/data-science-job-salaries?resource=download>

Reason for choosing:

- a. the website is well known for data sources
- b. the data itself was complete and appeared well organized (a good basis for a beginner)

3. Stock Prices

Source: www.alphavantage.co

[https://www.alphavantage.co/query?](https://www.alphavantage.co/query?function=TIME_SERIES_MONTHLY&symbol=V&apikey=NLZ2TGZGULE9VS10)

[function=TIME_SERIES_MONTHLY&symbol=V&apikey=NLZ2TGZGULE9VS10](https://www.alphavantage.co/query?function=TIME_SERIES_MONTHLY&symbol=V&apikey=NLZ2TGZGULE9VS10)

Reason for choosing:

a. website was used for demonstration during the course and I found it easy to use and understand the structure of the data retrieved

4. Tweets

Source: Kaggle.com

<https://www.kaggle.com/datasets/mmmarchetti/tweets-dataset>

Reason for choosing:

a. search for tweets datasets returned Kaggle, data is clear and understandable

Implementation process

Please refer to descriptions within the notebook at each section

Results

Please refer to descriptions within the notebook at each section

Insights

Summarized below but can also be found within the workbook at the relevant sections:

1. Stock Prices - prices for a stock (Visa) were being compared to a benchmark (S&P500 Index), the result showed a deep, sharp decline in the stock part way through the time period.
On further investigation, the stock went through a 4:1 split in the time frame the data was selected for.
The resulting chart (based on the original data retrieved) is not suitable to answer the problem statement, the data for the stock price will need to be restated to normalize for the stock split.
2. Stock Prices - Once Visa's stock prices are restated to reflect the stock split, the chart more accurately shows Visa's performance compared to the benchmark (S&P500 Index). Visa's performance was aligned to the Index until 2013 when Visa's growth was stronger than the general market. Dips in Visa's stock price in latter years broadly correspond to dips in the Index; Visa's stock is not immune to outside conditions which impact other stocks in the Index.
3. Wine Quality - Ridge and Lasso regression models returned poor accuracy (mid-20%), which was anticipated as the attempt to predict quality is a Classification issue. KNN Classifier model returned better accuracy than the Regression models, but still not good (at 45%) before adjusting for outliers, simplifying target values or optimizing # of neighbors
4. Wine Quality - Optimizing neighbors value to 25 returns a 70.4% accuracy - significantly improved from original model, but not considered a good result as model accuracy should exceed 90% to be considered useable.
5. Wine Quality - Further fine tuning of the model did not produce any better accuracy after optimizing neighbors to 25.
 - a. Changing target values (original had a range of 3 - 9) to 0 or 1 (original quality value of <6 being "Not Good" = 0, >5 being "Good" = 1)
 - b. Outliers made up 4% of the dataset. Removing them improved the KNN Classifier model (before target values were transformed to 1 / 0) marginally from 45% to 48%. As expected, removing outliers had little impact on accuracy after the target values were transformed

References

1. P. Cortez, A. Cerdeira, F. Almeida, T. Matos and J. Reis.

Modeling wine preferences by data mining from physicochemical properties. In Decision Support Systems, Elsevier, 47(4):547-553, 2009.

Special Mention

Appreciation to:

1. Riju Sathyan for his assistance with making the API data useable
2. Phillip Marsh for help with formatting text

Data Science Salaries - importing data, data analysis and cleaning

```
In [105... # Import data from csv, data analysis & cleaning (replace missing values, drop duplicate
# Data Science Salaries from Kaggle.com
```

```
In [106... # Import .csv file into a Pandas Dataframe
```

```
import pandas as pd
import numpy as np
```

```
In [107... # data source = Kaggle.com (https://www.kaggle.com/datasets/ruchi798/data-science-job-sa

df_sal = pd.read_csv('ds_salaries.csv')
```

```
In [108... # view what the data frame looks like - columns and beginning / ending data, confirm no

df_sal.head()
```

```
Out[108]:
```

| | Unnamed: 0 | work_year | experience_level | employment_type | job_title | salary | salary_currency | salary_in_usd | en |
|---|------------|-----------|------------------|-----------------|----------------------------|--------|-----------------|---------------|----|
| 0 | 0 | 2020 | MI | FT | Data Scientist | 70000 | EUR | 79833 | |
| 1 | 1 | 2020 | SE | FT | Machine Learning Scientist | 260000 | USD | 260000 | |
| 2 | 2 | 2020 | SE | FT | Big Data Engineer | 85000 | GBP | 109024 | |
| 3 | 3 | 2020 | MI | FT | Product Data Analyst | 20000 | USD | 20000 | |
| 4 | 4 | 2020 | SE | FT | Machine Learning Engineer | 150000 | USD | 150000 | |

```
In [109... df_sal.tail()
```

```
Out[109]:
```

| | Unnamed: 0 | work_year | experience_level | employment_type | job_title | salary | salary_currency | salary_in_usd | |
|-----|------------|-----------|------------------|-----------------|---------------|--------|-----------------|---------------|--|
| 602 | 602 | 2022 | SE | FT | Data Engineer | 154000 | USD | 154000 | |
| 603 | 603 | 2022 | SE | FT | Data | 126000 | USD | 126000 | |

| | | | | | | | | |
|------------|-----|------|----|----|--------------|--------|-----|--------|
| | | | | | Engineer | | | |
| 604 | 604 | 2022 | SE | FT | Data Analyst | 129000 | USD | 129000 |
| 605 | 605 | 2022 | SE | FT | Data Analyst | 150000 | USD | 150000 |
| 606 | 606 | 2022 | MI | FT | AI Scientist | 200000 | USD | 200000 |

```
In [110... # confirms no missing info - count for each column is same value as RangeIndex entries
df_sal.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 607 entries, 0 to 606
Data columns (total 12 columns):
#   Column                Non-Null Count  Dtype
---  -
0   Unnamed: 0             607 non-null   int64
1   work_year              607 non-null   int64
2   experience_level        607 non-null   object
3   employment_type        607 non-null   object
4   job_title              607 non-null   object
5   salary                 607 non-null   int64
6   salary_currency        607 non-null   object
7   salary_in_usd          607 non-null   int64
8   employee_residence     607 non-null   object
9   remote_ratio           607 non-null   int64
10  company_location       607 non-null   object
11  company_size           607 non-null   object
dtypes: int64(5), object(7)
memory usage: 57.0+ KB
```

```
In [111... # Data Cleaning - the index column is repeated in the first (unnamed) column, use drop b
# creating df2 to retain original format of data

df_sal2 = df_sal.drop(df_sal.columns[0], axis=1)
```

```
In [112... df_sal2
```

Out[112]:

| | work_year | experience_level | employment_type | job_title | salary | salary_currency | salary_in_usd | employee_re |
|------------|-----------|------------------|-----------------|----------------------------|--------|-----------------|---------------|-------------|
| 0 | 2020 | MI | FT | Data Scientist | 70000 | EUR | 79833 | |
| 1 | 2020 | SE | FT | Machine Learning Scientist | 260000 | USD | 260000 | |
| 2 | 2020 | SE | FT | Big Data Engineer | 85000 | GBP | 109024 | |
| 3 | 2020 | MI | FT | Product Data Analyst | 20000 | USD | 20000 | |
| 4 | 2020 | SE | FT | Machine Learning Engineer | 150000 | USD | 150000 | |
| ... | ... | ... | ... | ... | ... | ... | ... | |
| 602 | 2022 | SE | FT | Data Engineer | 154000 | USD | 154000 | |

| | | | | | | | |
|------------|------|----|----|---------------|--------|-----|--------|
| 603 | 2022 | SE | FT | Data Engineer | 126000 | USD | 126000 |
| 604 | 2022 | SE | FT | Data Analyst | 129000 | USD | 129000 |
| 605 | 2022 | SE | FT | Data Analyst | 150000 | USD | 150000 |
| 606 | 2022 | MI | FT | AI Scientist | 200000 | USD | 200000 |

607 rows × 11 columns

```
In [113... # Data cleaning - replace missing values. The original data did not having any missing
# created with some values missing to show the next competencies

# import amended file above to replace missing values

df_sal3 = pd.read_csv('ds_salaries_missing.csv')
```

```
In [114... df_sal3.head()
```

Out[114]:

| | Unnamed: 0 | work_year | experience_level | employment_type | job_title | salary | salary_currency | salary_in_usd | en |
|----------|------------|-----------|------------------|-----------------|----------------------------|--------|-----------------|---------------|----|
| 0 | 0 | 2020.0 | MI | FT | Data Scientist | 70000 | EUR | 79833 | |
| 1 | 1 | 2020.0 | SE | FT | Machine Learning Scientist | 260000 | USD | 260000 | |
| 2 | 2 | 2020.0 | SE | FT | Big Data Engineer | 85000 | GBP | 109024 | |
| 3 | 3 | 2020.0 | MI | FT | Product Data Analyst | 20000 | USD | 20000 | |
| 4 | 4 | 2020.0 | SE | FT | Machine Learning Engineer | 150000 | USD | 150000 | |

```
In [115... # shows missing data in column work_year - only 591 count, should be 607
# work_year has also been changed from integer to float during the process of creating m
# as the data frame is only being used to demonstrate data cleaning to replace missing d

df_sal3.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 607 entries, 0 to 606
Data columns (total 12 columns):
#   Column              Non-Null Count  Dtype
---  -
0   Unnamed: 0          607 non-null   int64
1   work_year           591 non-null   float64
2   experience_level     607 non-null   object
3   employment_type     607 non-null   object
4   job_title           607 non-null   object
5   salary              607 non-null   int64
6   salary_currency     607 non-null   object
7   salary_in_usd       607 non-null   int64
8   employee_residence  607 non-null   object
9   remote_ratio        607 non-null   int64
```

```
10 company_location      607 non-null object
11 company_size           607 non-null object
dtypes: float64(1), int64(4), object(7)
memory usage: 57.0+ KB
```

```
In [116... # same as above, more explicitly shows the exact number of missing values in the one col

df_sal3.isna().sum()
```

```
Out[116]: Unnamed: 0          0
work_year      16
experience_level 0
employment_type 0
job_title       0
salary          0
salary_currency 0
salary_in_usd   0
employee_residence 0
remote_ratio    0
company_location 0
company_size     0
dtype: int64
```

```
In [117... # missing data is in the year column, for which same years are grouped together - use pr

df_sal_cleaned=df_sal3.fillna(method="ffill")
```

```
In [118... # rechecking, no more missing data

df_sal_cleaned.isna().sum()
```

```
Out[118]: Unnamed: 0          0
work_year      0
experience_level 0
employment_type 0
job_title       0
salary          0
salary_currency 0
salary_in_usd   0
employee_residence 0
remote_ratio    0
company_location 0
company_size     0
dtype: int64
```

Stock Prices - importing data via API, dataframe merging and charts

```
In [119... # Import data via API, merge dataframe, iterator, dictionaries/lists) and
# visualization using stock data for Visa vs a benchmark (S&P 500 Index ETF)
```

```
In [120... # data set source = https://www.alphavantage.co/documentation/ with ticker symbol V sele
# a stock for which I will compare performance against a general market benchmark (S&P 5

import requests

dataV = requests.get("https://www.alphavantage.co/query?function=TIME_SERIES_MONTHLY&sym
```

```
In [121... dataV = dataV.json()
```

```
In [122... # view the format and structure of the data

dataV
```

```
{'Meta Data': {'1. Information': 'Monthly Prices (open, high, low, close) and Volumes',
```

Out[122]:

```
'2. Symbol': 'V',
'3. Last Refreshed': '2022-09-16',
'4. Time Zone': 'US/Eastern'},
'Monthly Time Series': {'2022-09-16': {'1. open': '198.7200',
'2. high': '207.1900',
'3. low': '188.2200',
'4. close': '193.3000',
'5. volume': '57174925'},
'2022-08-31': {'1. open': '208.4500',
'2. high': '217.6100',
'3. low': '198.6400',
'4. close': '198.7100',
'5. volume': '130178837'},
'2022-07-29': {'1. open': '196.7900',
'2. high': '218.0700',
'3. low': '194.1400',
'4. close': '212.1100',
'5. volume': '118596952'},
'2022-06-30': {'1. open': '212.0500',
'2. high': '217.5800',
'3. low': '185.9100',
'4. close': '196.8900',
'5. volume': '128123527'},
'2022-05-31': {'1. open': '211.7700',
'2. high': '214.8000',
'3. low': '189.9500',
'4. close': '212.1700',
'5. volume': '171858850'},
'2022-04-29': {'1. open': '223.0800',
'2. high': '229.2400',
'3. low': '201.1000',
'4. close': '213.1300',
'5. volume': '151474586'},
'2022-03-31': {'1. open': '214.4800',
'2. high': '228.8100',
'3. low': '186.6700',
'4. close': '221.7700',
'5. volume': '188732371'},
'2022-02-28': {'1. open': '226.9000',
'2. high': '235.8500',
'3. low': '201.4500',
'4. close': '216.1200',
'5. volume': '171668723'},
'2022-01-31': {'1. open': '217.5200',
'2. high': '228.1200',
'3. low': '195.6500',
'4. close': '226.1700',
'5. volume': '224640154'},
'2021-12-31': {'1. open': '196.0300',
'2. high': '219.7300',
'3. low': '190.1000',
'4. close': '216.7100',
'5. volume': '189072557'},
'2021-11-30': {'1. open': '213.4900',
'2. high': '221.6100',
'3. low': '192.5500',
'4. close': '193.7700',
'5. volume': '303787625'},
'2021-10-29': {'1. open': '224.1700',
'2. high': '236.9600',
'3. low': '208.5400',
'4. close': '211.7700',
'5. volume': '170235962'},
'2021-09-30': {'1. open': '229.1000',
'2. high': '233.3300',
'3. low': '216.3100',
```

```
'4. close': '222.7500',
'5. volume': '175674100'},
'2021-08-31': {'1. open': '246.2400',
'2. high': '247.8300',
'3. low': '228.6600',
'4. close': '229.1000',
'5. volume': '148464103'},
'2021-07-30': {'1. open': '234.2000',
'2. high': '252.6700',
'3. low': '234.0499',
'4. close': '246.3900',
'5. volume': '157809397'},
'2021-06-30': {'1. open': '229.4400',
'2. high': '238.4800',
'3. low': '226.2800',
'4. close': '233.8200',
'5. volume': '151631040'},
'2021-05-28': {'1. open': '234.0500',
'2. high': '235.7400',
'3. low': '220.3100',
'4. close': '227.3000',
'5. volume': '127250043'},
'2021-04-30': {'1. open': '213.7840',
'2. high': '237.5000',
'3. low': '212.3000',
'4. close': '233.5600',
'5. volume': '152922449'},
'2021-03-31': {'1. open': '214.9700',
'2. high': '228.2298',
'3. low': '205.7800',
'4. close': '211.7300',
'5. volume': '228910433'},
'2021-02-26': {'1. open': '195.1400',
'2. high': '220.5300',
'3. low': '195.0200',
'4. close': '212.3900',
'5. volume': '196654813'},
'2021-01-29': {'1. open': '220.2500',
'2. high': '220.2500',
'3. low': '192.8100',
'4. close': '193.2500',
'5. volume': '198356580'},
'2020-12-31': {'1. open': '212.1300',
'2. high': '220.3900',
'3. low': '204.5000',
'4. close': '218.7300',
'5. volume': '178457456'},
'2020-11-30': {'1. open': '184.5100',
'2. high': '217.6500',
'3. low': '183.8900',
'4. close': '210.3500',
'5. volume': '156651025'},
'2020-10-30': {'1. open': '202.2100',
'2. high': '207.9700',
'3. low': '179.2300',
'4. close': '181.7100',
'5. volume': '172181178'},
'2020-09-30': {'1. open': '212.2100',
'2. high': '217.3500',
'3. low': '193.1300',
'4. close': '199.9700',
'5. volume': '176375547'},
'2020-08-31': {'1. open': '191.8000',
'2. high': '216.1600',
'3. low': '190.0800',
'4. close': '211.9900',
```



```
'5. volume': '161589042'},
'2020-07-31': {'1. open': '193.8500',
'2. high': '200.9500',
'3. low': '187.1800',
'4. close': '190.4000',
'5. volume': '168844674'},
'2020-06-30': {'1. open': '194.7100',
'2. high': '202.1800',
'3. low': '186.2100',
'4. close': '193.1700',
'5. volume': '192103395'},
'2020-05-29': {'1. open': '174.4500',
'2. high': '198.2900',
'3. low': '171.7200',
'4. close': '195.2400',
'5. volume': '189585116'},
'2020-04-30': {'1. open': '156.3200',
'2. high': '182.2500',
'3. low': '150.6000',
'4. close': '178.7200',
'5. volume': '263495312'},
'2020-03-31': {'1. open': '186.3200',
'2. high': '194.4900',
'3. low': '133.9300',
'4. close': '161.1200',
'5. volume': '417542977'},
'2020-02-28': {'1. open': '199.9400',
'2. high': '214.1700',
'3. low': '172.9800',
'4. close': '181.7600',
'5. volume': '199776179'},
'2020-01-31': {'1. open': '189.0000',
'2. high': '210.1300',
'3. low': '187.1600',
'4. close': '198.9700',
'5. volume': '183582543'},
'2019-12-31': {'1. open': '184.2400',
'2. high': '189.8900',
'3. low': '179.6600',
'4. close': '187.9000',
'5. volume': '160394084'},
'2019-11-29': {'1. open': '180.1300',
'2. high': '184.8500',
'3. low': '175.1800',
'4. close': '184.5100',
'5. volume': '134065026'},
'2019-10-31': {'1. open': '173.0200',
'2. high': '180.1800',
'3. low': '168.5900',
'4. close': '178.8600',
'5. volume': '162923578'},
'2019-09-30': {'1. open': '180.5200',
'2. high': '187.0500',
'3. low': '172.0100',
'4. close': '172.0100',
'5. volume': '171931176'},
'2019-08-30': {'1. open': '179.1900',
'2. high': '182.4000',
'3. low': '166.9800',
'4. close': '180.8200',
'5. volume': '154470525'},
'2019-07-31': {'1. open': '175.3300',
'2. high': '184.0700',
'3. low': '172.7400',
'4. close': '178.0000',
'5. volume': '126736340'},
```

```
'2019-06-28': {'1. open': '161.5400',  
  '2. high': '174.9400',  
  '3. low': '156.7500',  
  '4. close': '173.5500',  
  '5. volume': '158885114'},  
'2019-05-31': {'1. open': '165.5400',  
  '2. high': '165.7700',  
  '3. low': '156.4200',  
  '4. close': '161.3300',  
  '5. volume': '147282119'},  
'2019-04-30': {'1. open': '157.5300',  
  '2. high': '165.7000',  
  '3. low': '156.3200',  
  '4. close': '164.4300',  
  '5. volume': '136490658'},  
'2019-03-29': {'1. open': '149.4600',  
  '2. high': '156.8200',  
  '3. low': '144.5000',  
  '4. close': '156.1900',  
  '5. volume': '207401562'},  
'2019-02-28': {'1. open': '135.3900',  
  '2. high': '148.8200',  
  '3. low': '135.2600',  
  '4. close': '148.1200',  
  '5. volume': '154776247'},  
'2019-01-31': {'1. open': '130.0000',  
  '2. high': '139.9000',  
  '3. low': '127.8800',  
  '4. close': '135.0100',  
  '5. volume': '193205412'},  
'2018-12-31': {'1. open': '145.0000',  
  '2. high': '145.7200',  
  '3. low': '121.6000',  
  '4. close': '131.9400',  
  '5. volume': '242677721'},  
'2018-11-30': {'1. open': '139.0000',  
  '2. high': '145.4600',  
  '3. low': '129.5400',  
  '4. close': '141.7100',  
  '5. volume': '208766205'},  
'2018-10-31': {'1. open': '150.8900',  
  '2. high': '151.5600',  
  '3. low': '129.7900',  
  '4. close': '137.8500',  
  '5. volume': '254092004'},  
'2018-09-28': {'1. open': '146.9300',  
  '2. high': '150.6400',  
  '3. low': '142.5400',  
  '4. close': '150.0900',  
  '5. volume': '147500495'},  
'2018-08-31': {'1. open': '137.7400',  
  '2. high': '147.7100',  
  '3. low': '137.0000',  
  '4. close': '146.8900',  
  '5. volume': '143157273'},  
'2018-07-31': {'1. open': '131.9600',  
  '2. high': '143.1400',  
  '3. low': '131.1500',  
  '4. close': '136.7400',  
  '5. volume': '161562542'},  
'2018-06-29': {'1. open': '131.8400',  
  '2. high': '136.6900',  
  '3. low': '129.5300',  
  '4. close': '132.4500',  
  '5. volume': '154720393'},  
'2018-05-31': {'1. open': '126.8600',
```

```
'2. high': '132.5000',
'3. low': '125.3200',
'4. close': '130.7200',
'5. volume': '147562270'},
'2018-04-30': {'1. open': '119.2700',
'2. high': '127.9000',
'3. low': '116.7100',
'4. close': '126.8800',
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'3. low': '180.1100',  
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'3. low': '175.0500',  
'4. close': '191.1000',  
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'3. low': '172.2100',  
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'2013-07-31': {'1. open': '183.9000',  
'2. high': '196.0000',  
'3. low': '170.9900',  
'4. close': '177.0100',  
'5. volume': '84007800'},  
'2013-06-28': {'1. open': '178.7500',  
'2. high': '185.2300',  
'3. low': '175.6800',  
'4. close': '182.7500',  
'5. volume': '62189200'},  
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'3. low': '163.6000',  
'4. close': '178.1400',  
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'3. low': '161.2700',  
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'4. close': '138.7600',
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'2. high': '132.3500',
'3. low': '119.1000',
'4. close': '129.0700',
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'2. high': '124.9500',
'3. low': '111.9401',
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'5. volume': '73804200'},
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'3. low': '112.5000',
'4. close': '115.2000',
'5. volume': '100344000'},
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'4. close': '122.9800',
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'3. low': '100.6025',
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'3. low': '81.7100',
'4. close': '93.2600',
'5. volume': '104767000'},
'2011-09-30': {'1. open': '87.7200',
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'3. low': '83.2500',
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'2. high': '88.8500',
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'5. volume': '160948700'},
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'3. low': '83.6000',
'4. close': '85.5400',
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'5. volume': '99881900'},
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'4. close': '78.1200',
'5. volume': '80182500'},
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'3. low': '70.4500',
'4. close': '73.6200',
'5. volume': '132083000'},
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'3. low': '72.5810',
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'3. low': '64.9000',
'4. close': '74.2600',
'5. volume': '158973300'},
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'3. low': '68.0100',
'4. close': '68.9800',
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'4. close': '73.3500',
'5. volume': '117947400'},
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'3. low': '70.0200',
'4. close': '70.7500',
'5. volume': '197268700'},
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'3. low': '68.2900',
'4. close': '72.4600',
'5. volume': '329707000'},
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'3. low': '90.0200',
'4. close': '90.2300',
'5. volume': '82607100'},
'2010-03-31': {'1. open': '85.5000',
'2. high': '93.6300',
'3. low': '85.2800',
'4. close': '91.0300',
'5. volume': '117882000'},
'2010-02-26': {'1. open': '82.2900',
'2. high': '87.7600',
'3. low': '80.5400',
'4. close': '85.2800',
'5. volume': '99527800'},
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'3. low': '78.7100',
'4. close': '87.4600',
'5. volume': '204952500'},
'2009-11-30': {'1. open': '76.0900',
'2. high': '81.9700',
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'3. low': '75.8000',
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'2. high': '74.9900',
'3. low': '68.6100',
'4. close': '69.1100',
'5. volume': '99051700'},
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'2. high': '71.3200',
'3. low': '65.9000',
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'5. volume': '93978700'},
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'2. high': '69.6800',
'3. low': '58.0000',
'4. close': '65.4600',
'5. volume': '153747700'},
'2009-06-30': {'1. open': '68.5000',
'2. high': '71.2400',
'3. low': '60.2700',
'4. close': '62.2600',
'5. volume': '193053500'},
'2009-05-29': {'1. open': '64.1500',
'2. high': '68.5600',
'3. low': '62.6400',
'4. close': '67.7100',
'5. volume': '198672200'},
'2009-04-30': {'1. open': '54.7500',
'2. high': '68.0000',
'3. low': '53.6300',
'4. close': '64.9600',
'5. volume': '222924500'},
'2009-03-31': {'1. open': '55.9300',
'2. high': '56.9700',
'3. low': '48.7400',
'4. close': '55.6000',
'5. volume': '231948800'},
'2009-02-27': {'1. open': '48.2500',
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'3. low': '47.5400',
'4. close': '56.7100',
'5. volume': '186385800'},
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'3. low': '41.7800',
'4. close': '49.3500',
'5. volume': '160611600'},
'2008-12-31': {'1. open': '51.0000',
'2. high': '57.6700',
'3. low': '47.5300',
'4. close': '52.4500',
'5. volume': '141021400'},
'2008-11-28': {'1. open': '55.3500',
'2. high': '60.4500',
'3. low': '43.5400',
'4. close': '52.5600',
'5. volume': '191852000'},
'2008-10-31': {'1. open': '60.7500',
'2. high': '62.1100',
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'4. close': '55.3500',
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'2008-09-30': {'1. open': '76.8300',
'2. high': '77.5000',
'3. low': '55.8900',
'4. close': '61.3900',
'5. volume': '254818400'},
'2008-08-29': {'1. open': '73.3000',
'2. high': '76.5300',
'3. low': '69.1100',
'4. close': '75.9000',
'5. volume': '158540800'},
'2008-07-31': {'1. open': '79.2000',
'2. high': '82.4000',
'3. low': '66.5100',
'4. close': '73.0600',
'5. volume': '333151100'},
'2008-06-30': {'1. open': '86.2100',
'2. high': '88.1000',
'3. low': '77.6000',
'4. close': '81.3100',
'5. volume': '255456900'},
'2008-05-30': {'1. open': '84.6800',
'2. high': '89.8400',
'3. low': '74.3600',
'4. close': '86.3600',
'5. volume': '388428400'},
'2008-04-30': {'1. open': '63.0000',
'2. high': '84.8100',
'3. low': '60.3100',
'4. close': '83.4500',
'5. volume': '346330900'}}

```

```

In [124... # create static shortcut for stock symbol from Meta Data for future use and test it retu

mts_visa = dataV['Meta Data']['2. Symbol']

```

```

In [125... mts_visa

```

```

Out[125]: 'V'

```

```

In [126... # extract only the required data from the entirety brought in from the website:
# - create lists for the 3 needed items (name, date and price)
# - run a loop to take data from dataV (created above) and extract the price at each dat
#   above (with appreciation to Riju Sathyan for the assistance in getting this code to

from datetime import datetime

stock_nameV=[]
date_stampV=[]
close_priceV=[]

for x,y in dataV['Monthly Time Series'].items():
    stock_nameV.append(mts_visa)
    date_stampV.append(datetime.strptime(x, '%Y-%m-%d'))
    close_priceV.append(float(y['4. close']))

```

```

In [127... # combine the lists, adding column headers, to then create the dataframe

dataV_pd = {"date_stamp": date_stampV, "ticker": stock_nameV, "close_price": close_price

```

```

In [128... df_mtsV=pd.DataFrame(dataV_pd)

```

In [129... df_mtsV

Out[129]:

| | date_stamp | ticker | close_price |
|-----|------------|--------|-------------|
| 0 | 2022-09-16 | V | 193.30 |
| 1 | 2022-08-31 | V | 198.71 |
| 2 | 2022-07-29 | V | 212.11 |
| 3 | 2022-06-30 | V | 196.89 |
| 4 | 2022-05-31 | V | 212.17 |
| ... | ... | ... | ... |
| 169 | 2008-08-29 | V | 75.90 |
| 170 | 2008-07-31 | V | 73.06 |
| 171 | 2008-06-30 | V | 81.31 |
| 172 | 2008-05-30 | V | 86.36 |
| 173 | 2008-04-30 | V | 83.45 |

174 rows × 3 columns

In [130...

```
# Repeat the above process to take S&P500 Index prices from www.alphavantage.co to merge
# Additional cleaning step needed to drop additional rows so the chart starts at the sam

# data set source = https://www.alphavantage.co/documentation/ with ticker symbol IVV se
# as a benchmark for the general market
dataIVV = requests.get("https://www.alphavantage.co/query?function=TIME_SERIES_MONTHLY&s
```

In [131...

```
dataIVV = dataIVV.json()
```

In [132...

```
dataIVV
```

Out[132]:

```
{'Meta Data': {'1. Information': 'Monthly Prices (open, high, low, close) and Volumes',
  '2. Symbol': 'IVV',
  '3. Last Refreshed': '2022-09-16',
  '4. Time Zone': 'US/Eastern'},
'Monthly Time Series': {'2022-09-16': {'1. open': '394.9000',
  '2. high': '413.9400',
  '3. low': '385.6900',
  '4. close': '389.1000',
  '5. volume': '48649568'},
'2022-08-31': {'1. open': '411.3400',
  '2. high': '434.0299',
  '3. low': '397.0900',
  '4. close': '397.1800',
  '5. volume': '93399466'},
'2022-07-29': {'1. open': '378.5200',
  '2. high': '415.2000',
  '3. low': '372.9700',
  '4. close': '414.2800',
  '5. volume': '95301237'},
'2022-06-30': {'1. open': '416.9900',
  '2. high': '419.2900',
  '3. low': '364.0300',
  '4. close': '379.1500',
  '5. volume': '146298953'},
'2022-05-31': {'1. open': '413.6200',
  '2. high': '431.5000',
  '3. low': '382.1700',
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```
'4. close': '414.8700',
'5. volume': '148309359'},
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'2. high': '459.7900',
'3. low': '412.9800',
'4. close': '413.5600',
'5. volume': '120564640'},
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'2. high': '464.0500',
'3. low': '416.9100',
'4. close': '453.6900',
'5. volume': '177475497'},
'2022-02-28': {'1. open': '452.6900',
'2. high': '460.1400',
'3. low': '412.4000',
'4. close': '438.7200',
'5. volume': '164962179'},
'2022-01-31': {'1. open': '478.3800',
'2. high': '482.0700',
'3. low': '422.5600',
'4. close': '451.7700',
'5. volume': '198009750'},
'2021-12-31': {'1. open': '463.4500',
'2. high': '481.0900',
'3. low': '450.7400',
'4. close': '476.9900',
'5. volume': '142018898'},
'2021-11-30': {'1. open': '462.1300',
'2. high': '475.5000',
'3. low': '457.1300',
'4. close': '457.6300',
'5. volume': '91345480'},
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'2. high': '461.3900',
'3. low': '428.0050',
'4. close': '460.9900',
'5. volume': '82756752'},
'2021-09-30': {'1. open': '454.5500',
'2. high': '456.0800',
'3. low': '430.6000',
'4. close': '430.8200',
'5. volume': '93219169'},
'2021-08-31': {'1. open': '442.2800',
'2. high': '455.0900',
'3. low': '438.0100',
'4. close': '453.7100',
'5. volume': '79085486'},
'2021-07-30': {'1. open': '430.7100',
'2. high': '443.7161',
'3. low': '423.8100',
'4. close': '440.4000',
'5. volume': '98582631'},
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'2. high': '430.6186',
'3. low': '416.4800',
'4. close': '429.9200',
'5. volume': '86553485'},
'2021-05-28': {'1. open': '421.0200',
'2. high': '424.4300',
'3. low': '406.3400',
'4. close': '421.6500',
'5. volume': '94609260'},
'2021-04-30': {'1. open': '399.8800',
'2. high': '422.2800',
'3. low': '399.6600',
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```

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'5. volume': '97180254'},
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'2. high': '399.6500',
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'5. volume': '104556905'},
'2021-02-26': {'1. open': '375.1700',
'2. high': '395.6500',
'3. low': '372.7000',
'4. close': '381.7700',
'5. volume': '65082702'},
'2021-01-29': {'1. open': '376.6900',
'2. high': '387.2000',
'3. low': '366.1600',
'4. close': '371.5200',
'5. volume': '93227993'},
'2020-12-31': {'1. open': '366.9000',
'2. high': '376.0400',
'3. low': '363.3800',
'4. close': '375.3900',
'5. volume': '93094341'},
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'2. high': '365.6900',
'3. low': '328.3800',
'4. close': '363.3200',
'5. volume': '81441796'},
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'2. high': '355.2500',
'3. low': '323.7200',
'4. close': '327.6200',
'5. volume': '79596800'},
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'2. high': '360.2600',
'3. low': '320.9200',
'4. close': '336.0600',
'5. volume': '86022831'},
'2020-08-31': {'1. open': '329.6600',
'2. high': '352.7700',
'3. low': '329.0639',
'4. close': '350.7700',
'5. volume': '59150438'},
'2020-07-31': {'1. open': '310.7400',
'2. high': '330.0600',
'3. low': '310.2500',
'4. close': '327.8200',
'5. volume': '76578094'},
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'2. high': '324.5500',
'3. low': '296.4900',
'4. close': '309.6900',
'5. volume': '115249434'},
'2020-05-29': {'1. open': '286.1900',
'2. high': '307.9100',
'3. low': '275.0000',
'4. close': '305.1800',
'5. volume': '113650186'},
'2020-04-30': {'1. open': '248.7600',
'2. high': '295.8400',
'3. low': '244.6200',
'4. close': '291.1600',
'5. volume': '166337553'},
'2020-03-31': {'1. open': '299.3400',
'2. high': '315.1500',
'3. low': '220.2800',
'4. close': '258.4000',
'5. volume': '306347948'},
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```
'2020-02-28': {'1. open': '324.8100',  
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'2. high': '121.6500',
'3. low': '118.2100',
'4. close': '120.7500',
'5. volume': '14345600'},
'2005-01-31': {'1. open': '121.7000',
'2. high': '121.8985',
'3. low': '116.5300',
'4. close': '118.2900',
'5. volume': '15538300'},
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'2. high': '122.2600',
'3. low': '118.1700',
'4. close': '121.0000',
'5. volume': '17184200'},
'2004-11-30': {'1. open': '113.5800',
'2. high': '119.5200',
'3. low': '113.2600',
'4. close': '118.2200',
'5. volume': '13129300'},
'2004-10-29': {'1. open': '112.3500',
'2. high': '114.6800',
'3. low': '109.4100',
'4. close': '113.2000',
'5. volume': '9305400'},
'2004-09-30': {'1. open': '111.0400',
'2. high': '113.9700',
'3. low': '110.5000',
'4. close': '111.8000',
'5. volume': '7105900'},
'2004-08-31': {'1. open': '110.2300',
'2. high': '111.6700',
'3. low': '106.6400',
'4. close': '111.2000',
'5. volume': '7684500'},
'2004-07-30': {'1. open': '114.3900',
'2. high': '114.4300',
'3. low': '108.2400',
'4. close': '110.9800',
'5. volume': '14111300'},
'2004-06-30': {'1. open': '112.5600',
'2. high': '115.3600',
'3. low': '111.9500',
'4. close': '114.5700',
'5. volume': '9531500'},
'2004-05-28': {'1. open': '111.4600',
'2. high': '113.2300',
'3. low': '108.1300',
'4. close': '112.9700',
'5. volume': '9276500'},
'2004-04-30': {'1. open': '113.2200',
'2. high': '115.4500',
'3. low': '110.9600',
'4. close': '111.1100',
'5. volume': '12980000'},
'2004-03-31': {'1. open': '115.4900',
'2. high': '117.0000',
'3. low': '108.4800',
'4. close': '113.2300',
'5. volume': '14486700'},
'2004-02-27': {'1. open': '113.7400',
'2. high': '116.4800',
'3. low': '112.8700',
'4. close': '115.0400',
'5. volume': '7021900'},
'2004-01-30': {'1. open': '111.6300',
'2. high': '116.0000',
```

```
'3. low': '10.8100',
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'5. volume': '14379600'},
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'2. high': '111.5800',
'3. low': '106.0500',
'4. close': '111.2200',
'5. volume': '16350200'},
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'2. high': '106.9100',
'3. low': '103.7400',
'4. close': '106.5800',
'5. volume': '4475600'},
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'2. high': '105.8800',
'3. low': '100.2000',
'4. close': '105.3000',
'5. volume': '9098200'},
'2003-09-30': {'1. open': '101.8000',
'2. high': '104.3500',
'3. low': '99.2600',
'4. close': '99.9000',
'5. volume': '8747800'},
'2003-08-29': {'1. open': '99.3100',
'2. high': '101.7500',
'3. low': '96.4500',
'4. close': '101.3300',
'5. volume': '7824900'},
'2003-07-31': {'1. open': '97.3400',
'2. high': '101.8800',
'3. low': '96.5000',
'4. close': '99.4600',
'5. volume': '7436600'},
'2003-06-30': {'1. open': '97.6100',
'2. high': '101.8000',
'3. low': '96.9500',
'4. close': '97.7800',
'5. volume': '15700100'},
'2003-05-30': {'1. open': '91.9500',
'2. high': '97.0200',
'3. low': '90.5500',
'4. close': '96.9900',
'5. volume': '10693500'},
'2003-04-30': {'1. open': '85.2000',
'2. high': '92.7200',
'3. low': '84.9410',
'4. close': '92.0100',
'5. volume': '10338000'},
'2003-03-31': {'1. open': '85.4000',
'2. high': '89.8200',
'3. low': '79.0600',
'4. close': '84.8100',
'5. volume': '12538600'},
'2003-02-28': {'1. open': '85.9300',
'2. high': '86.7800',
'3. low': '81.0000',
'4. close': '84.9700',
'5. volume': '4042900'},
'2003-01-31': {'1. open': '89.1900',
'2. high': '93.7700',
'3. low': '84.3400',
'4. close': '86.1700',
'5. volume': '18096000'},
'2002-12-31': {'1. open': '95.4700',
'2. high': '96.0100',
'3. low': '87.0900',
```



```
'4. close': '88.3500',  
'5. volume': '17106000'},  
'2002-11-29': {'1. open': '88.1000',  
'2. high': '94.7200',  
'3. low': '87.5900',  
'4. close': '93.7800',  
'5. volume': '11185200'},  
'2002-10-31': {'1. open': '82.3000',  
'2. high': '91.3300',  
'3. low': '77.0500',  
'4. close': '88.7000',  
'5. volume': '8073100'},  
'2002-09-30': {'1. open': '90.3500',  
'2. high': '93.2200',  
'3. low': '80.1300',  
'4. close': '81.8900',  
'5. volume': '7050300'},  
'2002-08-30': {'1. open': '91.1000',  
'2. high': '96.9900',  
'3. low': '83.6000',  
'4. close': '91.7600',  
'5. volume': '4778800'},  
'2002-07-31': {'1. open': '99.1700',  
'2. high': '99.5500',  
'3. low': '77.7700',  
'4. close': '91.3300',  
'5. volume': '11207600'},  
'2002-06-28': {'1. open': '107.1000',  
'2. high': '107.6000',  
'3. low': '95.2400',  
'4. close': '99.0200',  
'5. volume': '4460400'},  
'2002-05-31': {'1. open': '108.0000',  
'2. high': '111.2000',  
'3. low': '104.9000',  
'4. close': '107.1000',  
'5. volume': '7202600'},  
'2002-04-30': {'1. open': '115.0000',  
'2. high': '115.0000',  
'3. low': '106.7000',  
'4. close': '108.0000',  
'5. volume': '5141100'},  
'2002-03-28': {'1. open': '111.6000',  
'2. high': '117.8000',  
'3. low': '111.5000',  
'4. close': '114.5000',  
'5. volume': '4699100'},  
'2002-02-28': {'1. open': '113.3000',  
'2. high': '113.3000',  
'3. low': '107.8000',  
'4. close': '111.0000',  
'5. volume': '3872500'},  
'2002-01-31': {'1. open': '115.0000',  
'2. high': '118.0000',  
'3. low': '108.5000',  
'4. close': '113.1000',  
'5. volume': '4699500'},  
'2001-12-31': {'1. open': '113.9000',  
'2. high': '117.9000',  
'3. low': '111.9000',  
'4. close': '114.3000',  
'5. volume': '5547500'},  
'2001-11-30': {'1. open': '106.6000',  
'2. high': '116.6000',  
'3. low': '105.9000',  
'4. close': '114.1000',
```

```
'5. volume': '3264200'},
'2001-10-31': {'1. open': '104.1000',
'2. high': '111.1000',
'3. low': '103.3000',
'4. close': '105.9000',
'5. volume': '4821600'},
'2001-09-28': {'1. open': '114.0000',
'2. high': '116.1000',
'3. low': '94.2500',
'4. close': '104.4000',
'5. volume': '5869700'},
'2001-08-31': {'1. open': '122.0000',
'2. high': '123.1000',
'3. low': '112.9000',
'4. close': '114.2000',
'5. volume': '2628400'},
'2001-07-31': {'1. open': '123.0000',
'2. high': '124.2000',
'3. low': '116.7000',
'4. close': '121.3000',
'5. volume': '8972700'},
'2001-06-29': {'1. open': '126.2000',
'2. high': '129.2000',
'3. low': '120.7000',
'4. close': '122.7000',
'5. volume': '8452500'},
'2001-05-31': {'1. open': '125.1000',
'2. high': '132.0000',
'3. low': '123.5000',
'4. close': '125.7000',
'5. volume': '11307200'},
'2001-04-30': {'1. open': '116.1000',
'2. high': '127.3000',
'3. low': '109.5000',
'4. close': '125.2000',
'5. volume': '11260300'},
'2001-03-30': {'1. open': '124.0000',
'2. high': '127.2000',
'3. low': '108.4000',
'4. close': '116.7000',
'5. volume': '9610200'},
'2001-02-28': {'1. open': '136.8000',
'2. high': '137.9000',
'3. low': '122.0000',
'4. close': '124.1000',
'5. volume': '2017900'},
'2001-01-31': {'1. open': '131.5000',
'2. high': '138.4000',
'3. low': '127.8000',
'4. close': '136.9000',
'5. volume': '2672900'},
'2000-12-29': {'1. open': '132.9000',
'2. high': '139.3000',
'3. low': '125.7000',
'4. close': '131.4000',
'5. volume': '2888400'},
'2000-11-30': {'1. open': '142.7000',
'2. high': '144.3000',
'3. low': '129.9000',
'4. close': '132.3000',
'5. volume': '3381700'},
'2000-10-31': {'1. open': '144.5000',
'2. high': '145.7000',
'3. low': '131.0000',
'4. close': '143.1000',
'5. volume': '2921000'},
```

```

'2000-09-29': {'1. open': '153.0000',
'2. high': '153.5000',
'3. low': '142.3000',
'4. close': '143.7000',
'5. volume': '2701500'},
'2000-08-31': {'1. open': '143.3000',
'2. high': '153.0000',
'3. low': '142.9000',
'4. close': '152.3000',
'5. volume': '5156700'},
'2000-07-31': {'1. open': '145.5000',
'2. high': '151.9000',
'3. low': '141.5000',
'4. close': '142.9000',
'5. volume': '8460400'},
'2000-06-30': {'1. open': '143.9000',
'2. high': '149.0000',
'3. low': '143.6000',
'4. close': '145.5000',
'5. volume': '3683300'}}

```

```
In [134... mts_sp500etf = dataIVV['Meta Data']['2. Symbol']
```

```
In [135... mts_sp500etf
```

```
Out[135]: 'IVV'
```

```
In [136... stock_nameIVV=[]
date_stampIVV=[]
close_priceIVV=[]

for x,y in dataIVV['Monthly Time Series'].items():
    stock_nameIVV.append(mts_sp500etf)
    date_stampIVV.append(datetime.strptime(x, '%Y-%m-%d'))
    close_priceIVV.append(float(y['4. close']))
```

```
In [137... dataIVV_pd = {"date_stamp": date_stampIVV,"ticker": stock_nameIVV, "close_price": close_
```

```
In [138... df_mtsIVV=pd.DataFrame(dataIVV_pd)
```

```
In [139... # remove rows from df_mtsIVV for data prior to earliest date in df_mtsV for chart vizual
# (so that both time series are same length)
```

```
df_mtsIVV.drop(df_mtsIVV.index[174:268],0,inplace=True)
```

C:\Users\Lisa Wagner\AppData\Local\Temp\ipykernel_29292\3245525353.py:4: FutureWarning:
In a future version of pandas all arguments of DataFrame.drop except for the argument 'labels' will be keyword-only.

```
df_mtsIVV.drop(df_mtsIVV.index[174:268],0,inplace=True)
```

```
In [140... df_mtsIVV
```

```
Out[140]:
```

| | date_stamp | ticker | close_price |
|---|------------|--------|-------------|
| 0 | 2022-09-16 | IVV | 389.10 |
| 1 | 2022-08-31 | IVV | 397.18 |
| 2 | 2022-07-29 | IVV | 414.28 |
| 3 | 2022-06-30 | IVV | 379.15 |
| 4 | 2022-05-31 | IVV | 414.87 |

| | | | |
|------------|------------|-----|--------|
| ... | ... | ... | ... |
| 169 | 2008-08-29 | IVV | 128.94 |
| 170 | 2008-07-31 | IVV | 127.05 |
| 171 | 2008-06-30 | IVV | 128.00 |
| 172 | 2008-05-30 | IVV | 140.39 |
| 173 | 2008-04-30 | IVV | 138.61 |

174 rows × 3 columns

In [141... *# check dataframes have same columns*

```
df_mtsV.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 174 entries, 0 to 173
Data columns (total 3 columns):
#   Column          Non-Null Count  Dtype  
---  -
0   date_stamp      174 non-null   datetime64[ns]
1   ticker          174 non-null   object  
2   close_price     174 non-null   float64 
dtypes: datetime64[ns](1), float64(1), object(1)
memory usage: 4.2+ KB
```

In [142... df_mtsIVV.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 174 entries, 0 to 173
Data columns (total 3 columns):
#   Column          Non-Null Count  Dtype  
---  -
0   date_stamp      174 non-null   datetime64[ns]
1   ticker          174 non-null   object  
2   close_price     174 non-null   float64 
dtypes: datetime64[ns](1), float64(1), object(1)
memory usage: 4.2+ KB
```

In [143... *#merge data frame based on date so prices of each stock (including ticker symbol) are co*

```
pd.merge(df_mtsV,df_mtsIVV, on="date_stamp", how = "inner")
```

Out[143]:

| | date_stamp | ticker_x | close_price_x | ticker_y | close_price_y |
|------------|------------|----------|---------------|----------|---------------|
| 0 | 2022-09-16 | V | 193.30 | IVV | 389.10 |
| 1 | 2022-08-31 | V | 198.71 | IVV | 397.18 |
| 2 | 2022-07-29 | V | 212.11 | IVV | 414.28 |
| 3 | 2022-06-30 | V | 196.89 | IVV | 379.15 |
| 4 | 2022-05-31 | V | 212.17 | IVV | 414.87 |
| ... | ... | ... | ... | ... | ... |
| 169 | 2008-08-29 | V | 75.90 | IVV | 128.94 |
| 170 | 2008-07-31 | V | 73.06 | IVV | 127.05 |
| 171 | 2008-06-30 | V | 81.31 | IVV | 128.00 |
| 172 | 2008-05-30 | V | 86.36 | IVV | 140.39 |
| 173 | 2008-04-30 | V | 83.45 | IVV | 138.61 |

174 rows × 5 columns

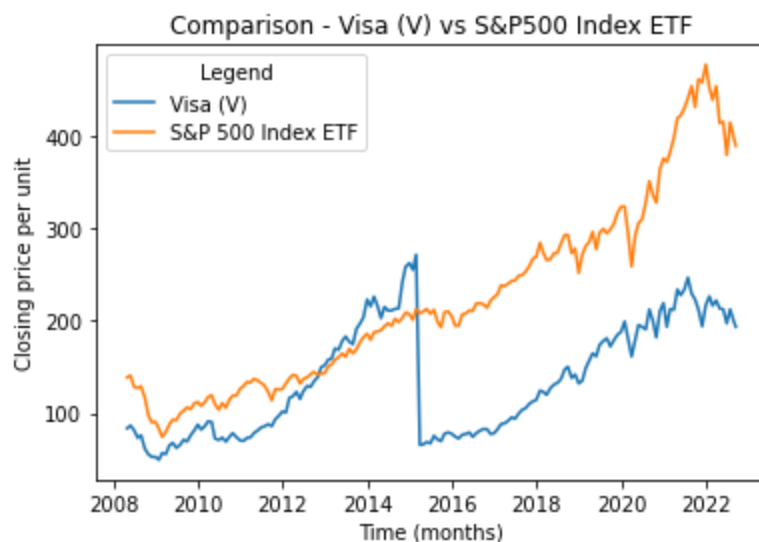
```
In [144... import matplotlib.pyplot as plt
import numpy as np
```

```
In [145... fig, ax = plt.subplots()

ax.plot(df_mtsV["date_stamp"],df_mtsV["close_price"], label = 'Visa (V)')
ax.plot(df_mtsIVV["date_stamp"],df_mtsIVV["close_price"], label = 'S&P 500 Index ETF')
ax.set_xlabel("Time (months)")
ax.set_ylabel("Closing price per unit")
ax.set_title("Comparison - Visa (V) vs S&P500 Index ETF")

ax.legend(title = 'Legend',loc = 'upper left')

plt.show()
```



```
In [146... # At first glance, the chart above appears to show Visa's price crashed around 2015. A
# a 4 for 1 Stock Split in March 2015. In order for the chart to show the relationship
# accurately, Visa stock prices will need to be restated to normalize the price across t
```

```
In [147... # Restate prices post stock split - extract post stock split prices, apply factor of 4,
# prices to form new df with prices restated. Inelegant and likely more code than needed
# that restated only those prices post the stock split date - but it works in the end!

# removing rows for dates pre-stock split

df_postss = df_mtsV.loc[~df_mtsV['date_stamp'].isin(pd.date_range(start='20080430', end=
```

```
In [148... df_postss
```

```
Out[148]:
```

| | date_stamp | ticker | close_price |
|-----|------------|--------|-------------|
| 0 | 2022-09-16 | V | 193.30 |
| 1 | 2022-08-31 | V | 198.71 |
| 2 | 2022-07-29 | V | 212.11 |
| 3 | 2022-06-30 | V | 196.89 |
| 4 | 2022-05-31 | V | 212.17 |
| ... | ... | ... | ... |

| | | | |
|-----------|------------|---|-------|
| 86 | 2015-07-31 | V | 75.34 |
| 87 | 2015-06-30 | V | 67.15 |
| 88 | 2015-05-29 | V | 68.68 |
| 89 | 2015-04-30 | V | 66.05 |
| 90 | 2015-03-31 | V | 65.41 |

91 rows × 3 columns

```
In [149... # restate stock prices post stock split based on 4:1 split factor

df_postss.loc[:, 'close_price'] *= 4
```

```
In [150... df_postss
```

```
Out[150]:
```

| | date_stamp | ticker | close_price |
|-----------|------------|--------|-------------|
| 0 | 2022-09-16 | V | 773.20 |
| 1 | 2022-08-31 | V | 794.84 |
| 2 | 2022-07-29 | V | 848.44 |
| 3 | 2022-06-30 | V | 787.56 |
| 4 | 2022-05-31 | V | 848.68 |
| ... | ... | ... | ... |
| 86 | 2015-07-31 | V | 301.36 |
| 87 | 2015-06-30 | V | 268.60 |
| 88 | 2015-05-29 | V | 274.72 |
| 89 | 2015-04-30 | V | 264.20 |
| 90 | 2015-03-31 | V | 261.64 |

91 rows × 3 columns

```
In [151... # extract stock prices pre-stock split (remain unchanged)

df_press=df_mtsV[~df_mtsV['date_stamp'].isin(pd.date_range(start='20150331', end='202209
```

```
In [152... df_press
```

```
Out[152]:
```

| | date_stamp | ticker | close_price |
|------------|------------|--------|-------------|
| 91 | 2015-02-27 | V | 271.31 |
| 92 | 2015-01-30 | V | 254.91 |
| 93 | 2014-12-31 | V | 262.20 |
| 94 | 2014-11-28 | V | 258.19 |
| 95 | 2014-10-31 | V | 241.43 |
| ... | ... | ... | ... |
| 169 | 2008-08-29 | V | 75.90 |
| 170 | 2008-07-31 | V | 73.06 |

| | | | |
|-----|------------|---|-------|
| 171 | 2008-06-30 | V | 81.31 |
| 172 | 2008-05-30 | V | 86.36 |
| 173 | 2008-04-30 | V | 83.45 |

83 rows × 3 columns

```
In [153... # merge restated stock prices with pre-stock split (unchanged) prices

frames = [df_postss, df_press]

df_mtsV_rs = pd.concat(frames)
display(df_mtsV_rs)
```

| | date_stamp | ticker | close_price |
|-----|------------|--------|-------------|
| 0 | 2022-09-16 | V | 773.20 |
| 1 | 2022-08-31 | V | 794.84 |
| 2 | 2022-07-29 | V | 848.44 |
| 3 | 2022-06-30 | V | 787.56 |
| 4 | 2022-05-31 | V | 848.68 |
| ... | ... | ... | ... |
| 169 | 2008-08-29 | V | 75.90 |
| 170 | 2008-07-31 | V | 73.06 |
| 171 | 2008-06-30 | V | 81.31 |
| 172 | 2008-05-30 | V | 86.36 |
| 173 | 2008-04-30 | V | 83.45 |

174 rows × 3 columns

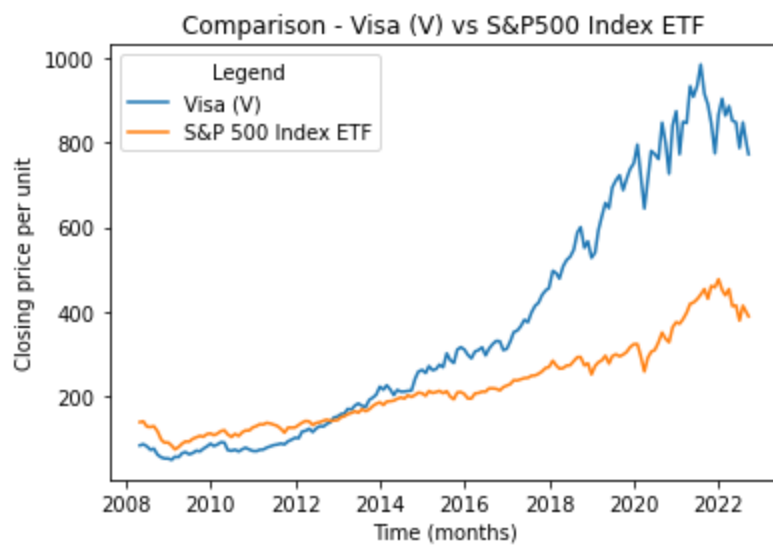
```
In [154... # Rerun chart comparing V and S&P500 Index with V prices restated post March 2015 stock

fig, ax = plt.subplots()

ax.plot(df_mtsV_rs["date_stamp"],df_mtsV_rs["close_price"], label = 'Visa (V)')
ax.plot(df_mtsIVV["date_stamp"],df_mtsIVV["close_price"], label = 'S&P 500 Index ETF')
ax.set_xlabel("Time (months)")
ax.set_ylabel("Closing price per unit")
ax.set_title("Comparison - Visa (V) vs S&P500 Index ETF")

ax.legend(title = 'Legend',loc = 'upper left')

plt.show()
```



```
In [155... # Restated chart shows Visa's performance was aligned with the S&P500 Index until 2013 w
# Visa's stock price has grown faster since 2013, but also has followed the general peak
# This shows that Visa has been a generally better performing stock than most stocks in
# to the same factors which cause price declines in the general market
```

Tweets - Regex to extract pattern in data

```
In [156... # Import dataset from Kaggle.com (https://www.kaggle.com/datasets/mmmarchetti/tweets-dat

import re

df = pd.read_csv('tweets.csv')
```

```
In [157... df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 52542 entries, 0 to 52541
Data columns (total 10 columns):
 #   Column                Non-Null Count  Dtype
---  -
 0   author                52542 non-null  object
 1   content               52542 non-null  object
 2   country               36 non-null     object
 3   date_time             52542 non-null  object
 4   id                    52542 non-null  float64
 5   language              52542 non-null  object
 6   latitude              1 non-null      float64
 7   longitude             1 non-null      float64
 8   number_of_likes       52542 non-null  int64
 9   number_of_shares      52542 non-null  int64
dtypes: float64(3), int64(2), object(5)
memory usage: 4.0+ MB
```

```
In [158... # Find all instances of "learning" in the "contents" column, irrespective of upper/lower

results = df['content'].str.contains(r'learning', flags=re.IGNORECASE, regex=True, na=Fa

print(df[results])
```

| | author | content |
|-------|-----------|---|
| 942 | katyperry | SHAME on schools that allow students to have t... |
| 1559 | katyperry | YO! Impress all ur homies & stay straight ... |
| 11347 | rihanna | Learning how to be selfish... |
| 13273 | YouTube | Learning begins with listening. \r\n\r\nFirst-... |
| 13955 | YouTube | Learning about black holes while blindfolded w... |

| | | |
|-------|--------------|---|
| 16747 | ladygaga | Learning lines, writing songs, rolling around ... |
| 21940 | Twitter | We've acquired Magic Pony Technology to enhanc... |
| 22209 | Twitter | @avneeshk91 Keep learning and growing, Avneesh... |
| 22555 | Twitter | Yesterday we opened the @NeighborNest, our loc... |
| 23086 | Twitter | That's great! "@melissacrn: @twitter #ladies... |
| 23476 | Twitter | Had the pleasure of learning what Bollywood th... |
| 32410 | Cristiano | You asked: Hi Cristiano! You are my idol and i... |
| 34038 | Cristiano | You and @Ochocinco both. @shrue I just starte... |
| 36662 | selenagomez | Loving, learning and growing with @Rock_Mafia ... |
| 43897 | ArianaGrande | learning/feeling so many new things at the mom... |
| 44903 | ArianaGrande | need to clean up this mouth of mine & set ... |
| 45391 | shakira | Join me in creating a #LearningGeneration to p... |
| 45989 | shakira | RT @HispanicEd's Commissioner @Shakira on Earl... |
| 46002 | shakira | Agree! RT @arneduncan .@FeimM Please challenge... |
| 46011 | shakira | .@stumpteacher babies have an innate thirst fo... |
| 46103 | shakira | Learning to read with mommy / Aprendiendo a l... |
| 46303 | shakira | +400 children now have access to quality early... |
| 46569 | shakira | ¿Dónde debemos invertir el primer dólar para c... |
| 46570 | shakira | Where should we invest the first dollar to get... |
| 46581 | shakira | Millions of kids cannot reach the first step o... |
| 46955 | shakira | Important conversations in Miami today on the ... |
| 46957 | shakira | Participation in quality early learning prog. ... |
| 48548 | instagram | Bicycling from Mexico to Argentina, learning t... |
| 49569 | instagram | Learning to embrace yourself with @euvulcanica... |
| 51762 | ddlovato | I'm learning so much every day by this new cha... |

| | country | date_time | id | language | latitude | longitude | \ |
|-------|---------|------------------|--------------|----------|----------|-----------|---|
| 942 | NaN | 15/07/2015 00:39 | 6.211170e+17 | en | NaN | NaN | |
| 1559 | NaN | 24/07/2014 14:07 | 4.923100e+17 | en | NaN | NaN | |
| 11347 | NaN | 22/08/2013 18:51 | 3.706190e+17 | en | NaN | NaN | |
| 13273 | NaN | 21/11/2016 20:30 | 8.007980e+17 | en | NaN | NaN | |
| 13955 | NaN | 27/08/2016 19:00 | 7.696100e+17 | en | NaN | NaN | |
| 16747 | NaN | 20/09/2015 00:56 | 6.454010e+17 | en | NaN | NaN | |
| 21940 | NaN | 20/06/2016 13:00 | 7.448780e+17 | en | NaN | NaN | |
| 22209 | NaN | 21/03/2016 17:21 | 7.119660e+17 | en | NaN | NaN | |
| 22555 | NaN | 21/05/2015 23:35 | 6.015320e+17 | en | NaN | NaN | |
| 23086 | NaN | 18/07/2011 19:28 | 9.303940e+16 | en | NaN | NaN | |
| 23476 | NaN | 02/03/2010 03:06 | 9.856313e+09 | en | NaN | NaN | |
| 32410 | NaN | 29/08/2014 15:45 | 5.053810e+17 | en | NaN | NaN | |
| 34038 | NaN | 10/12/2010 17:43 | 1.328760e+16 | en | NaN | NaN | |
| 36662 | NaN | 07/04/2011 00:58 | 5.579660e+16 | en | NaN | NaN | |
| 43897 | NaN | 03/11/2015 15:27 | 6.615650e+17 | en | NaN | NaN | |
| 44903 | NaN | 08/07/2015 22:12 | 6.189060e+17 | en | NaN | NaN | |
| 45391 | NaN | 18/09/2016 17:12 | 7.775560e+17 | en | NaN | NaN | |
| 45989 | NaN | 10/12/2014 15:43 | 5.427060e+17 | en | NaN | NaN | |
| 46002 | NaN | 10/12/2014 15:20 | 5.427000e+17 | en | NaN | NaN | |
| 46011 | NaN | 10/12/2014 15:13 | 5.426990e+17 | en | NaN | NaN | |
| 46103 | NaN | 24/09/2014 14:42 | 5.147870e+17 | en | NaN | NaN | |
| 46303 | NaN | 15/05/2014 08:33 | 4.668590e+17 | en | NaN | NaN | |
| 46569 | NaN | 20/03/2014 14:15 | 4.466510e+17 | es | NaN | NaN | |
| 46570 | NaN | 20/03/2014 14:15 | 4.466510e+17 | en | NaN | NaN | |
| 46581 | NaN | 18/03/2014 15:35 | 4.459470e+17 | en | NaN | NaN | |
| 46955 | NaN | 18/09/2013 16:17 | 3.803650e+17 | en | NaN | NaN | |
| 46957 | NaN | 17/09/2013 13:31 | 3.799610e+17 | en | NaN | NaN | |
| 48548 | NaN | 22/08/2016 17:30 | 7.677760e+17 | en | NaN | NaN | |
| 49569 | NaN | 06/04/2016 21:29 | 7.178270e+17 | en | NaN | NaN | |
| 51762 | NaN | 04/09/2015 11:02 | 6.397550e+17 | en | NaN | NaN | |

| | number_of_likes | number_of_shares |
|-------|-----------------|------------------|
| 942 | 18708 | 9156 |
| 1559 | 8550 | 6304 |
| 11347 | 7493 | 15152 |
| 13273 | 994 | 175 |
| 13955 | 1401 | 208 |
| 16747 | 6303 | 3143 |
| 21940 | 1156 | 744 |

| | | |
|-------|-------|-------|
| 22209 | 108 | 36 |
| 22555 | 671 | 261 |
| 23086 | 54 | 59 |
| 23476 | 50 | 113 |
| 32410 | 1824 | 675 |
| 34038 | 60 | 80 |
| 36662 | 779 | 2254 |
| 43897 | 40840 | 22137 |
| 44903 | 79767 | 49582 |
| 45391 | 2481 | 602 |
| 45989 | 586 | 307 |
| 46002 | 344 | 170 |
| 46011 | 393 | 184 |
| 46103 | 5169 | 2831 |
| 46303 | 1294 | 477 |
| 46569 | 604 | 351 |
| 46570 | 615 | 312 |
| 46581 | 1155 | 700 |
| 46955 | 286 | 270 |
| 46957 | 316 | 416 |
| 48548 | 826 | 173 |
| 49569 | 981 | 196 |
| 51762 | 36204 | 28035 |

Wine Quality - Machine Learning

Wine Quality - Predict wine quality based on the chemical attributes (features) for each wine and test against quality (target) assigned to the wine.

```
In [159... from sklearn.linear_model import LinearRegression, Ridge, Lasso
from sklearn.metrics import confusion_matrix
from sklearn.neighbors import KNeighborsClassifier
```

```
In [160... # data source = UCI Machine Learning Repository (https://archive.ics.uci.edu/ml/datasets
df_wine = pd.read_csv('winequality-white.csv')
```

```
In [161... # view what the data frame looks like - columns and beginning / ending data, confirm no
df_wine.head()
```

Out[161]:

| | fixed acidity | volatile acidity | citric acid | residual sugar | chlorides | free sulfur dioxide | total sulfur dioxide | density | pH | sulphates | alcohol | quality |
|----------|------------------|---------------------|----------------|-------------------|-----------|---------------------------|----------------------------|---------|------|-----------|---------|---------|
| 0 | 7.0 | 0.27 | 0.36 | 20.7 | 0.045 | 45.0 | 170.0 | 1.0010 | 3.00 | 0.45 | 8.8 | 6 |
| 1 | 6.3 | 0.30 | 0.34 | 1.6 | 0.049 | 14.0 | 132.0 | 0.9940 | 3.30 | 0.49 | 9.5 | 6 |
| 2 | 8.1 | 0.28 | 0.40 | 6.9 | 0.050 | 30.0 | 97.0 | 0.9951 | 3.26 | 0.44 | 10.1 | 6 |
| 3 | 7.2 | 0.23 | 0.32 | 8.5 | 0.058 | 47.0 | 186.0 | 0.9956 | 3.19 | 0.40 | 9.9 | 6 |
| 4 | 7.2 | 0.23 | 0.32 | 8.5 | 0.058 | 47.0 | 186.0 | 0.9956 | 3.19 | 0.40 | 9.9 | 6 |

```
In [162... df_wine.tail()
```

Out[162]:

| | fixed acidity | volatile acidity | citric acid | residual sugar | chlorides | free sulfur dioxide | total sulfur dioxide | density | pH | sulphates | alcohol | quality |
|-------------|------------------|---------------------|----------------|-------------------|-----------|---------------------------|----------------------------|---------|------|-----------|---------|---------|
| 4893 | 6.2 | 0.21 | 0.29 | 1.6 | 0.039 | 24.0 | 92.0 | 0.99114 | 3.27 | 0.50 | 11.2 | 6 |

| | | | | | | | | | | | | |
|-------------|-----|------|------|-----|-------|------|-------|---------|------|------|------|---|
| 4894 | 6.6 | 0.32 | 0.36 | 8.0 | 0.047 | 57.0 | 168.0 | 0.99490 | 3.15 | 0.46 | 9.6 | 5 |
| 4895 | 6.5 | 0.24 | 0.19 | 1.2 | 0.041 | 30.0 | 111.0 | 0.99254 | 2.99 | 0.46 | 9.4 | 6 |
| 4896 | 5.5 | 0.29 | 0.30 | 1.1 | 0.022 | 20.0 | 110.0 | 0.98869 | 3.34 | 0.38 | 12.8 | 7 |
| 4897 | 6.0 | 0.21 | 0.38 | 0.8 | 0.020 | 22.0 | 98.0 | 0.98941 | 3.26 | 0.32 | 11.8 | 6 |

In [163... `df_wine.info()`

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4898 entries, 0 to 4897
Data columns (total 12 columns):
#   Column                Non-Null Count  Dtype
---  -
0   fixed acidity          4898 non-null   float64
1   volatile acidity       4898 non-null   float64
2   citric acid            4898 non-null   float64
3   residual sugar         4898 non-null   float64
4   chlorides              4898 non-null   float64
5   free sulfur dioxide    4898 non-null   float64
6   total sulfur dioxide   4898 non-null   float64
7   density                4898 non-null   float64
8   pH                    4898 non-null   float64
9   sulphates             4898 non-null   float64
10  alcohol               4898 non-null   float64
11  quality               4898 non-null   int64
dtypes: float64(11), int64(1)
memory usage: 459.3 KB
```

In [164... `df_wine.describe()`

Out[164]:

| | fixed acidity | volatile acidity | citric acid | residual sugar | chlorides | free sulfur dioxide | total sulfur dioxide | density |
|--------------|--------------------------|-----------------------------|--------------------|---------------------------|------------------|--------------------------------|---------------------------------|----------------|
| count | 4898.000000 | 4898.000000 | 4898.000000 | 4898.000000 | 4898.000000 | 4898.000000 | 4898.000000 | 4898.000000 |
| mean | 6.854788 | 0.278241 | 0.334192 | 6.391415 | 0.045772 | 35.308085 | 138.360657 | 0.994027 |
| std | 0.843868 | 0.100795 | 0.121020 | 5.072058 | 0.021848 | 17.007137 | 42.498065 | 0.002991 |
| min | 3.800000 | 0.080000 | 0.000000 | 0.600000 | 0.009000 | 2.000000 | 9.000000 | 0.987110 |
| 25% | 6.300000 | 0.210000 | 0.270000 | 1.700000 | 0.036000 | 23.000000 | 108.000000 | 0.991723 |
| 50% | 6.800000 | 0.260000 | 0.320000 | 5.200000 | 0.043000 | 34.000000 | 134.000000 | 0.993740 |
| 75% | 7.300000 | 0.320000 | 0.390000 | 9.900000 | 0.050000 | 46.000000 | 167.000000 | 0.996100 |
| max | 14.200000 | 1.100000 | 1.660000 | 65.800000 | 0.346000 | 289.000000 | 440.000000 | 1.038980 |

In [165... `# count of all results in the target (quality)`

```
count = df_wine['quality'].value_counts(ascending=False)
countd = count.to_dict()
df_count = pd.DataFrame(list(countd.items()), columns = ['quality score', 'count'])
print(df_count)
```

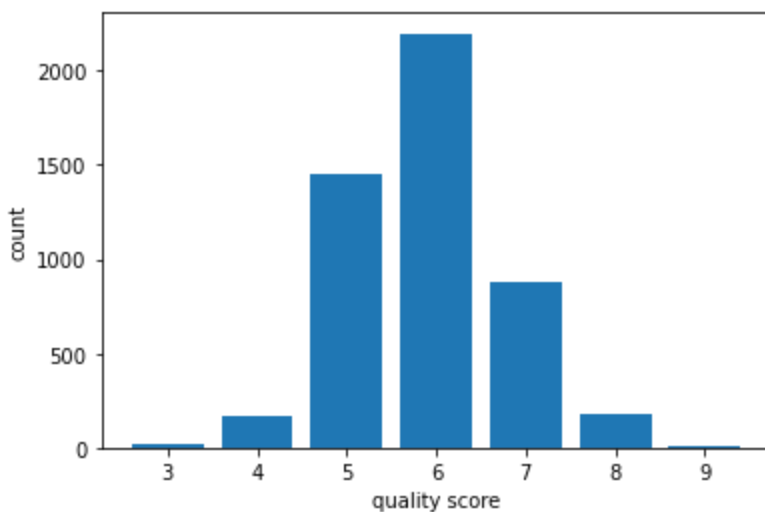
| | quality score | count |
|---|----------------------|--------------|
| 0 | 6 | 2198 |
| 1 | 5 | 1457 |
| 2 | 7 | 880 |
| 3 | 8 | 175 |
| 4 | 4 | 163 |
| 5 | 3 | 20 |
| 6 | 9 | 5 |

In [166... df_count.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7 entries, 0 to 6
Data columns (total 2 columns):
#   Column          Non-Null Count  Dtype
---  -
0   quality score    7 non-null      int64
1   count            7 non-null      int64
dtypes: int64(2)
memory usage: 240.0 bytes
```

In [167... *# show the count of quality variables - consider to split quality into two buckets being
lower (5 and below - 35%) and higher (6 and above - 65%)
the bar chart also implies outliers in both lower (quality = 3,4) and upper (8,9) rang*

```
plt.bar(df_count['quality score'], df_count['count'])
plt.xlabel("quality score")
plt.ylabel("count")
plt.show()
```



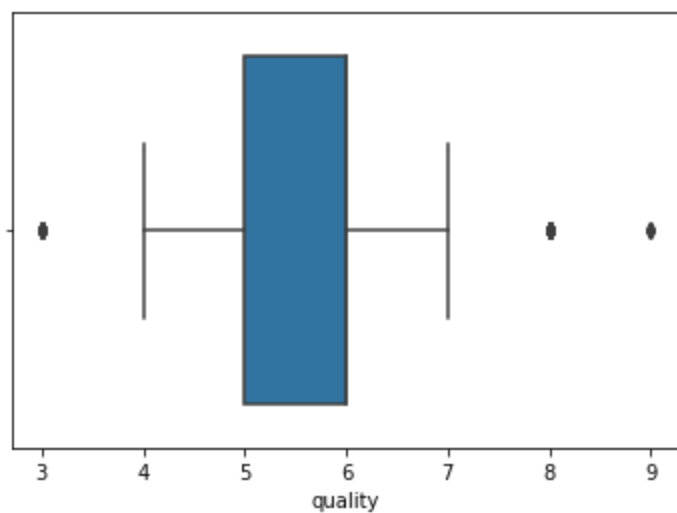
In [168... *# use Box Plot to identify outliers - quality values 3, 8 and 9 are acting as outliers,*

```
import seaborn as sns

sns.boxplot(df_wine['quality'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pas
s the following variable as a keyword arg: x. From version 0.12, the only valid position
al argument will be `data`, and passing other arguments without an explicit keyword will
result in an error or misinterpretation.
  warnings.warn(
```

Out[168]: <AxesSubplot: xlabel='quality'>



```
In [169... # import train_test_split as need to split the data into a training and a test set to ch
from sklearn.model_selection import train_test_split
```

```
In [170... # assign feature and target arrays for the model, check type is numpy
```

```
X = df_wine.drop("quality", axis=1).values
y = df_wine["quality"].values
names = df_wine.drop("quality", axis=1).columns
print(type(X), type(y))
```

```
<class 'numpy.ndarray'> <class 'numpy.ndarray'>
```

```
In [171... # check shape - y (target) can be 1 dimensional, but X (features) must be two dimensiona
```

```
print(y.shape, X.shape)
```

```
(4898,) (4898, 11)
```

```
In [172... # create the train and test data sets
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42
print(type(X_train), type(y_train))
```

```
<class 'numpy.ndarray'> <class 'numpy.ndarray'>
```

```
In [173... # Model #1 - Ridge Regression
# scores show this model is not a good fit for the data;
# score does not material change as the alpha is varied, implies tuning not likely to im
```

```
alphas = [0.1, 1.0, 10.0, 100.0, 1000.0, 10000.0]
ridge_scores = []
for alpha in alphas:
```

```
    # Create a Ridge regression model
    ridge = Ridge(alpha=alpha)
```

```
    # Fit the data
    ridge.fit(X_train, y_train)
```

```
    # Obtain R-squared
    score = ridge.score(X_test, y_test)
    ridge_scores.append(score)
print(ridge_scores)
```

```
[0.253882033094209, 0.2537816239676387, 0.25355183350458244, 0.23366235986958594, 0.2105
5971854463496, 0.1318418298130537]
```

```
In [174... # Model #2 - Lasso Regression
```

```
# scores show this model is also not a good fit for the data, also progressively worse as alpha increases

# Lasso Regression module

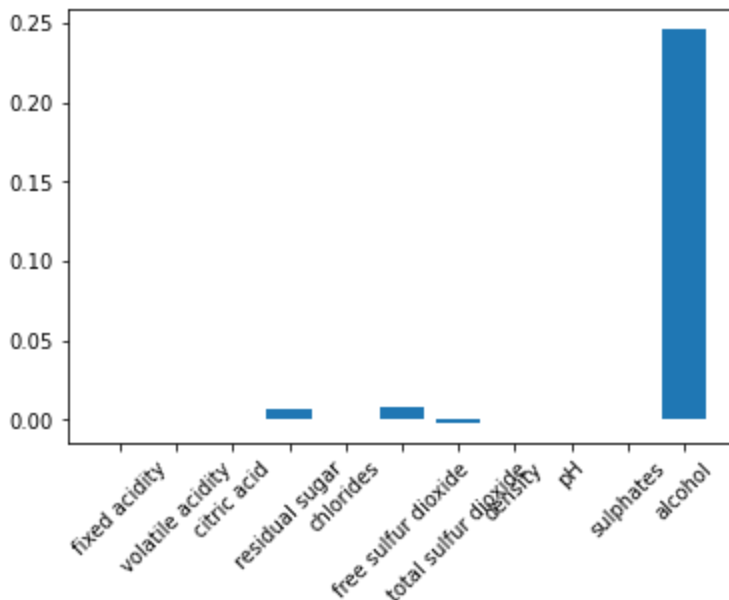
scores = []

for alpha in [0.01, 1.0, 10.0, 20.0, 50.0]:
    lasso = Lasso(alpha=alpha)
    lasso.fit(X_train, y_train)
    lasso_pred = lasso.predict(X_test)
    scores.append(lasso.score(X_test, y_test))
print(scores)

[0.24492793942460256, 0.04739580078497285, -0.0011619661806652193, -0.0011619661806652193, -0.0011619661806652193]
```

```
In [175]: # use Lasso to check which (if any) feature(s) have more of an impact in predicting high quality
# single best predictor of quality, none of the remaining features predict quality at a significant level

lasso = Lasso(alpha=0.1)
lasso_coef = lasso.fit(X, y).coef_
plt.bar(names, lasso_coef)
plt.xticks(rotation=45)
plt.show()
```



```
In [176]: # running a simple correlation on the data is another data focused method to present same data in a different way

df_wine.corr()
```

Out[176]:

| | fixed acidity | volatile acidity | citric acid | residual sugar | chlorides | free sulfur dioxide | total sulfur dioxide | density | pH | sulphates |
|----------------------|---------------|------------------|-------------|----------------|-----------|---------------------|----------------------|-----------|-----------|-----------|
| fixed acidity | 1.000000 | -0.022697 | 0.289181 | 0.089021 | 0.023086 | -0.049396 | 0.091070 | 0.265331 | -0.425858 | -0.017351 |
| volatile acidity | -0.022697 | 1.000000 | -0.149472 | 0.064286 | 0.070512 | -0.097012 | 0.089261 | 0.027114 | -0.031915 | -0.035206 |
| citric acid | 0.289181 | -0.149472 | 1.000000 | 0.094212 | 0.114364 | 0.094077 | 0.121131 | 0.149503 | -0.163748 | 0.062846 |
| residual sugar | 0.089021 | 0.064286 | 0.094212 | 1.000000 | 0.088685 | 0.299098 | 0.401439 | 0.838966 | -0.194133 | -0.026057 |
| chlorides | 0.023086 | 0.070512 | 0.114364 | 0.088685 | 1.000000 | 0.101392 | 0.198910 | 0.257211 | -0.090439 | 0.016975 |
| free sulfur dioxide | -0.049396 | -0.097012 | 0.094077 | 0.299098 | 0.101392 | 1.000000 | 0.247554 | 0.017749 | 0.091548 | -0.050814 |
| total sulfur dioxide | 0.091070 | 0.089261 | 0.121131 | 0.401439 | 0.198910 | 0.247554 | 1.000000 | 0.004694 | 0.111533 | -0.014350 |
| density | 0.265331 | 0.027114 | 0.149503 | 0.838966 | 0.257211 | 0.017749 | 0.004694 | 1.000000 | -0.118856 | -0.034304 |
| pH | -0.425858 | -0.031915 | -0.163748 | -0.194133 | -0.090439 | 0.091548 | 0.111533 | -0.118856 | 1.000000 | 0.015912 |
| sulphates | -0.017351 | -0.035206 | 0.062846 | -0.026057 | 0.016975 | -0.050814 | -0.014350 | -0.034304 | 0.015912 | 1.000000 |

| | | | | | | | | | | |
|-----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| free sulfur dioxide | -0.049396 | -0.097012 | 0.094077 | 0.299098 | 0.101392 | 1.000000 | 0.615501 | 0.294210 | -0.000618 | 0.0591 |
| total sulfur dioxide | 0.091070 | 0.089261 | 0.121131 | 0.401439 | 0.198910 | 0.615501 | 1.000000 | 0.529881 | 0.002321 | 0.1341 |
| density | 0.265331 | 0.027114 | 0.149503 | 0.838966 | 0.257211 | 0.294210 | 0.529881 | 1.000000 | -0.093591 | 0.0741 |
| pH | -0.425858 | -0.031915 | -0.163748 | -0.194133 | -0.090439 | -0.000618 | 0.002321 | -0.093591 | 1.000000 | 0.1551 |
| sulphates | -0.017143 | -0.035728 | 0.062331 | -0.026664 | 0.016763 | 0.059217 | 0.134562 | 0.074493 | 0.155951 | 1.0000 |
| alcohol | -0.120881 | 0.067718 | -0.075729 | -0.450631 | -0.360189 | -0.250104 | -0.448892 | -0.780138 | 0.121432 | -0.0171 |
| quality | -0.113663 | -0.194723 | -0.009209 | -0.097577 | -0.209934 | 0.008158 | -0.174737 | -0.307123 | 0.099427 | 0.0531 |

Initial review of model accuracy

Originally, I wondered if regression models might work better given the multiple values in the target column, but ultimately this is really a classification problem.

Out of curiosity, I ran the regression models first to see their accuracy (or lack thereof), result being the regression models were not accurate.

From that (and presented below), applied KNN Classifier model, optimized the neighbors value and compared results of further fine-tuning to:

1. Remove Outliers
2. Simplify target values from original options of 3 - 9 to 1 or 0:
 - a. Good (6 and above)
 - b. Not Good (5 and below)

Results were:

- a - KNN on original data with a randomly selected neighbors value of 6 = 44.9% (not great)
- b - KNN on original data with optimized neighbors of 25 = 47.6% (marginally improved)
- c - KNN on simplified data with optimized neighbors of 25 = 70.4% (significantly improved but still not accurate enough)
- d - KNN on original data with optimized neighbors of 25 and outliers removed = 47.3% (worse in absolute %, but statistically same as version b)
- e - KNN on simplified data with optimized neighbors of 25 and outliers removed = 70.4% (outliers removed from simplified data had no impact on accuracy)

```
In [177... # APPLY KNN CLASSIFIER MODEL

# Model #3 (original) - run Classifier Model before removing outliers and changing target
# in order to see impact of optimization and fine-tuning

# Create a KNN classifier with 6 neighbors
knn = KNeighborsClassifier(n_neighbors=6)
```

```
In [178... # Fit the classifier to the data, predict the labels for X and print

knn.fit(X, y)
y_pred = knn.predict(X)
print("Predictions: {}".format(y_pred))

Predictions: [6 5 6 ... 6 6 6]
```

```
In [179... # Fit the classifier to the training data and print accuracy
# Accuracy is not great at 46%
```

```
knn.fit(X_train,y_train)
print(knn.score(X_test, y_test))
```

0.4489795918367347

In [180... *# Check Model complexity and find optimal knn neighbor value*

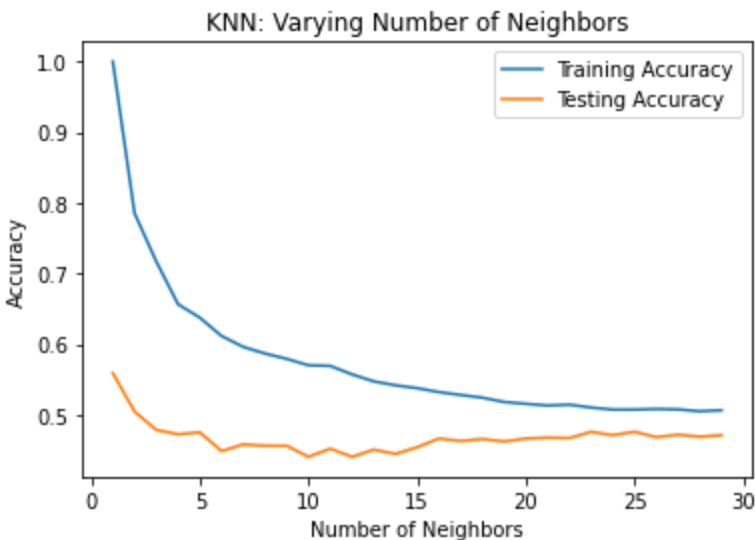
```
neighbors = np.arange(1, 30)
train_accuracies = {}
test_accuracies = {}

for neighbor in neighbors:
    knn = KNeighborsClassifier(n_neighbors=neighbor)
    knn.fit(X_train, y_train)
    train_accuracies[neighbor] = knn.score(X_train, y_train)
    test_accuracies[neighbor] = knn.score(X_test, y_test)
print(neighbors, '\n', train_accuracies, '\n', test_accuracies)
```

```
[ 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
 25 26 27 28 29]
{1: 1.0, 2: 0.7852975495915986, 3: 0.7170361726954493, 4: 0.6566511085180864, 5: 0.6376
896149358227, 6: 0.6117269544924154, 7: 0.5962660443407235, 8: 0.5869311551925321, 9: 0.
5793465577596266, 10: 0.5703033838973163, 11: 0.5694282380396732, 12: 0.557467911318553
1, 13: 0.5475495915985997, 14: 0.5420070011668612, 15: 0.5379229871645275, 16: 0.5323803
967327888, 17: 0.5282963827304551, 18: 0.5245040840140023, 19: 0.5183780630105017, 20:
0.5157526254375729, 21: 0.5134189031505251, 22: 0.514585764294049, 23: 0.510501750291715
3, 24: 0.5075845974329055, 25: 0.5075845974329055, 26: 0.5084597432905484, 27: 0.5078763
127187864, 28: 0.5052508751458576, 29: 0.5067094515752626}
{1: 0.5591836734693878, 2: 0.5047619047619047, 3: 0.47891156462585033, 4: 0.47278911564
625853, 5: 0.47551020408163264, 6: 0.4489795918367347, 7: 0.45850340136054424, 8: 0.4564
625850340136, 9: 0.4564625850340136, 10: 0.44081632653061226, 11: 0.4523809523809524, 1
2: 0.44081632653061226, 13: 0.45102040816326533, 14: 0.4448979591836735, 15: 0.454421768
707483, 16: 0.46666666666666667, 17: 0.463265306122449, 18: 0.46598639455782315, 19: 0.46
258503401360546, 20: 0.46666666666666667, 21: 0.46802721088435373, 22: 0.467346938775510
2, 23: 0.47619047619047616, 24: 0.4714285714285714, 25: 0.47619047619047616, 26: 0.46870
748299319726, 27: 0.47210884353741495, 28: 0.46938775510204084, 29: 0.4714285714285714}
```

In [181... *# plot the results on a chart to visualize where optimal # of neighbors is - appears aro*

```
plt.title("KNN: Varying Number of Neighbors")
plt.plot(neighbors, train_accuracies.values(), label="Training Accuracy")
plt.plot(neighbors, test_accuracies.values(), label="Testing Accuracy")
plt.legend()
plt.xlabel("Number of Neighbors")
plt.ylabel("Accuracy")
plt.show()
```




```
In [182... # Model #3 KNN (optimalN) - re run Classifier Model using optimal neighbors value of 25
```

```
knn = KNeighborsClassifier(n_neighbors=25)
```

```
In [183... knn.fit(X, y)
y_pred = knn.predict(X)
print("Predictions: {}".format(y_pred))
```

```
Predictions: [6 5 6 ... 6 6 6]
```

```
In [184... # rerunning the model improves marginally to 47.6% from 44.9%
```

```
knn.fit(X_train,y_train)
print(knn.score(X_test, y_test))
```

```
0.47619047619047616
```

```
In [185... # Rerun Model #3 KNN (simplify) - Simplify the target values to reflect:
#      1.  <6 as 0 (being Not Good); and
#      2.  >5 as 1 (being Good)
```

```
df_wine2 = df_wine.replace({'quality':{3:0, 4:0, 5:0, 6:1, 7:1, 8:1, 9:1}})
df_wine2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 4898 entries, 0 to 4897
```

```
Data columns (total 12 columns):
```

| # | Column | Non-Null Count | Dtype |
|----|----------------------|----------------|---------|
| 0 | fixed acidity | 4898 non-null | float64 |
| 1 | volatile acidity | 4898 non-null | float64 |
| 2 | citric acid | 4898 non-null | float64 |
| 3 | residual sugar | 4898 non-null | float64 |
| 4 | chlorides | 4898 non-null | float64 |
| 5 | free sulfur dioxide | 4898 non-null | float64 |
| 6 | total sulfur dioxide | 4898 non-null | float64 |
| 7 | density | 4898 non-null | float64 |
| 8 | pH | 4898 non-null | float64 |
| 9 | sulphates | 4898 non-null | float64 |
| 10 | alcohol | 4898 non-null | float64 |
| 11 | quality | 4898 non-null | int64 |

```
dtypes: float64(11), int64(1)
```

```
memory usage: 459.3 KB
```

```
In [186... # Check that all target values are either 1 or 0 - confirmed
```

```
count2 = df_wine2['quality'].value_counts(ascending=False)
countd2 = count2.to_dict()
df_count2 = pd.DataFrame(list(countd2.items()),columns = ['quality score','count'])
print(df_count2)
```

| | quality score | count |
|---|---------------|-------|
| 0 | 1 | 3258 |
| 1 | 0 | 1640 |

```
In [187... #RERUN MODEL #3 AFTER TARGET VALUES CHANGED TO 1/0
```

```
# Revise feature and target arrays for the model, check type is numpy
```

```
X2 = df_wine2.drop("quality", axis=1).values
y2 = df_wine2["quality"].values
names = df_wine2.drop("quality", axis=1).columns
print(type(X2), type(y2))
```

```
<class 'numpy.ndarray'> <class 'numpy.ndarray'>
```

```
# Revise the train and test data sets
```

```
In [188... X2_train, X2_test, y2_train, y2_test = train_test_split(X2, y2, test_size=0.3, random_st
print(type(X2_train), type(y2_train))
```

```
<class 'numpy.ndarray'> <class 'numpy.ndarray'>
```

```
In [189... # Fit the classifier to the new data, predict the labels and print
```

```
knn.fit(X2, y2)
y2_pred = knn.predict(X2)
print("Predictions: {}".format(y2_pred))
```

```
Predictions: [1 0 1 ... 1 1 1]
```

```
In [190... # Fit the classifier to the revised training data
# Print the accuracy of the model after the target values are simplified
# Accuracy has improved, but it is still not high enough (would expect 90% or higher)
```

```
#Score for Model #3 KNN (simplify) (simplified with optimal neighbors of 25) is 70.4%
```

```
knn.fit(X2_train,y2_train)
print(knn.score(X2_test, y2_test))
```

```
0.7040816326530612
```

```
In [191... # RERUN MODEL #3 KNN(ex-outliers) REVISED FOR OUTLIERS
# Identify and drop outliers using IQR method (interquartile range), then revise all ste
```

```
df_wine3 = df_wine
```

```
# IQR
```

```
Q1 = np.percentile(df_wine3['quality'], 25,
                    interpolation = 'midpoint')
```

```
Q3 = np.percentile(df_wine3['quality'], 75,
                    interpolation = 'midpoint')
```

```
IQR = Q3 - Q1
```

```
print("Old Shape: ", df_wine.shape)
```

```
# Upper bound
```

```
upper = np.where(df_wine3['quality'] >= (Q3+1.5*IQR))
```

```
# Lower bound
```

```
lower = np.where(df_wine3['quality'] <= (Q1-1.5*IQR))
```

```
''' Removing the Outliers '''
```

```
df_wine3.drop(upper[0], inplace = True)
```

```
df_wine3.drop(lower[0], inplace = True)
```

```
print("New Shape: ", df_wine3.shape)
```

```
Old Shape: (4898, 12)
```

```
New Shape: (4698, 12)
```

```
In [192... df_wine3.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
Int64Index: 4698 entries, 0 to 4897
```

```
Data columns (total 12 columns):
```

| # | Column | Non-Null Count | Dtype |
|---|------------------|----------------|---------|
| 0 | fixed acidity | 4698 non-null | float64 |
| 1 | volatile acidity | 4698 non-null | float64 |
| 2 | citric acid | 4698 non-null | float64 |
| 3 | residual sugar | 4698 non-null | float64 |
| 4 | chlorides | 4698 non-null | float64 |

```

5   free sulfur dioxide      4698 non-null    float64
6   total sulfur dioxide     4698 non-null    float64
7   density                  4698 non-null    float64
8   pH                       4698 non-null    float64
9   sulphates                4698 non-null    float64
10  alcohol                  4698 non-null    float64
11  quality                  4698 non-null    int64
dtypes: float64(11), int64(1)
memory usage: 477.1 KB

```

```

In [193... X3 = df_wine3.drop("quality", axis=1).values
y3 = df_wine3["quality"].values
names = df_wine3.drop("quality", axis=1).columns
print(type(X3), type(y3))
print(y3.shape, X3.shape)

<class 'numpy.ndarray'> <class 'numpy.ndarray'>
(4698,) (4698, 11)

```

```

In [194... X3_train, X3_test, y3_train, y3_test = train_test_split(X3, y3, test_size=0.3, random_st
print(type(X3_train), type(y3_train))

<class 'numpy.ndarray'> <class 'numpy.ndarray'>

```

```

In [195... # ACCURACY OF MODEL #3 AFTER OUTLIERS DROPPED - DECREASES FROM 47.6% TO 47.3% WHEN USING

#Score for Model #3 KNN(ex-outliers) (not simplified, outliers removed, optimal neighbor

knn = KNeighborsClassifier(n_neighbors=25)
knn.fit(X3, y3)
y3_pred = knn.predict(X3)
print("Predictions: {}".format(y3_pred))
knn.fit(X3_train,y3_train)
print(knn.score(X3_test, y3_test))

Predictions: [6 5 6 ... 6 6 6]
0.47304964539007094

```

```

In [196... # MODEL #3 KNN(simplified + ex-outliers) REVISED FURTHER FOR:
# Drop outliers and then transform target values to 1/0 - revise all steps
# this version is not expected to change the overall accuracy as what was previously con
# and the volume of outliers are 200 ~ 4% of the original dataset

df_wine4 = df_wine

# IQR
Q1 = np.percentile(df_wine4['quality'], 25,
                    interpolation = 'midpoint')

Q3 = np.percentile(df_wine4['quality'], 75,
                    interpolation = 'midpoint')
IQR = Q3 - Q1

print("Old Shape: ", df_wine.shape)

# Upper bound
upper = np.where(df_wine4['quality'] >= (Q3+1.5*IQR))
# Lower bound
lower = np.where(df_wine4['quality'] <= (Q1-1.5*IQR))

''' Removing the Outliers '''
df_wine4.drop(upper[0], inplace = True)
df_wine4.drop(lower[0], inplace = True)

print("New Shape: ", df_wine4.shape)

Old Shape:  (4698, 12)

```

New Shape: (4698, 12)

```
In [197... df_wine4 = df_wine4.replace({'quality':{3:0, 4:0, 5:0, 6:1, 7:1, 8:1, 9:1}})
df_wine4.info()
count4 = df_wine4['quality'].value_counts(ascending=False)
countd4 = count4.to_dict()
df_count4 = pd.DataFrame(list(countd4.items()), columns = ['quality score', 'count'])
print(df_count4)
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4698 entries, 0 to 4897
Data columns (total 12 columns):
#   Column                Non-Null Count  Dtype
---  -
0   fixed acidity          4698 non-null   float64
1   volatile acidity       4698 non-null   float64
2   citric acid            4698 non-null   float64
3   residual sugar         4698 non-null   float64
4   chlorides              4698 non-null   float64
5   free sulfur dioxide    4698 non-null   float64
6   total sulfur dioxide   4698 non-null   float64
7   density               4698 non-null   float64
8   pH                    4698 non-null   float64
9   sulphates             4698 non-null   float64
10  alcohol               4698 non-null   float64
11  quality               4698 non-null   int64
dtypes: float64(11), int64(1)
memory usage: 477.1 KB
   quality score  count
0              1   3078
1              0   1620
```

```
In [198... X4 = df_wine4.drop("quality", axis=1).values
y4 = df_wine4["quality"].values
names = df_wine4.drop("quality", axis=1).columns
print(type(X4), type(y4))
print(y4.shape, X4.shape)
```

```
<class 'numpy.ndarray'> <class 'numpy.ndarray'>
(4698,) (4698, 11)
```

```
In [199... X4_train, X4_test, y4_train, y4_test = train_test_split(X4, y4, test_size=0.3, random_st
print(type(X4_train), type(y4_train))
```

```
<class 'numpy.ndarray'> <class 'numpy.ndarray'>
```

```
In [200... # ACCURACY OF MODEL #3 AFTER TARGET SIMPLIFIED AND OUTLIERS DROPPED - NO CHANGE FROM Mod
# Removing outliers from the dataset once target values simplified had no effect on the mo

knn = KNeighborsClassifier(n_neighbors=25)
knn.fit(X2, y2)
y2_pred = knn.predict(X)
print("Predictions: {}".format(y2_pred))
knn.fit(X2_train, y2_train)
print(knn.score(X2_test, y2_test))
```

```
Predictions: [1 0 1 ... 1 1 1]
0.7040816326530612
```

THE END

```
In [ ]:
```