

What factors affect profits in Fortune 500 companies?

1 Introduction

In this project, the Fortune 500 dataset from 2017 ([available here](#)), created by Aurielle Perlmann, will be analysed to attempt to find factors that affect the profit of each company. Multiple variations of two regression models will try to predict profits. The Fortune 500 is a list of the largest companies in the United States ranked by their total revenue for the fiscal year (1). A company is considered successful or high quality if they are on the list. As such, these companies are expected to make good profits every year. The companies operate in a broad range of sectors, from retailing to finance and exhibit different characteristics based on their sector. Therefore, it would be helpful to determine whether there are factors that successful companies exhibit that correlate to high profits. The project can be broken down into the following subtasks:

1. Determining the most significant hyperparameters.
2. Identifying possible outliers and outliers in multiple categories and attempting to understand their effect on the model.
3. Determining if a simple regression model is more accurate than a more complicated one and why that might be.

Other attempts at predicting profits have shown that it is a complicated process (2). A high degree of accuracy is very difficult to obtain. However, even if the prediction is not highly accurate, there are still insights to be made from the model.

2 Methodology

2.1 Dataset

The dataset consists of 23 columns and 500 rows. Each row is a company and each column is a feature. There are no null values in the dataset and Table 1 describes the attributes, their types and what they show. Figure 1 shows how a row of the data looks; some of the columns are missing to allow the image to fit on the page.

Rank	Title	Employees	Sector	Industry	Hqcity	Hqstate	Revenues	Revchange	Profits	Prftchange	Assets	Totshequity	
0	1	Walmart	2300000	Retailing	General Merchandisers	Bentonville	AR	485873	0.8	13643.0	-7.2	198825	77798.0
1	2	Berkshire Hathaway	367700	Financials	Insurance: Property and Casualty (Stock)	Omaha	NE	223604	6.1	24074.0	0.0	620854	283001.0
2	3	Apple	116000	Technology	Computers, Office Equipment	Cupertino	CA	215639	-7.7	45687.0	-14.4	321686	128249.0
3	4	Exxon Mobil	72700	Energy	Petroleum Refining	Irving	TX	205004	-16.7	7840.0	-51.5	330314	167325.0
4	5	McKesson	68000	Wholesalers	Wholesalers: Health Care	San Francisco	CA	192487	6.2	2258.0	53.0	56563	8924.0
...

Figure 1: Visual of the dataset.

Table 1: Dataset's Attributes

ID	Column Name	Type	Details
1	Rank	Integer	The rank of the company.
2	Title	string	The name of the company.
3	Website	URL	The website of the company.
4	Employees	Integer	The number of people employed at the company
5	Sector	String	The segment of the economy the company belongs in.
6	Industry	String	A more specific group of businesses that the company belongs to.
7	Hqlocation	String	The city a comma then the state (abbreviated into two capital letters) the Headquarters is located at.
8	Hqaddr	String	The number and street address for the company's Headquarters.
9	Hqcity	String	The city the companies Headquarters is located in.
10	Hqstate	String	The state in which the company headquarters is located is abbreviated in two capital letters.
11	Hqzip	Integer	The five integer zip the company's headquarters is located at.
12	Hqtel	String	The telephone number of the company in the form XXX-XXX-XXXX where X are integers.
13	Ceo	String	The first and last name of the CEO of the company.
14	Ceo_title	String	The full title of the CEO.
15	Address	String	The full address of the company's Headquarters including their number/name, road name, state and zipcode.
16	Ticker	String	A string of between 1 and 5 letters that uniquely identifies the company.
17	Fullname	String	The full name of the company.
18	Revenues	Integer	The total amount of money the company received for their goods or service in million US dollars.
19	Revchange	Decimal	The percentage change as a decimal of the profit change between 2016 and 2017.
20	Profits	Decimal	The profit of the company in million US dollars.
21	Prftchange	Decimal	The percentage change in profits from 2016 to 2017.
22	Assets	Integer	The value of the assets the company possesses in million US dollars.
23	Totshequity	Decimal	The net worth of a company is calculated by liquidating then summing all the assets that the company possesses then repaying all the company's debts, in millions of US dollars.

2.2 Data Exploration

Data exploration and cleaning is performed in [Section 1](#) of the JuPyter Notebook. The table of contents has links to the section on [outliers](#) and [correlation](#), which will be discussed in this section.

Firstly, the data is imported from a csv file into a data frame using the method.

```
import pandas as pd
df = pd.read_csv('fortune500.csv')
```

The dataset is checked for any null values that could affect the models. This is done using the pandas method `df.info()`. There are no null values in the dataset. Next, basic statistical analysis is done using the pandas python method `df.describe()`. Figure 2 shows the results of this analysis.

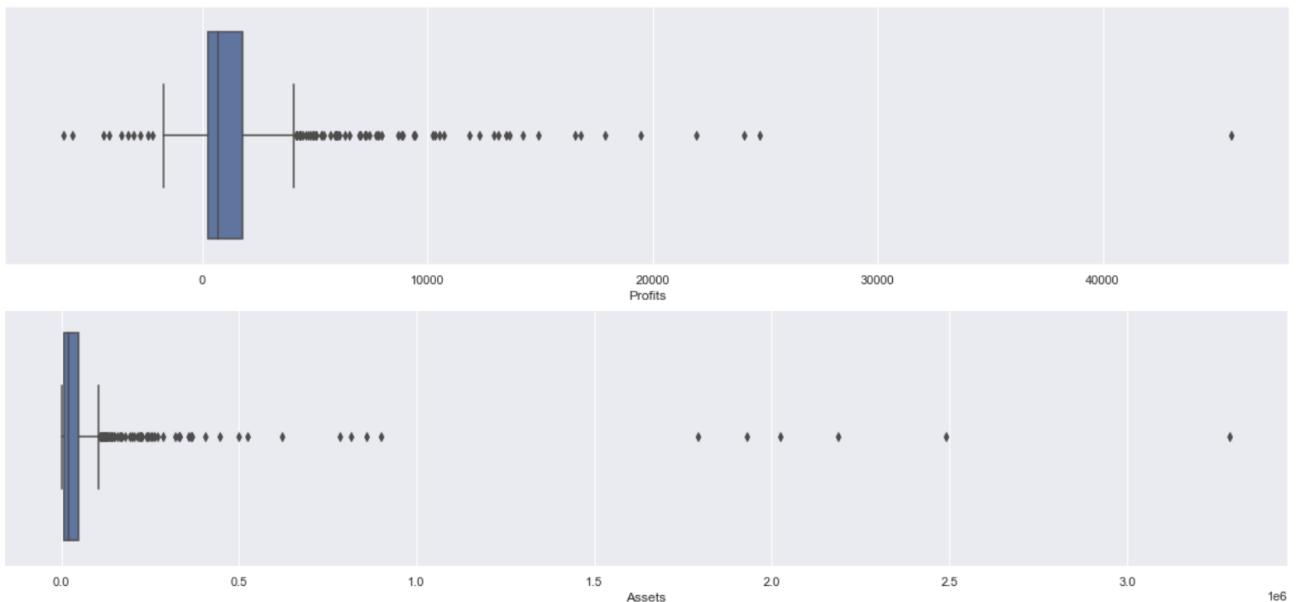
	Rank	Employees	Revenues	Revchange	Profits	Prftchange	Assets	Totshequity
count	500.000000	5.000000e+02	500.000000	500.00000	500.000000	494.000000	5.000000e+02	500.0000
mean	250.492000	5.635013e+04	24111.748000	3.75800	1779.479800	-1.309109	8.038934e+04	13640.1470
std	144.477366	1.234520e+05	38337.353337	19.96748	3937.558721	116.971196	2.704257e+05	30523.1538
min	1.000000	8.300000e+01	5145.000000	-57.50000	-6177.000000	-892.300000	4.370000e+02	-12688.0000
25%	125.750000	1.190000e+04	7245.000000	-3.82500	235.725000	-18.575000	8.436500e+03	1997.5000
50%	250.500000	2.500000e+04	11384.000000	1.90000	683.600000	2.350000	1.932450e+04	4981.0000
75%	375.250000	5.682525e+04	22605.250000	7.32500	1770.775000	20.200000	4.812600e+04	12467.7500
max	500.000000	2.300000e+06	485873.000000	197.30000	45687.000000	962.500000	3.287968e+06	283001.0000

Figure 2: Statistical analysis on dataset.

When comparing the max to the mean, there is a significant disparity between some values, suggesting there may be outliers. Outliers are defined by their z-score, a measure of how many standard deviations the value is outside the mean. This is calculated using the `scipy stats` module.

```
from scipy import stats
#Calculating the z score for profits.
z = np.abs(stats.zscore(df['Profits']))
print(z)
prof_out = np.where(z > 3.5)
print(prof_out)
```

For this project, anything more than 3.5 standard deviations away from the mean is classified as an outlier. Figure 3 uses box plots created using the `matplotlib` package to indicate the data's spread and visualise some possible outliers. It is important to identify outliers so that their effect on the data can be analysed, and if it is not useful, they can be removed. The z score of all the linear features for the companies is calculated, and the outliers are identified as a list of the company's index (or row beginning from zero) in the list. Companies with more than one outlying feature are considered strong outliers. A list of all outliers in each category was compiled and the indexes for companies that appeared more than once were found. There were ten companies that had outliers in multiple features. Their indexes were recorded for use later.



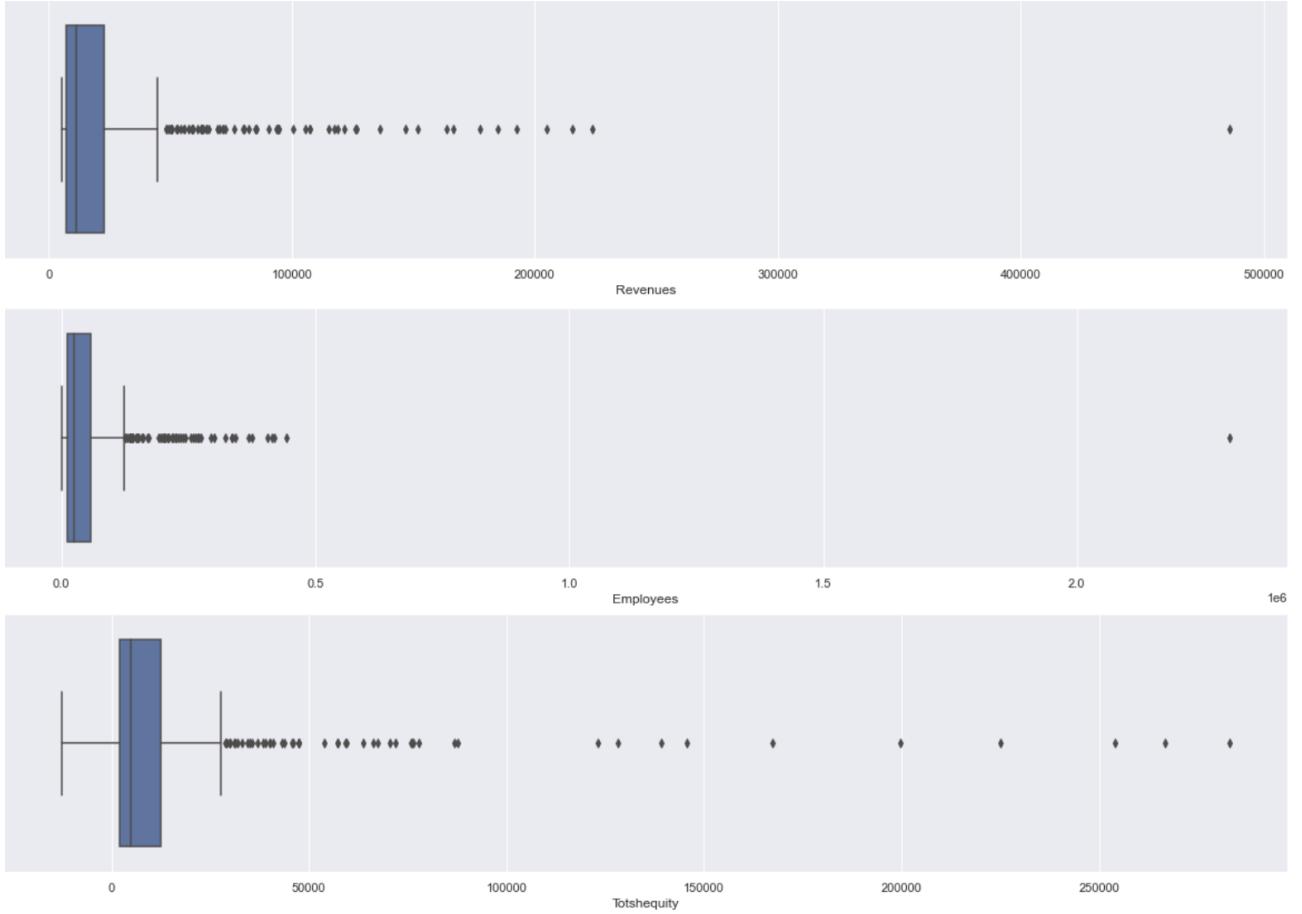


Figure 3: Box plots of the numeric features.

The following features were not needed for analysis and were removed to make the dataset smaller:

- Website
- Hqlocation
- Hqaddr
- Hqzip
- Hqtel
- Ceo
- Ceo-title
- Fullname
- Ticker
- Address

These features were not included in the analysis as it was difficult to make comparisons between them.

Next, graphs were created using the `matplotlib` and the `seaborn` package to identify relationships and correlations between the features. The full exploration is available in the JuPyter Notebook in the correlation section. A range of graphs, including Figures 4 and 5, show the clusters and variation between different factors. This analysis helps form the basis of good features to use in the models and possible ways to refine the model.

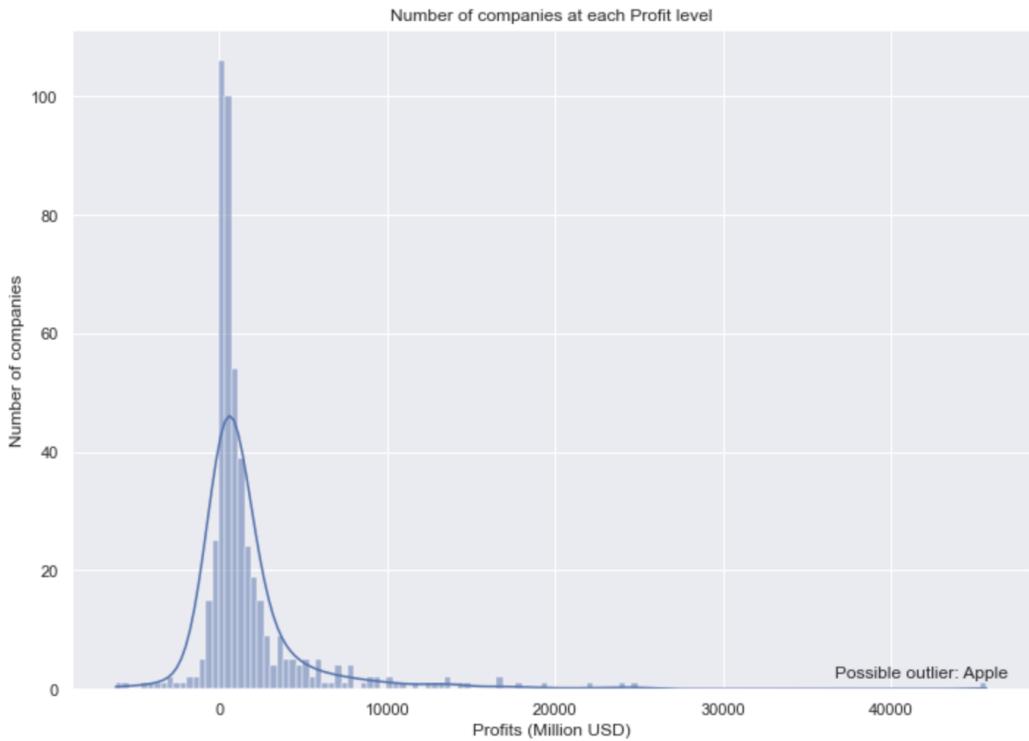


Figure 4: Histogram of the number of companies at each profit band. The largest band contains over 20% of the Fortune 500. This graph also shows that over 50 companies had negative profits.

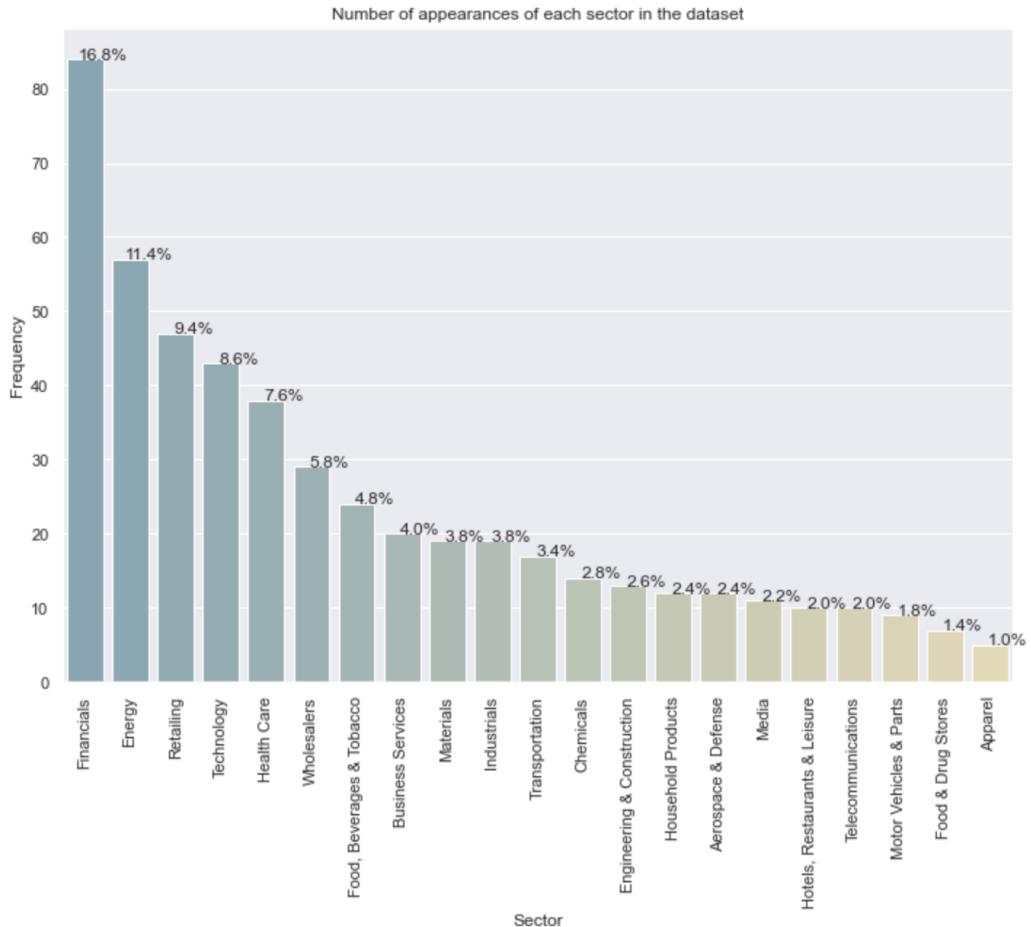


Figure 5: Countplot of companies in each sector with percentages. The most prevalent sectors are Financials (16.8%) and Energy (11.4%).

2.3 Feature Engineering

To maximise the success of a model the best features must be selected as hyperparameters. For regression models, features with a high correlation with the target are usually good hyperparameters. Correlations can be seen between the features using the seaborn `.pairplot()` method, shown in Figure 6, creates scatter plots of all the numerical features against each other.

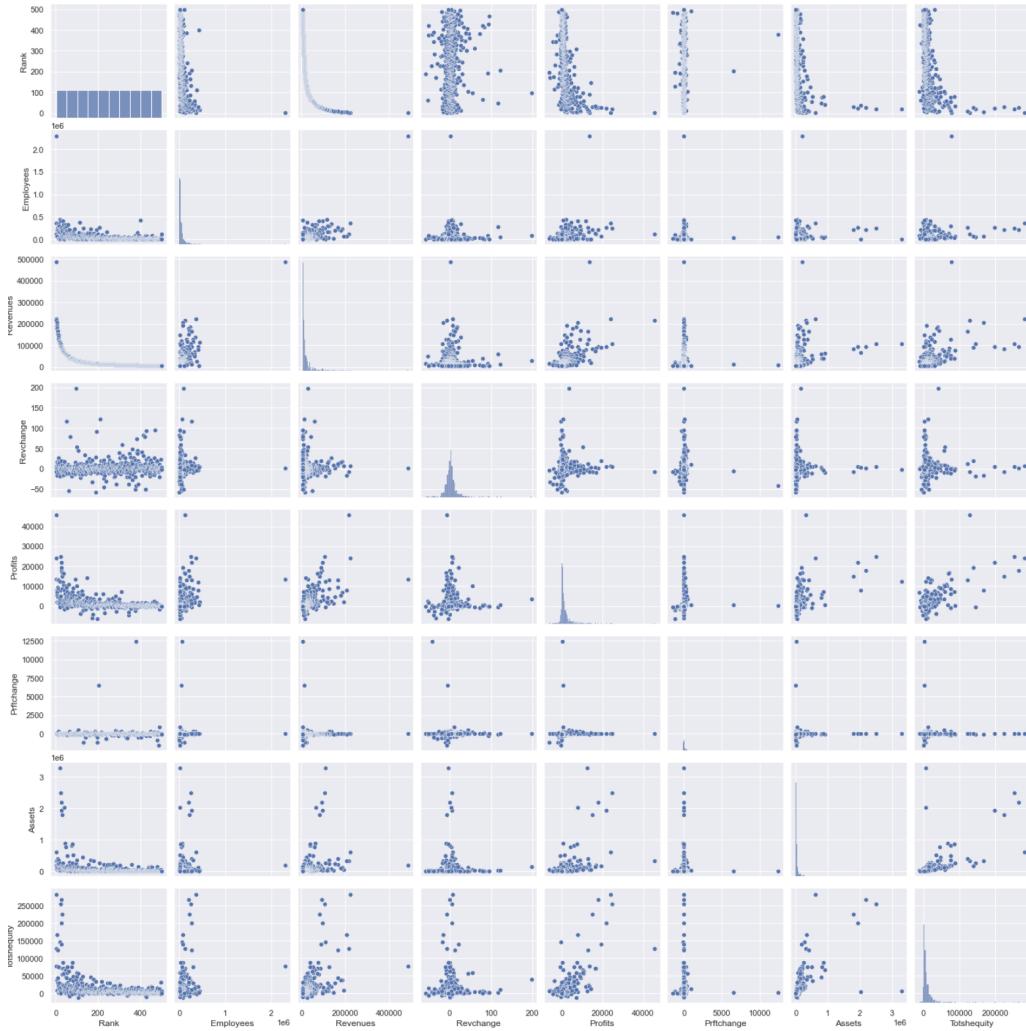


Figure 6: Pairplot of all the numeric features against each other to show patterns and correlations.

When looking at features against profits a weak linear relationship can be seen between Assets, Revenue, Employees and Totsheequity. Figure 7 shows a more detailed version of the profit against Totsheequity to illustrate the linear relationship present.

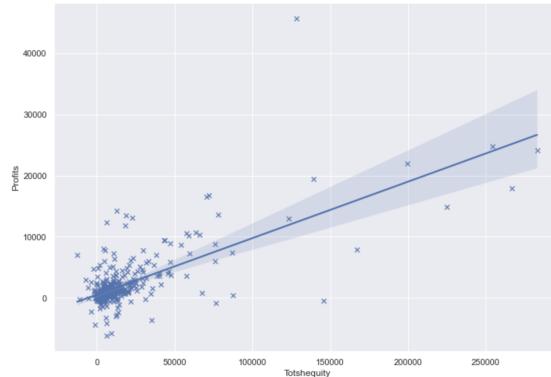


Figure 7: Scatter plot of Totsheequity against profits.

Figure 8 is created using the pandas method `corr()` to calculate the correlations between features and then seaborn method `.heatmap()` to display the heatmap.

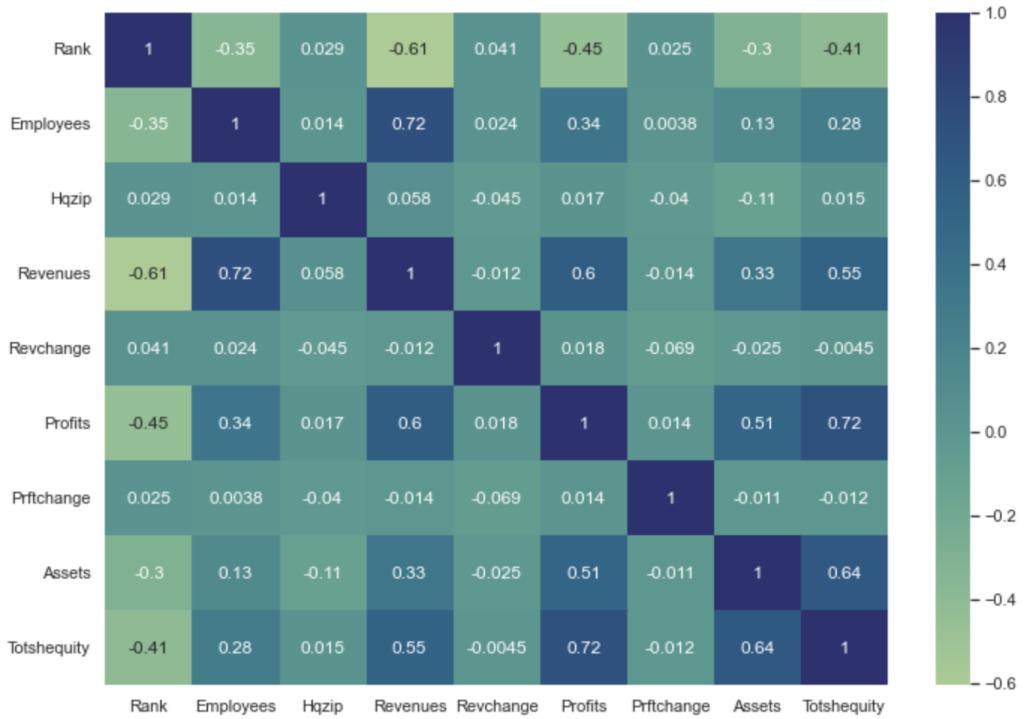


Figure 8: Correlation heatmap of all the numerical values in the dataset. A darker colour indicates a stronger correlation.

The four features with the highest correlation to profits are Assets, Revenues, Employees and Totshequity. These features will be selected as hyperparameters.

2.4 Models

The two models that were chosen were Multiple linear regression (MLR) and Multi-layer perceptions (MLP). MLR was chosen because it is simple and explainable (3). The size coefficients for each feature will show how much that hyperparameter affects the results. This model was created using the `.LinearRegression()` function from the scikit-learn package version 1.1.3 (4). The model was trained on 70% of the data and tested on the other 30% using the scikit-learn `.train_test_split()` method. The accuracy was cross-validated using the `.KFold()` method. Other metrics including R^2 Score, Mean absolute error (MAE) and Mean squared error (MSE) are also calculated using the `.metrics` functions in scikit-learn. Six different versions of the model were created and their scores were compared. MLP was chosen because of its high accuracy due to its flexible decision boundaries (5). This model was created using the `.MLPRegressor()` function also from the scikit-learn package. The same testing and training split was used and the cross-validation and metrics were also the same to allow for easy comparisons. There were 2 models containing 128 versions each, the best of each model was found and their scores were compared.

3 Results

The complete model refinement process is available in [Section 2](#) of the JuPyter Notebook. Only the best version of each model will be discussed below.

The best MLR model was [Model 1.2](#). It had an input of four features: Employees, Assets, Revenues and Totshequity which were all standardised using the `.StandardScaler()` method in scikit-learn. Figures 9, 10 and 11 show the predicted results of the testing data compared with the true value.

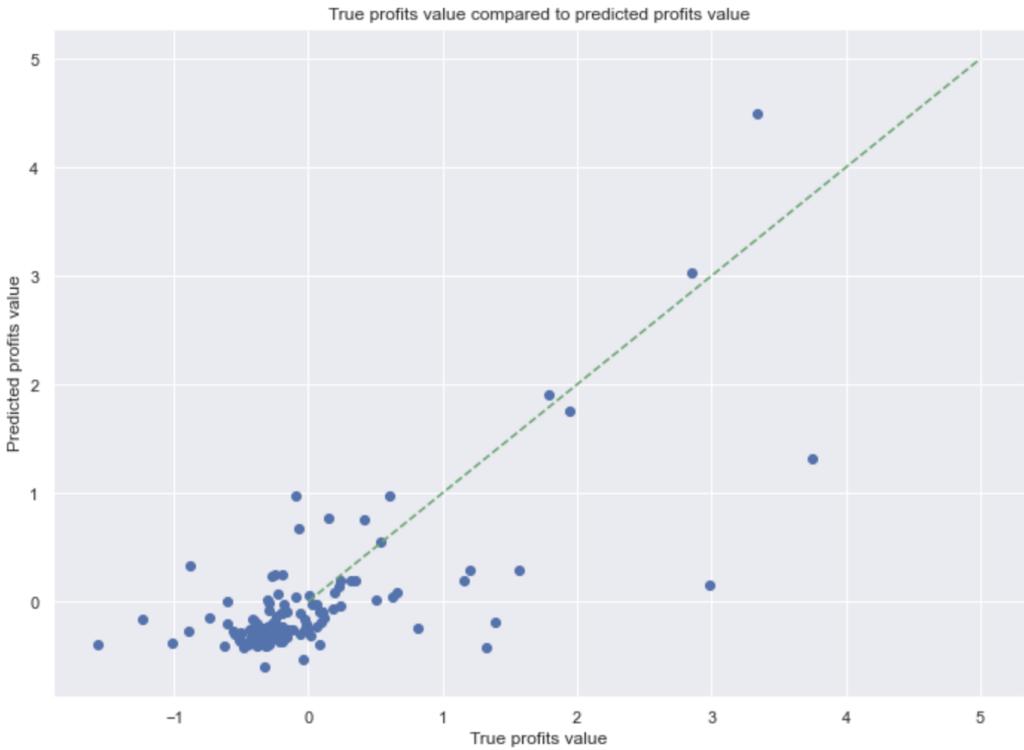


Figure 9: A scatter plot of predicted values against true values of the testing set. A perfect prediction would appear on the green dotted line. The predicted values are often close to the true values although there are a small number of very inaccurate predictions.

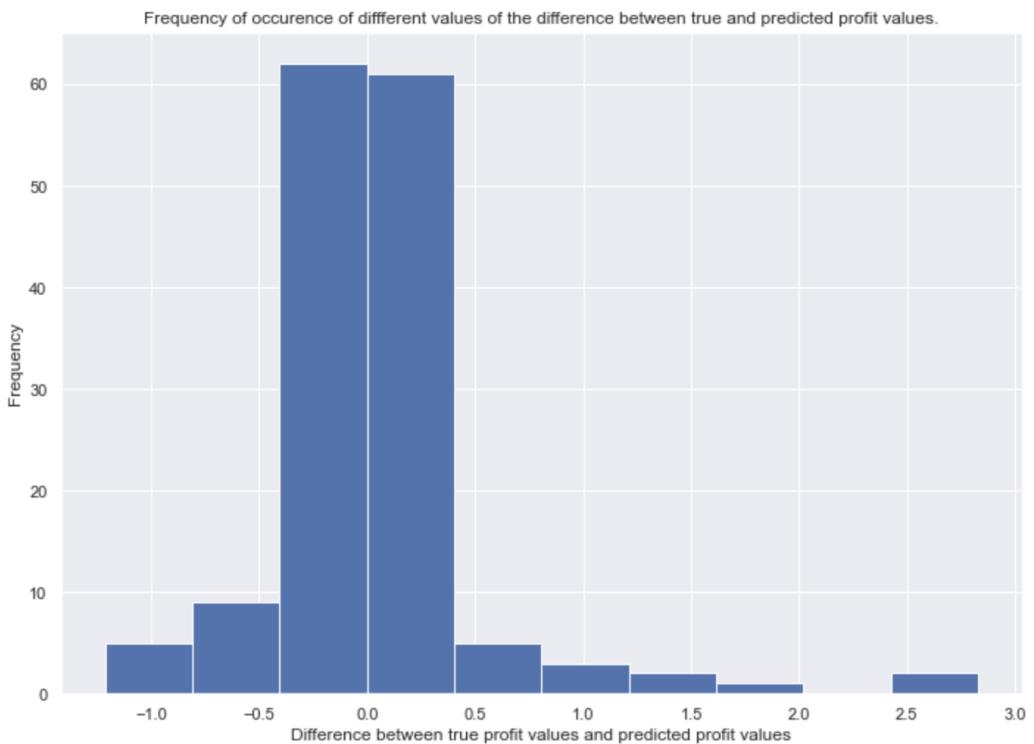


Figure 10: A histogram of the errors of the predicted values of the testing set. Most errors are within -0.5 and 0.5 of a unit. A small number of inaccurate predictions can be seen in this graph too.

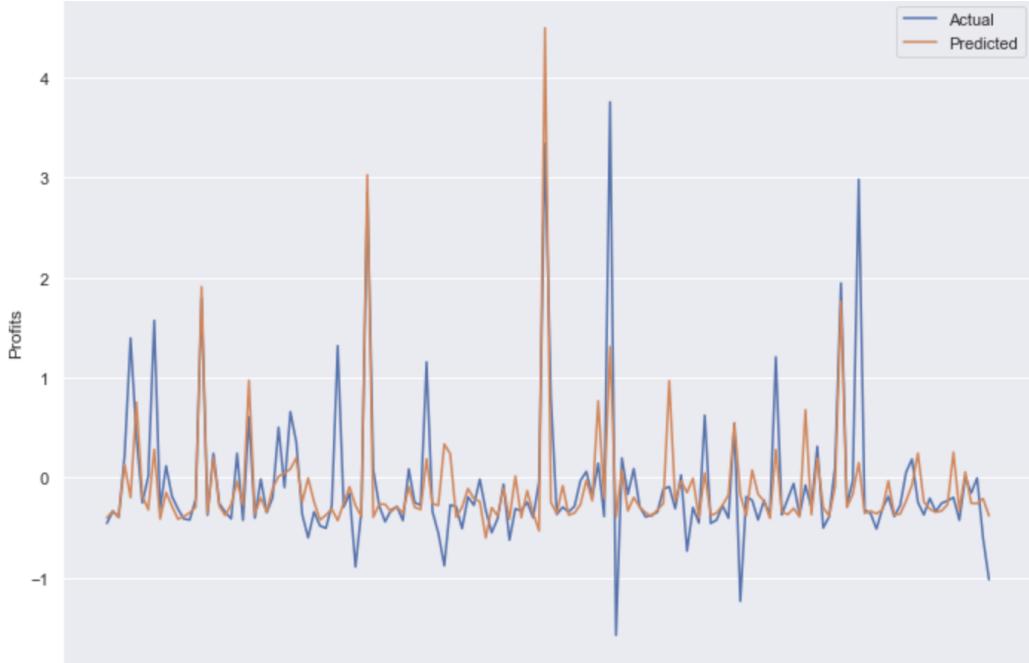


Figure 11: A line graph showing the true and predicted profits for the testing set. This figure highlights the difficulty the model has in predicting negative profits.

Accuracy metrics are shown in Figure 12; the first metric is cross-validated over 6 folds, and the others are not.

```

-----
Negative root mean squared error: mean: -0.6299711990022783 standard deviation: 0.4322145670772607
-----
R2 score = 0.5264293469574413
-----
Mean absolute error = 0.27009261092725895
-----
Mean squared error = 0.2520722214947627
-----
```

Figure 12: Metrics to analyse the performance of the MLR model.

The best MLP model was [Model 2.2](#); it had an input of 6 features: Employees, Assets, Revenue, Totshequity, Prftchange and Revchange which were all standardised using the `.StandardScaler()` method in scikit-learn. Using a `GridSearchCV` in scikit-learn a large range of parameters can be tested and the most accurate outputted. This MLP has the following parameters `{'activation': 'tanh', 'alpha': 0.05, 'hidden_layer_sizes': (200,), 'learning_rate': 'constant', 'max_iter': 1000, 'solver': 'sgd'}` Figures 13, 14 and 15 show the predicted results of the testing data compared with the true value.

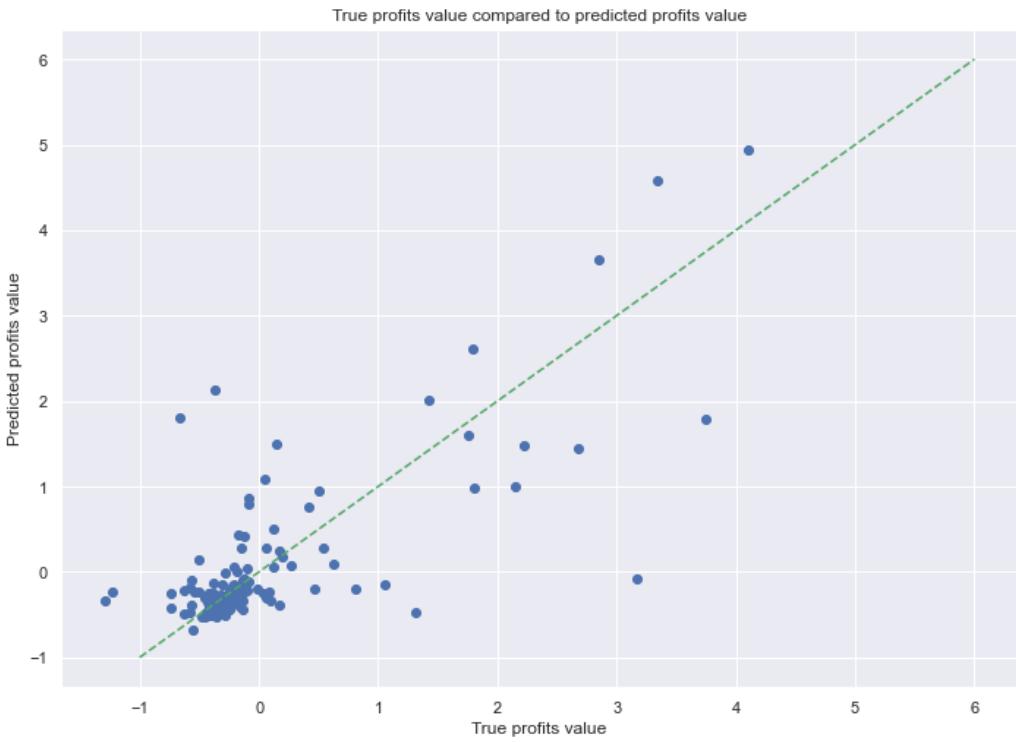


Figure 13: A scatter plot of predicted values against true values of the testing set. A perfect prediction would appear on the green dotted line. The predicted values are often close to the true values although there are a few inaccurate predictions.

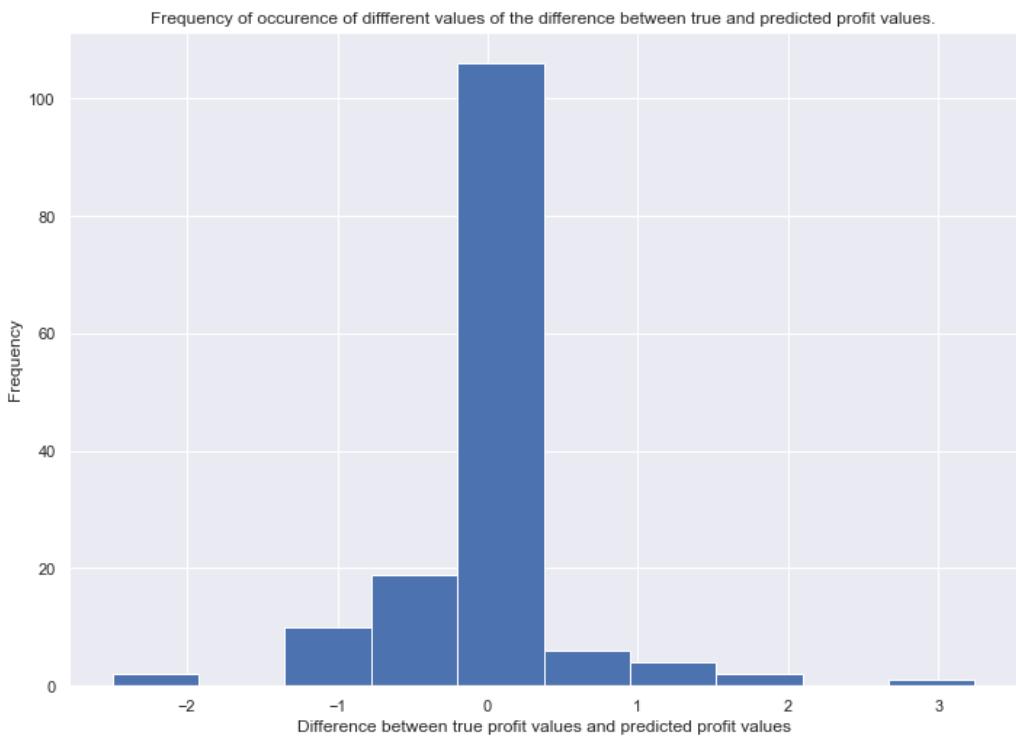


Figure 14: A histogram of the errors of the predicted values of the testing set. Most errors are within -0.5 and 0.5 of a unit. A small number of inaccurate predictions can be seen in this graph too.

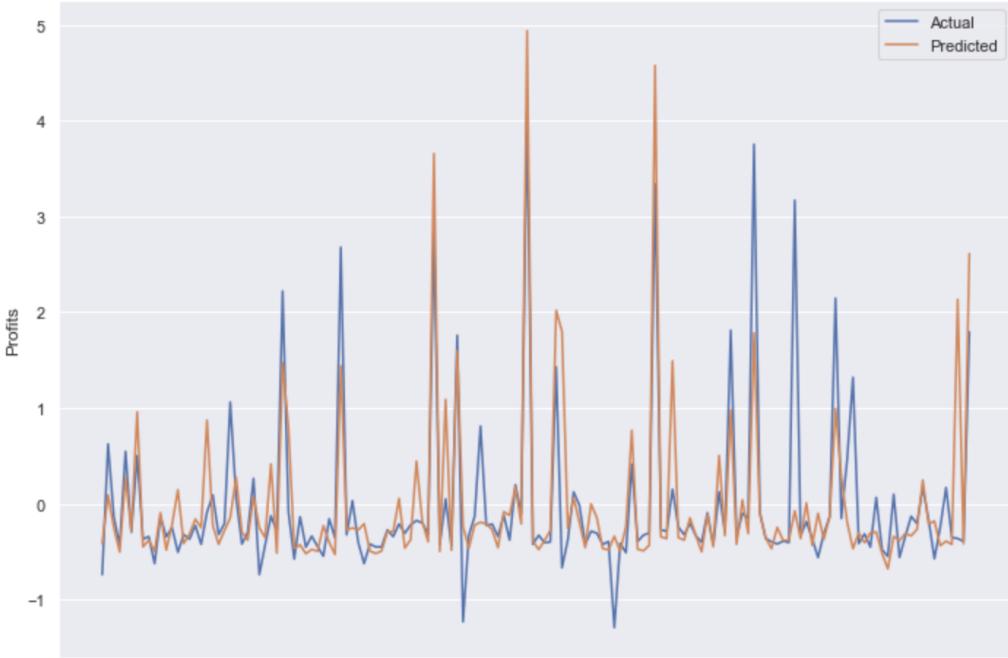


Figure 15: A line graph showing the true and predicted profits for the testing set.

Accuracy metrics are shown in Figure 16; the first metric is cross-validated over 6 folds, and the others are not.

```

-----  

Negative root mean squared error: mean: -0.537390331937597 standard deviation: 0.19320494164125837  

-----  

R2 score = 0.529307843494091  

-----  

Mean absolute error = 0.3215306169790056  

-----  

Mean squared error = 0.3514439880164748  

-----
```

Figure 16: Metrics to analyse the performance of the MLP model.

Section 3 of the JuPyter notebook contains a full comparison between the two best models. The MLP model had a smaller negative root mean squared error and a smaller standard deviation meaning the model is more consistent. It also has a higher R^2 score. However, the MLR model has a smaller MAE and MSE score which means that for that particular model there was slightly less error across predictions.

```

-----  

Model 1.2 Scores - Model 2.2 Scores  

-----  

Negative root mean squared error difference: mean: -0.1336451153009925 standard deviation: 0.22919522229626765  

-----  

R2 score difference = -0.002878496536649733  

-----  

Mean absolute error difference = -0.05143800605174664  

-----  

Mean squared error difference = -0.08135137708921586  

-----
```

Figure 17: Comparisons between the model's accuracy metrics. Scores 1, 3 and 4 should be minimised to improve accuracy whilst score 2 should be maximised.

4 Discussion

4.1 Insights

Subtask 1: The MLR model produces weights for each coefficient which show which hyperparameters have the largest effect on the prediction. Figure 18 suggests that Totshequity has the biggest impact. This can be explained as Total shared equity is a measure of net worth considering revenues and debts.

Coefficient	
Employees	-0.074261
Revenues	0.360205
Assets	0.119924
Totshequity	0.474350

Figure 18: Correlation coefficients for Model 1.2, the best MLR mode.

Employees have a negative correlation which can be explained as employee wages are a cost which reduces profit.

Subtask 2: The models were more accurate when the outliers were included; this suggests outliers are not always errors and that there is a pattern to the outliers that matches with the other datapoints. By including outliers the model may show which companies are overperforming or underperforming base on the trends within the features. This could be due to external factors, such as public opinion which is said to have a big impact on profit (6).

Subtask 3: The MLP model performed better in cross-validation and R^2 score and had fewer large inaccuracies. Therefore, the MLP model would be recommended as the final model. However, the improvement between the 2 models is small and the processes the MLP model used to get its result are unclear so not helpful in ascertaining why the model works.

4.2 Next Steps

The models might be more accurate if the dataset was separated into sectors. Often sectors have similar profiles for each factor, e.g. the Food and drug store sector has a higher revenue as shown in Figure 19 or the financial sector has a high amount of assets.

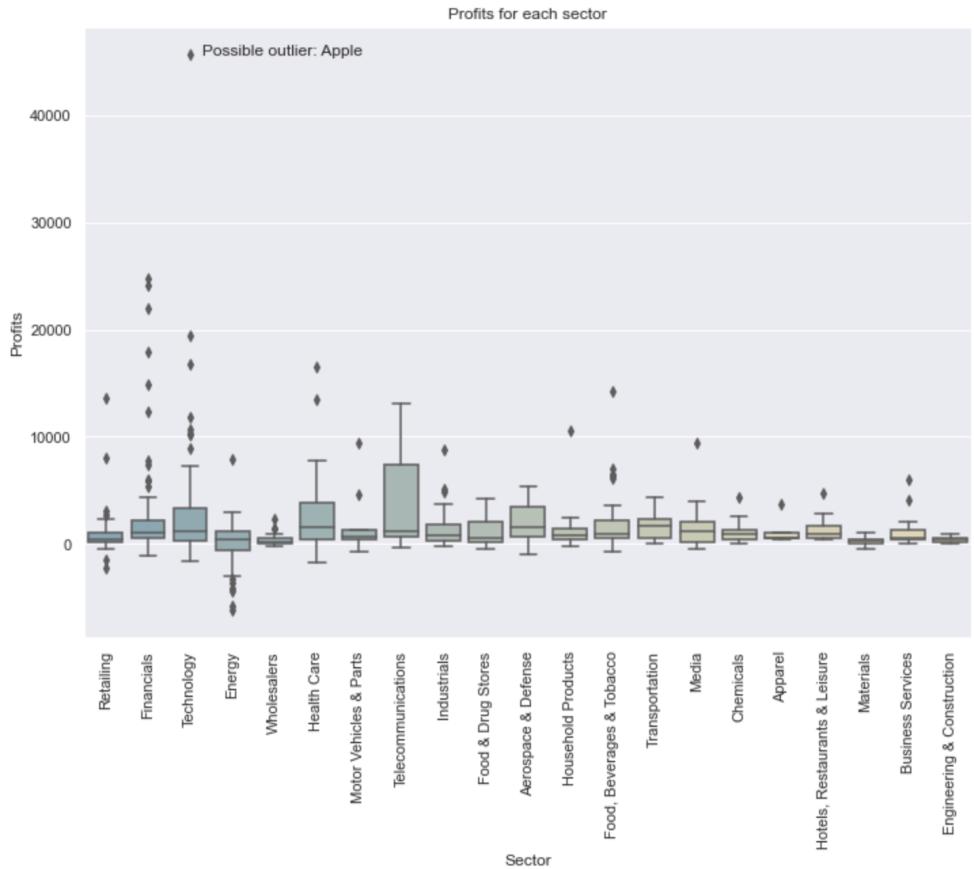


Figure 19: Boxplot of revenues per sector.

References

- [1] A. Hayes, *What Is a Fortune 500 Company? How Companies Are Ranked?*, Feb 2021. [Online]. Available: <https://www.investopedia.com/terms/f/fortune500.asp>
- [2] J. Green and W. Zhao, “Forecasting earnings and returns: A review of recent advancements,” *The Journal of Finance and Data Science*, vol. 8, pp. 120–137, 2022. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2405918822000046>
- [3] L. E. Eberly, *Multiple Linear Regression*. Totowa, NJ: Humana Press, 2007, pp. 165–187. [Online]. Available: https://doi.org/10.1007/978-1-59745-530-5_9
- [4] “Sklearn.linear_model.linearregression,” *scikit*. [Online]. Available: https://scikit-learn.org/stable/modules/generated/sklearn.linear_model.LinearRegression.html
- [5] F. Murtagh, “Multilayer perceptrons for classification and regression,” *Neurocomputing*, vol. 2, no. 5-6, pp. 183–197, 1991.
- [6] S. Wang, “On the relationship between csr and profit.” *Journal of International Business Ethics*, vol. 7, no. 1, 2014.

Appendix

Learning_from_data_profits

December 9, 2022

1 Learning from Data Coursework

This project attempts to predict the profits of fortune 500 companies using Employees, Revenues, Assets, Total Shared Equity and Profit Change.

1.1 Table of Contents

Each section is hyperlinked using this table of contents. To return to this table click the link “Back to contents” available at the beginning of every section and sub section.
* Section 1: Data Exploration and Cleaning
* Outliers
* Correlation
* Section 2: Machine Learning Models
* Model 1.1
* Model 1.2
* Model 1.3
* Model 1.4
* Model 1.5
* Model 1.6
* Model 2.1
* Model 2.1
* Section 3: Comparing Results

```
[1084]: %matplotlib inline
#Imports packages needed to be used for Section 1
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns
sns.set(rc={'figure.figsize':(11.7,8.27)})
```

Data about the fortune 500 companies in 2017 is imported from this [dataset](#) as a csv file.

```
[1085]: #Imports the csv file for the fortune 500 companies in 2017
df = pd.read_csv('fortune500.csv')
```

2 Section 1: Data Exploration and Cleaning

2.1 Visualisations of the data set to understand its structure and content.

In order to understand the strengths and limitations of the data, the data will be visualised using methods from the pandas, matplotlib and seaborn packages. The graphs will inform what question i will ask of the data.

```
[1217]: #Visualising the first 5 rows of the data
df.head()
```

```
[1217]: Rank Title Website Employees \
0    1     Walmart http://www.walmart.com 2300000
1    2  Berkshire Hathaway http://www.berkshirehathaway.com 367700
2    3     Apple http://www.apple.com 116000
3    4  Exxon Mobil http://www.exxonmobil.com 72700
4    5     McKesson http://www.mckesson.com 68000

Sector Industry Hqlocation \
0  Retailing General Merchandisers Bentonville, AR
1  Financials Insurance: Property and Casualty (Stock) Omaha, NE
2  Technology Computers, Office Equipment Cupertino, CA
3  Energy Petroleum Refining Irving, TX
4 Wholesalers Wholesalers: Health Care San Francisco, CA

Hqaddr Hqcity Hqstate ... \
0    702 S.W. Eighth St. Bentonville AR ...
1    3555 Farnam St. Omaha NE ...
2    1 Infinite Loop Cupertino CA ...
3  5959 Las Colinas Blvd. Irving TX ...
4    1 Post St. San Francisco CA ...

Ceo-title \
0 President, Chief Executive Officer & Director
1 Chairman & Chief Executive Officer
2 Chief Executive Officer & Director
3 Chairman & Chief Executive Officer
4 Chairman, President & Chief Executive Officer

Address Ticker Fullname \
0 702 S.W. Eighth St., Bentonville, AR 72716 WMT Wal-Mart Stores, Inc.
1      3555 Farnam St., Omaha, NE 68131 BRKA Berkshire Hathaway Inc.
2      1 Infinite Loop, Cupertino, CA 95014 AAPL Apple, Inc.
3  5959 Las Colinas Blvd., Irving, TX 75039 XOM Exxon Mobil Corporation
4      1 Post St., San Francisco, CA 94104 MCK McKesson Corporation

Revenues Revchange Profits Prftchange Assets Totshequity
0    485873      0.8  13643.0      -7.2  198825    77798.0
1    223604      6.1  24074.0       0.0  620854   283001.0
2    215639     -7.7  45687.0     -14.4  321686   128249.0
3    205004     -16.7  7840.0     -51.5  330314   167325.0
4    192487      6.2  2258.0       53.0  56563    8924.0
```

[5 rows x 23 columns]

```
[185]: #Visualising the last 5 rows of the data
df.tail()
```

[185] : Rank Title Website Employees \

495	496	Michaels Cos.	http://www.michaels.com	31000
496	497	Toll Brothers	http://www.tollbrothers.com	4200
497	498	Yahoo	http://www.yahoo.com	8500
498	499	Vistra Energy	http://www.vistraenergy.com	4431
499	500	ABM Industries	http://www.abm.com	110000

		Sector	Industry	\
495		Retailing	Specialty Retailers: Other	
496		Engineering & Construction	Homebuilders	
497		Technology	Internet Services and Retailing	
498		Energy	Energy	
499		Business Services	Diversified Outsourcing Services	

	Hqlocation	Hqaddr	Hqcity	Hqstate	...	\
495	Irving, TX	8000 Bent Branch Dr.	Irving	TX	...	
496	Horsham, PA	250 Gibraltar Rd.	Horsham	PA	...	
497	Sunnyvale, CA	701 First Ave.	Sunnyvale	CA	...	
498	Dallas, TX	1601 Bryan St.	Dallas	TX	...	
499	New York, NY	1 Liberty Plaza	New York	NY	...	

	Ceo-title	\
495	Chairman & Chief Executive Officer	
496	Chief Executive Officer & Director	
497	President, Chief Executive Officer & Director	
498	President, Chief Executive Officer & Director	
499	President, Chief Executive Officer & Director	

	Address	Ticker	\
495	8000 Bent Branch Dr., Irving, TX 75063	MIK	
496	250 Gibraltar Rd., Horsham, PA 19044	TOL	
497	701 First Ave., Sunnyvale, CA 94089	YHOO	
498	1601 Bryan St., Dallas, TX 75201	VST	
499	1 Liberty Plaza, New York, NY 10006	ABM	

	Fullname	Revenues	Revchange	Profits	Prftchange	\
495	The Michaels Companies, Inc.	5197	5.8	378.2	4.2	
496	Toll Brothers, Inc.	5170	23.9	382.1	5.2	
497	Yahoo! Inc.	5169	4.0	-214.3	5.2	
498	Vistra Energy Corp.	5164	4.0	-214.3	5.2	
499	ABM Industries Incorporated	5145	-2.8	57.2	-25	

	Assets	Totshequity
495	2148	-1698.0
496	9737	4229.0
497	48083	31049.0
498	15167	6597.0

```
499      2281      974.0
```

```
[5 rows x 23 columns]
```

```
[186]: #Prints the length of the data  
len(df)
```

```
[186]: 500
```

```
[187]: #Prints all the names and types of the columns  
df.dtypes
```

```
[187]: Rank          int64  
Title         object  
Website        object  
Employees      int64  
Sector         object  
Industry        object  
Hqlocation     object  
Hqaddr         object  
Hqcity         object  
Hqstate        object  
Hqzip          int64  
Hqtel           object  
Ceo            object  
Ceo-title       object  
Address         object  
Ticker          object  
Fullname        object  
Revenues        int64  
Revchange       float64  
Profits         float64  
Prftchange      object  
Assets          int64  
Totshequity    float64  
dtype: object
```

```
[198]: #Checks there are no null data entries  
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 500 entries, 0 to 499  
Data columns (total 23 columns):  
 #   Column      Non-Null Count  Dtype     
 ---  --          -----          -----  
 0   Rank        500 non-null    int64  
 1   Title       500 non-null    object
```

```

2   Website      500 non-null    object
3   Employees     500 non-null    int64
4   Sector        500 non-null    object
5   Industry       500 non-null    object
6   Hqlocation    500 non-null    object
7   Hqaddr        500 non-null    object
8   Hqcity         500 non-null    object
9   Hqstate        500 non-null    object
10  Hqzip          500 non-null    int64
11  Hqtel          500 non-null    object
12  Ceo            500 non-null    object
13  Ceo-title      500 non-null    object
14  Address         500 non-null    object
15  Ticker          500 non-null    object
16  Fullname       500 non-null    object
17  Revenues        500 non-null    int64
18  Revchange       500 non-null    float64
19  Profits         500 non-null    float64
20  Prftchange      500 non-null    float64
21  Assets           500 non-null    int64
22  Totshequity    500 non-null    float64
dtypes: float64(4), int64(5), object(14)
memory usage: 90.0+ KB

```

[177]: #Basic statistical analysis on the continuous numerical features is described
`df.describe()`

	Rank	Employees	Revenues	Revchange	Profits	\
count	500.000000	5.000000e+02	500.000000	500.00000	500.000000	
mean	250.492000	5.635013e+04	24111.748000	3.75800	1779.479800	
std	144.477366	1.234520e+05	38337.353337	19.96748	3937.558721	
min	1.000000	8.300000e+01	5145.000000	-57.50000	-6177.000000	
25%	125.750000	1.190000e+04	7245.000000	-3.82500	235.725000	
50%	250.500000	2.500000e+04	11384.000000	1.90000	683.600000	
75%	375.250000	5.682525e+04	22605.250000	7.32500	1770.775000	
max	500.000000	2.300000e+06	485873.000000	197.30000	45687.000000	
	Prftchange	Assets	Totshequity			
count	494.000000	5.000000e+02	500.0000			
mean	-1.309109	8.038934e+04	13640.1470			
std	116.971196	2.704257e+05	30523.1538			
min	-892.300000	4.370000e+02	-12688.0000			
25%	-18.575000	8.436500e+03	1997.5000			
50%	2.350000	1.932450e+04	4981.0000			
75%	20.200000	4.812600e+04	12467.7500			
max	962.500000	3.287968e+06	283001.0000			

```
[178]: #Calculating the mean profit and seeing which companies had a higher profit
average = df['Profits'].mean()
df.loc[df['Profits'] >= mean]
```

	Rank	Title	Employees	Sector	\			
0	1	Walmart	2300000	Retailing				
1	2	Berkshire Hathaway	367700	Financials				
2	3	Apple	116000	Technology				
3	4	Exxon Mobil	72700	Energy				
4	5	McKesson	68000	Wholesalers				
..				
356	357	Charles Schwab	16200	Financials				
364	365	PPL	12689	Energy				
458	459	S&P Global	20000	Business Services				
464	465	Symantec	11000	Technology				
476	477	Simon Property Group	4050	Financials				
		Industry	Hqcity	Hqstate	\			
0		General Merchandisers	Bentonville	AR				
1		Insurance: Property and Casualty (Stock)	Omaha	NE				
2		Computers, Office Equipment	Cupertino	CA				
3		Petroleum Refining	Irving	TX				
4		Wholesalers: Health Care	San Francisco	CA				
..					
356		Securities	San Francisco	CA				
364		Utilities: Gas and Electric	Allentown	PA				
458		Financial Data Services	New York	NY				
464		Computer Software	Mountain View	CA				
476		Real Estate	Indianapolis	IN				
		Revenues	Revchange	Profits	Prftchange	Assets	Totshequity	
0		485873	0.8	13643.0	-7.2	198825	77798.0	
1		223604	6.1	24074.0	0.0	620854	283001.0	
2		215639	-7.7	45687.0	-14.4	321686	128249.0	
3		205004	-16.7	7840.0	-51.5	330314	167325.0	
4		192487	6.2	2258.0	53.0	56563	8924.0	
..		
356		7644	17.6	1889.0	30.5	223383	16421.0	
364		7517	-2.0	1902.0	178.9	38315	9899.0	
458		5661	6.6	2106.0	82.2	8669	650.0	
464		5568	-14.4	2488.0	183.4	11767	3676.0	
476		5435	3.2	1838.9	0.6	31104	4310.0	

[124 rows x 13 columns]

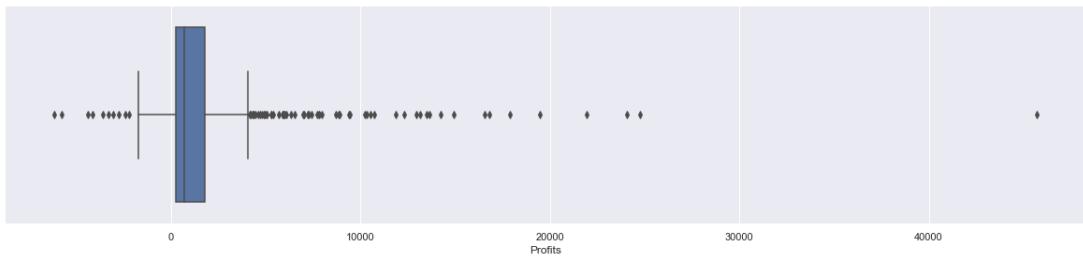
124 companies have profits above the mean value.

2.1.1 Detecting outliers

Analysis on statistical outliers in the dataset.

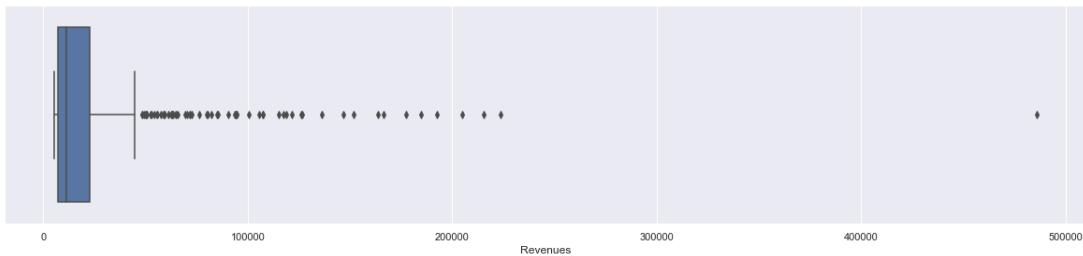
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```
[369]: sns.boxplot(x= df['Profits'])
plt.figure(figsize = (15,8))
plt.show()
```



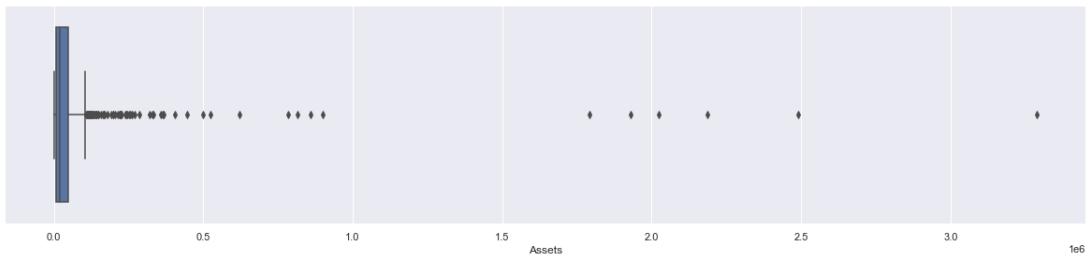
<Figure size 1080x576 with 0 Axes>

```
[370]: sns.boxplot(x= df['Revenues'])
plt.figure(figsize = (15,8))
plt.show()
```



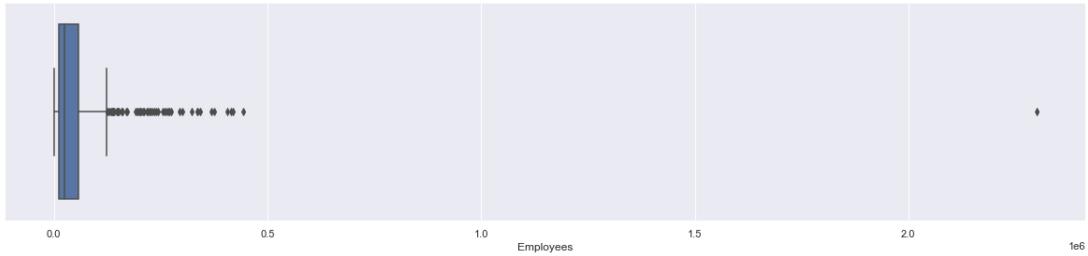
<Figure size 1080x576 with 0 Axes>

```
[372]: sns.boxplot(x= df['Assets'])
plt.figure(figsize = (15,8))
plt.show()
```



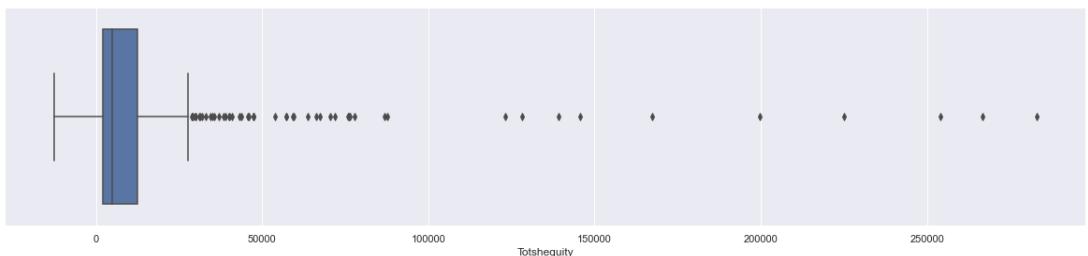
<Figure size 1080x576 with 0 Axes>

```
[373]: sns.boxplot(x= df['Employees'])
plt.figure(figsize = (15,8))
plt.show()
```



<Figure size 1080x576 with 0 Axes>

```
[375]: sns.boxplot(x= df['Totsequity'])
plt.figure(figsize = (15,8))
plt.show()
```



<Figure size 1080x576 with 0 Axes>

If the value is 3.5 standard deviations away from the mean it is classified as an outlier. It is important to identify outliers so the effect they have on the model can be minimised.

Checking Profits, Revenues, Assets, Employees and Totshequity for outliers

```
[1229]: from scipy import stats
z = np.abs(stats.zscore(df['Profits']))
print(z)

# Position of the outlier
prof_out = np.where(z > 3.5)
print(prof_out)
```

```
0      3.015930
1      5.667686
2     11.162118
3      1.540698
4      0.121649
...
495    0.356232
496    0.355240
497    0.506856
498    0.506856
499    0.437836
Name: Profits, Length: 500, dtype: float64
(array([ 1,  2, 20, 24, 25, 26, 27, 34]),)
```

```
[1230]: from scipy import stats
z = np.abs(stats.zscore(df['Revenues']))
print(z)
```

```
# Position of the outlier
rev_out = np.where(z > 3.5)
print(rev_out)

0      12.056745
1      5.208811
2      5.000843
3      4.723159
4      4.396336
...
495    0.493871
496    0.494576
497    0.494602
498    0.494732
499    0.495228
Name: Revenues, Length: 500, dtype: float64
(array([0, 1, 2, 3, 4, 5, 6, 7, 8]),)
```

```
[1231]: from scipy import stats
z = np.abs(stats.zscore(df['Assets']))
print(z)
```

```
# Position of the outlier
asst_out = np.where(z > 3.5)
print(asst_out)
```

```
0      0.438399
1      2.000571
2      0.893178
3      0.925115
4      0.088195
...
495    0.289616
496    0.261525
497    0.119584
498    0.241426
499    0.289124
Name: Assets, Length: 500, dtype: float64
(array([19, 20, 24, 25, 29, 38]),)
```

```
[1232]: from scipy import stats
z = np.abs(stats.zscore(df['Employees']))
print(z)
```

```
# Position of the outlier
emp_out = np.where(z > 3.5)
print(emp_out)
```

```
0      18.192467
1      2.524557
2      0.483666
3      0.132572
4      0.094462
...
495    0.205550
496    0.422855
497    0.387989
498    0.420982
499    0.435016
Name: Employees, Length: 500, dtype: float64
(array([0]),)
```

```
[1233]: from scipy import stats
z = np.abs(stats.zscore(df['Totshequity']))
```

```

print(z)

# Position of the outlier
tot_out = np.where(z > 3.5)
print(tot_out)

```

```

0      2.104046
1      8.833642
2      3.758577
3      5.040068
4      0.154665
...
495     0.503012
496     0.308637
497     0.570920
498     0.230979
499     0.415384
Name: Totshequity, Length: 500, dtype: float64
(array([ 1,  2,  3,  8, 18, 20, 24, 25, 26, 29]),)

```

```

[1234]: outliers = [1, 2, 20, 24, 25, 26, 27, 34, 0, 1, 2, 3, 4, 5, 6, 7, 8, 19, 20,
             ↪24, 25, 29, 38, 0, 1, 2, 3, 8, 18, 20, 24, 25, 26, 29]
def Repeat(x):
    _size = len(x)
    repeated = []
    for i in range(_size):
        k = i + 1
        for j in range(k, _size):
            if x[i] == x[j] and x[i] not in repeated:
                repeated.append(x[i])
    return repeated

print(Repeat(outliers))

```

```
[1, 2, 20, 24, 25, 26, 0, 3, 8, 29]
```

According to z score companies at index 0,1,2,3,8,20,24,25,26,29 are outliers in multiple categories. They could cause the model to be unreliable at predicting other companies. However as the fortune 500 companies are a list of successful companies and the aim is to see what effects profits it could be counter intuitive to remove the “most successful” companies for different aspects as we remove the possibility to find out possible reasons why these companies are successful or the ability to identify companies the model shows are underperforming based on their features.

2.1.2 Calculating the company with the highest profits.

```
[1222]: #The index of the highest profiting company is found and the row printed
loc = df['Profits'].idxmax()
df.iloc[loc]
```

```
[1222]: Rank           3
Title          Apple
Employees      116000
Sector         Technology
Industry       Computers, Office Equipment
Hqcity         Cupertino
Hqstate        CA
Revenues       215639
Revchange      -7.7
Profits        45687.0
Prftchange    -14.4
Assets         321686
Totshequity   128249.0
Name: 2, dtype: object
```

2.1.3 Calculating the company with the highest revenue.

```
[180]: #The index of the company with the highest revenue is found and the row printed
loc = df['Revenues'].idxmax()
df.iloc[loc]
```

```
[180]: Rank           1
Title          Walmart
Employees      2300000
Sector         Retailing
Industry      General Merchandisers
Hqcity         Bentonville
Hqstate        AR
Revenues       485873
Revchange      0.8
Profits        13643.0
Prftchange    -7.2
Assets         198825
Totshequity   77798.0
Name: 0, dtype: object
```

2.1.4 Calculating the company with the highest assets.

```
[181]: #The index of the company with the most assets is found and the row printed  
loc = df['Assets'].idxmax()  
df.iloc[loc]
```

```
[181]: Rank           20  
Title          Fannie Mae  
Employees      7000  
Sector         Financials  
Industry       Diversified Financials  
Hqcity         Washington  
Hqstate        DC  
Revenues       107162  
Revchange      -2.9  
Profits        12313.0  
Prftchange     12.4  
Assets          3287968  
Totshequity    6071.0  
Name: 19, dtype: object
```

2.1.5 Calculating the company with the highest number of employees

```
[376]: #The index of the company with the most employees is found and the row printed  
loc = df['Employees'].idxmax()  
df.iloc[loc]
```

```
[376]: Rank           1  
Title          Walmart  
Employees      2300000  
Sector         Retailing  
Industry       General Merchandisers  
Hqcity         Bentonville  
Hqstate        AR  
Revenues       485873  
Revchange      0.8  
Profits        13643.0  
Prftchange     -7.2  
Assets          198825  
Totshequity    77798.0  
Name: 0, dtype: object
```

2.1.6 Data which will not be used in the models are removed for clarity in the process of feature selection. This process is known as cleaning.

Data columns includle: * Website * Hqlocation * Hqaddr * Hqzip * Hqtel * Ceo * Ceo-title * Fullname * Ticker * Address

```
[1218]: df.
    ↪drop(columns=['Website', 'Hqlocation', 'Hqaddr', 'Hqzip', 'Hqtel', 'Ceo', 'Ceo-title', 'Fullname',
    ↪'Ticker', 'Address'], inplace=True)
```

```
[1219]: #Shows the remaining columns in the data
df.head()
```

	Rank	Title	Employees	Sector	\
0	1	Walmart	2300000	Retailing	
1	2	Berkshire Hathaway	367700	Financials	
2	3	Apple	116000	Technology	
3	4	Exxon Mobil	72700	Energy	
4	5	McKesson	68000	Wholesalers	

	Industry	Hqcity	Hqstate	Revenues	\
0	General Merchandisers	Bentonville	AR	485873	
1	Insurance: Property and Casualty (Stock)	Omaha	NE	223604	
2	Computers, Office Equipment	Cupertino	CA	215639	
3	Petroleum Refining	Irving	TX	205004	
4	Wholesalers: Health Care	San Francisco	CA	192487	

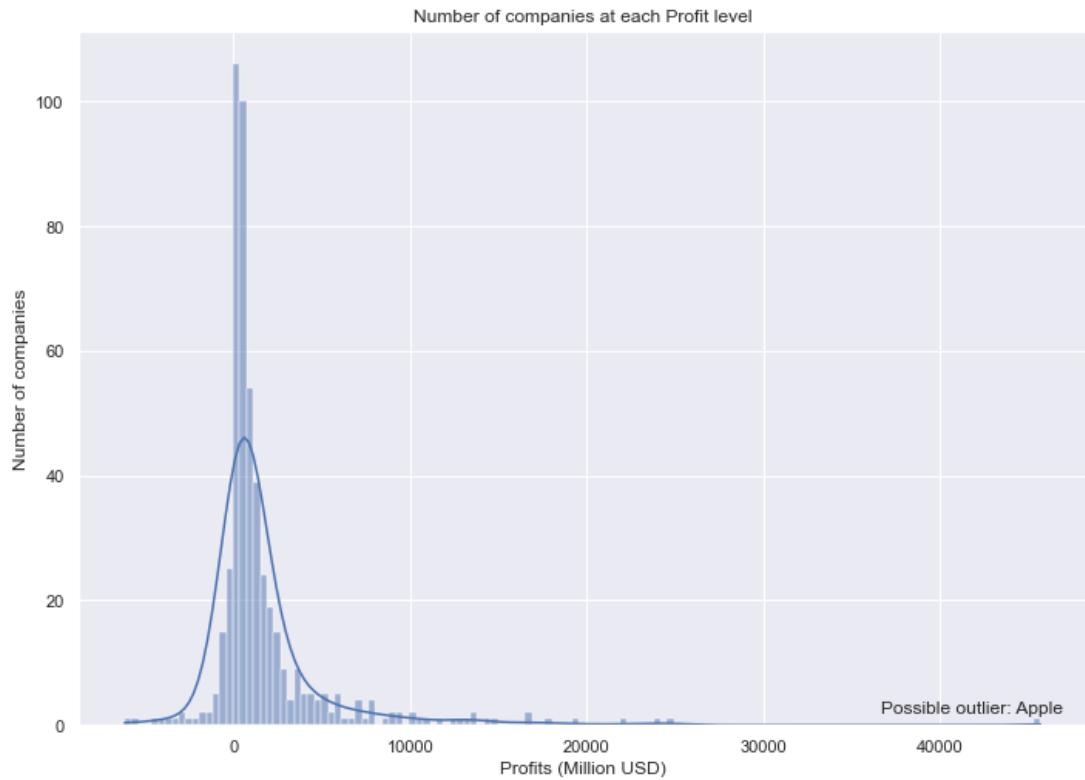
	Revchange	Profits	Prftchange	Assets	Totshequity	
0	0.8	13643.0	-7.2	198825	77798.0	
1	6.1	24074.0	0.0	620854	283001.0	
2	-7.7	45687.0	-14.4	321686	128249.0	
3	-16.7	7840.0	-51.5	330314	167325.0	
4	6.2	2258.0	53.0	56563	8924.0	

2.1.7 Corelations in the data

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2.1.8 Plotting a histogram to see the profit levels of all the fortune 500 companies in an attempt to identify trends and show outliers.

```
[1228]: sns.histplot(data=df, x="Profits", palette = 'blend:#7AB,#EDA', kde=True)
plt.title('Number of companies at each Profit level')
plt.xlabel('Profits (Million USD)')
plt.ylabel('Number of companies')
plt.text(x=(df.Profits[(df.Profits==df.Profits.max())])-9000, y=2, s='Possible outlier: Apple')
plt.show()
```

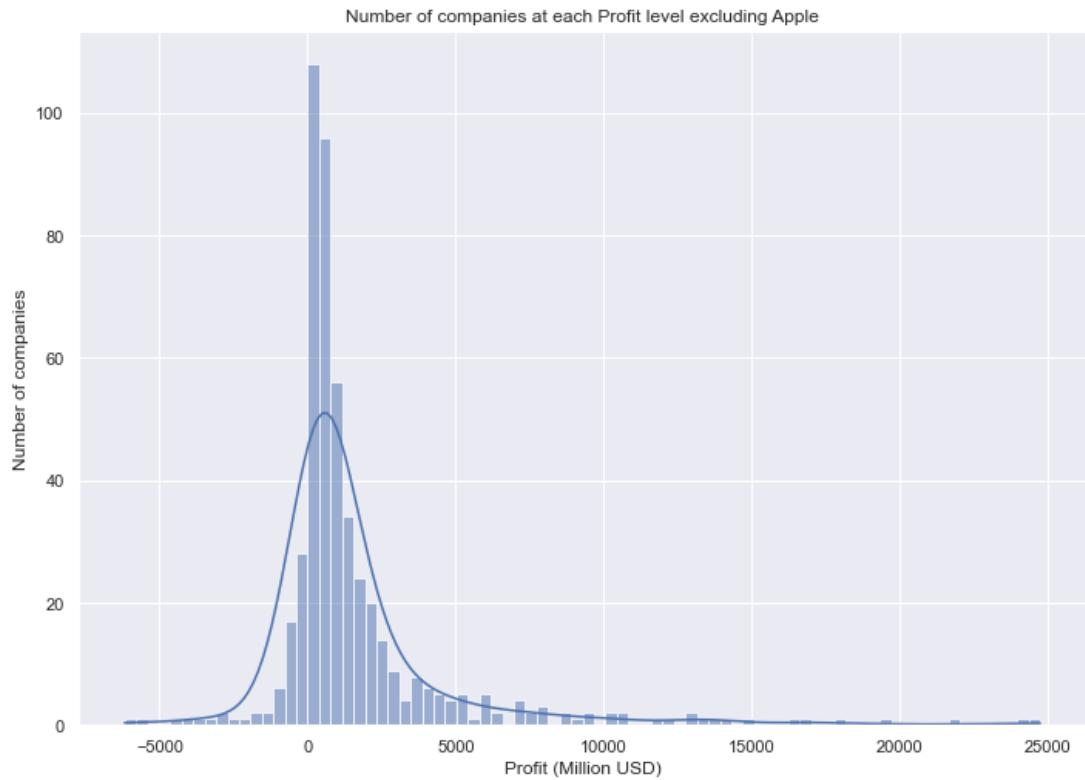


A histogram of profits shows the different bands of profit and how many of the companies fall into each band. The greatest occurring band has over 100 of the 500 companies in it, and the that the profits are clustered around that band to form a bell curve. There is one outlier that has a profit of 45,687 million USD more than 42,000 million USD more than the next highest profiting company. Another thing to note is that over 50 companies had negative profits (or a loss) which may impact the model.

The outlier has been identified as Apple, the graph has been constructed again without the outlier to see if the patterns are clearer.

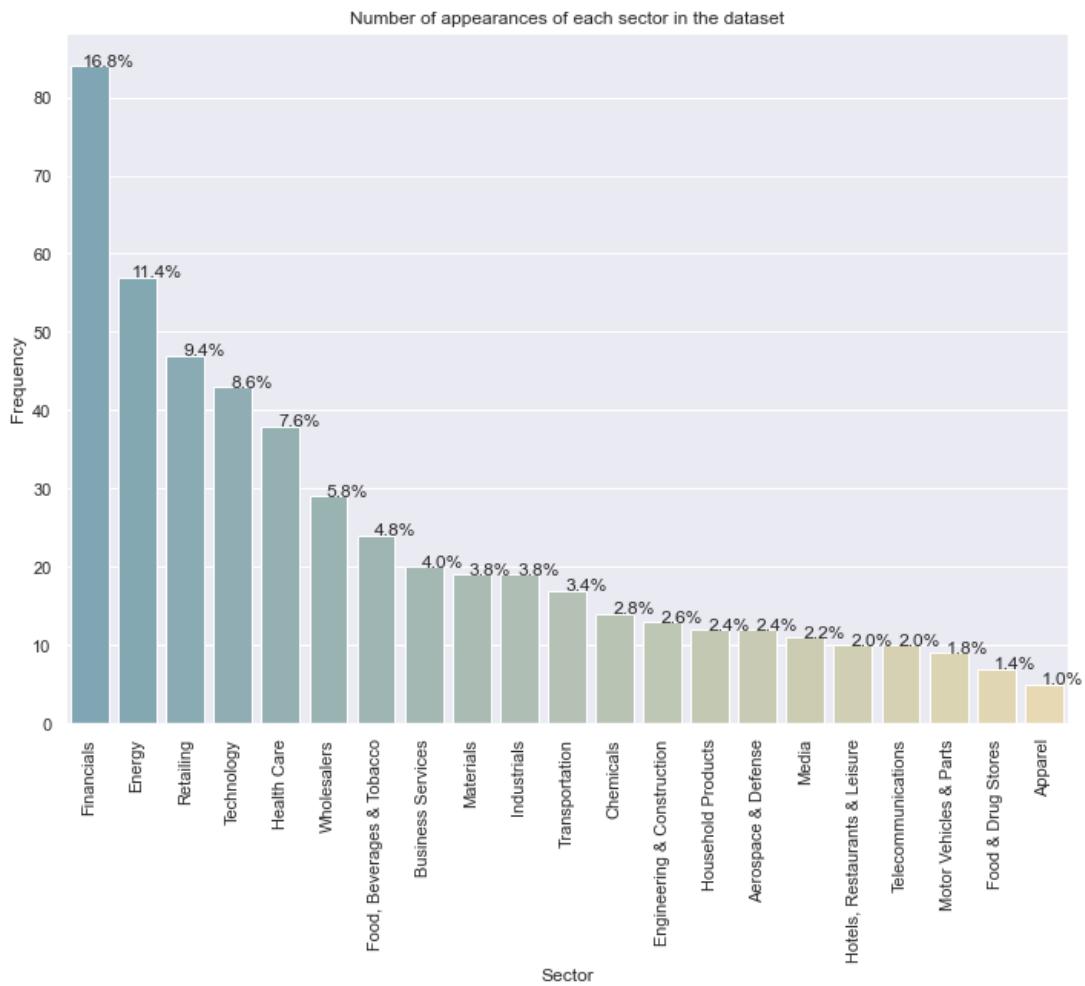
```
[224]: #Creates a new dataset without Apple
apple_removed_df = df.drop(2)

sns.histplot(data=apple_removed_df, x="Profits", cmap="crest", kde=True, 
             stat='count')
plt.title('Number of companies at each Profit level excluding Apple')
plt.xlabel('Profit (Million USD)')
plt.ylabel('Number of companies')
plt.show()
```



2.1.9 Plotting a countplot to see the number of fortune 500 companies in each sector.

```
[203]: ax = sns.countplot(data=df, x='Sector', order=df.Sector.value_counts().index, palette='blend:#7AB,#EDA')
plt.title('Number of appearances of each sector in the dataset')
plt.xlabel('Sector')
plt.ylabel('Frequency')
plt.xticks(rotation=90)
total = float(len(df))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width()
    y = p.get_height()
    ax.annotate(percentage, (x,y), ha='center')
plt.show()
```



This graph shows that the sector with the most companies on the Fortune 500 list is Financials at 16.8% then Energy at 11.4%.

2.1.10 Using box plots to see if there is a relation between profits and sector or revenue and sector.

The Figure shows that there are some results which are outliers in almost every field. It also shows that the variance is quite low for all sectors other than telecommunications and the mean for all is very similar.

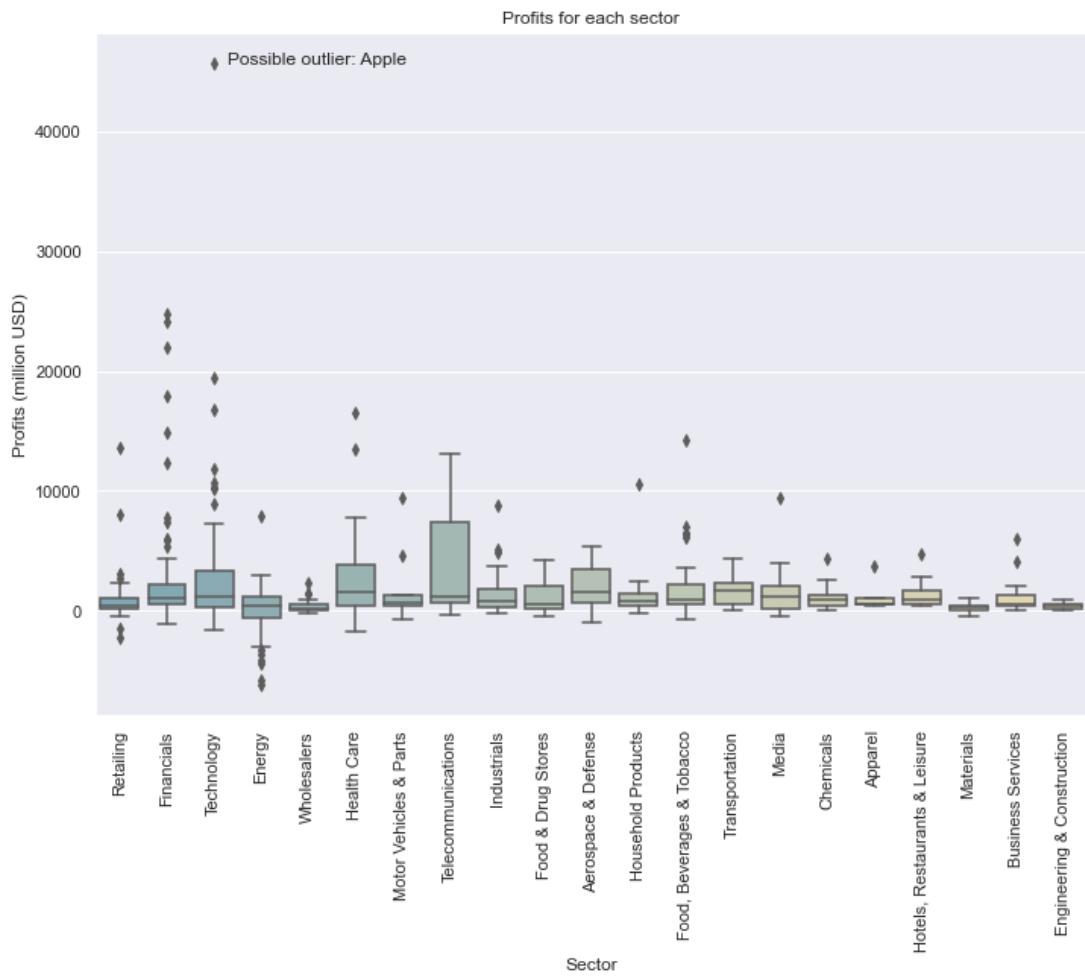
```
[1208]: sns.boxplot(data=df, x='Sector', y='Profits', palette='blend:#7AB,#EDA')
plt.title('Profits for each sector')
plt.xlabel('Sector')
plt.ylabel('Profits (million USD)')
plt.xticks(rotation=90)
```

```

plt.text(y=df.Profits[df.Profits==df.Profits.max()], x=2.3, s='Possible outlier:  

    ↳ Apple')
plt.show()

```



The figure shows there are outliers for revenue with Food and drug stores having a higher mean profit than ever other company and a larger variance between the upper and lower quarter. Telecommunications also had a larger variance in revenue compared with all the other sectors which have similar means and small variances.

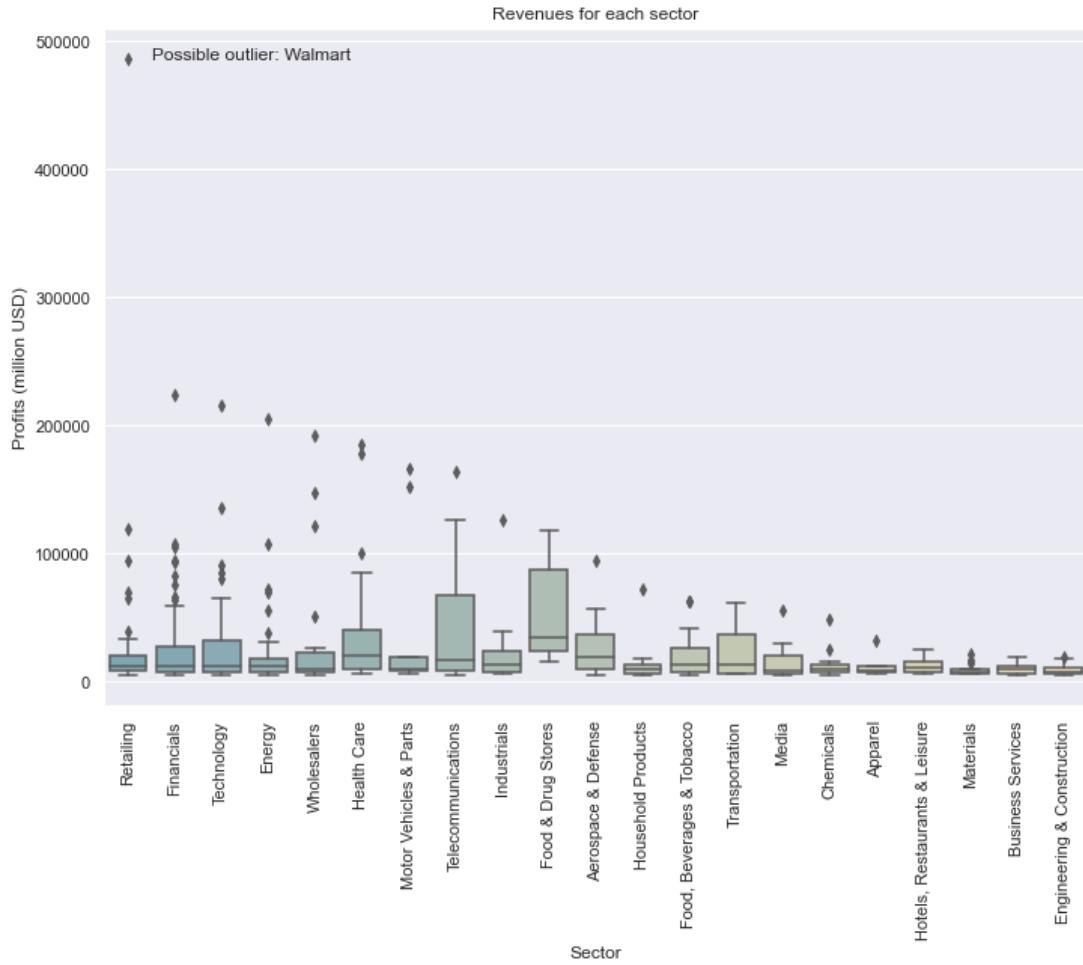
```

[1207]: sns.boxplot(data=df, x='Sector', y='Revenues', palette='blend:#7AB,#EDA')
plt.title('Revenues for each sector')
plt.xlabel('Sector')
plt.ylabel('Profits (million USD)')
plt.xticks(rotation=90)
plt.text(y=df.Revenues[df.Revenues==df.Revenues.max()], x=0.5, s='Possible outlier:  

    ↳outlier: Walmart')

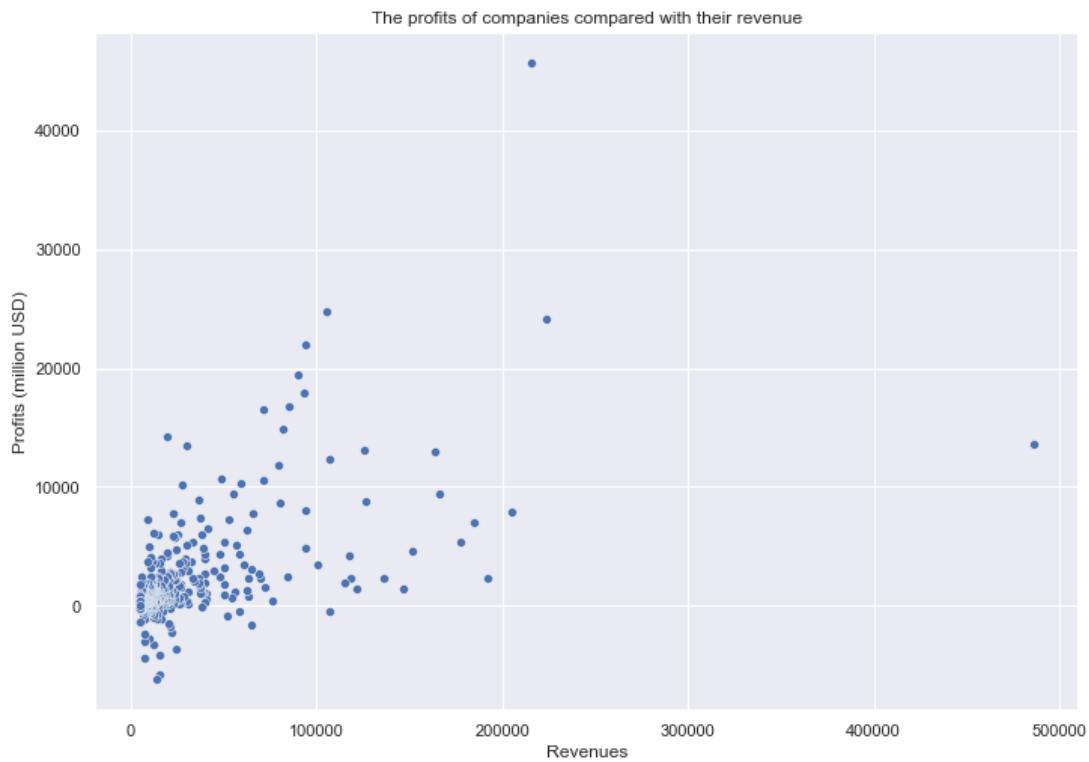
```

```
plt.show()
```



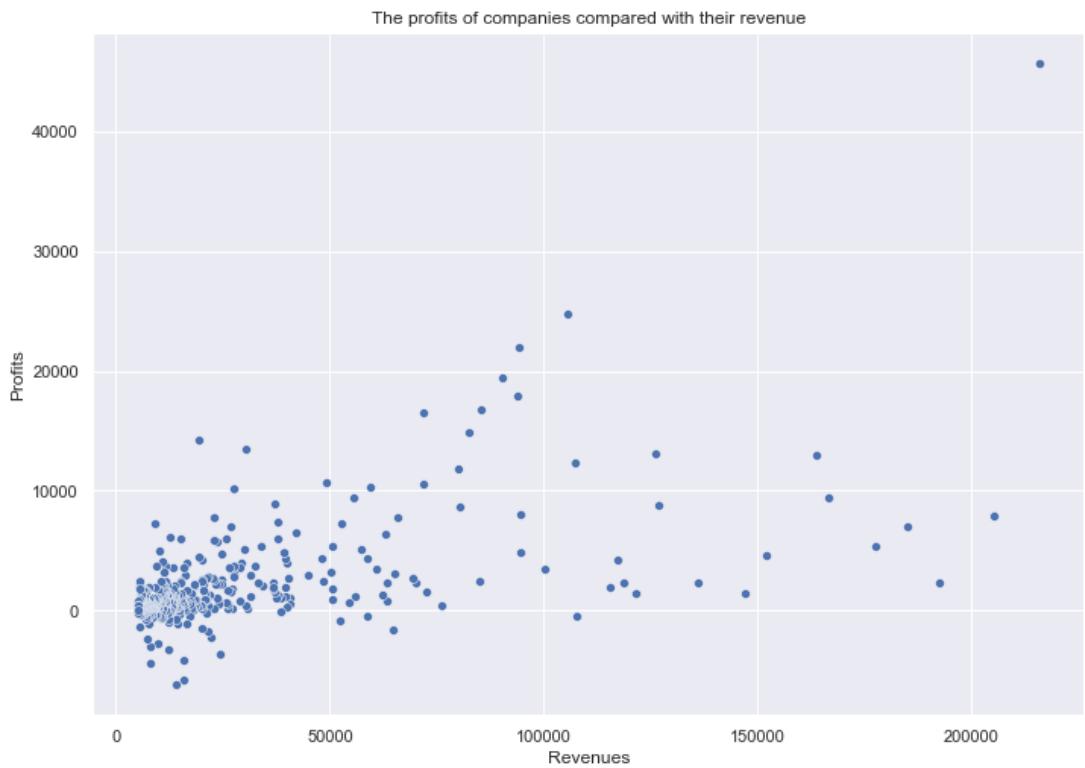
Comparing Revenues with profits to see if there is a relationship between them.

```
[1210]: sns.set(rc={'figure.figsize':(11.7,8.27)})
ax = sns.scatterplot(y ='Profits', x = 'Revenues', data = df, cmap="crest")
plt.ylabel('Profits (million USD)')
plt.title("The profits of companies compared with their revenue")
plt.show()
```

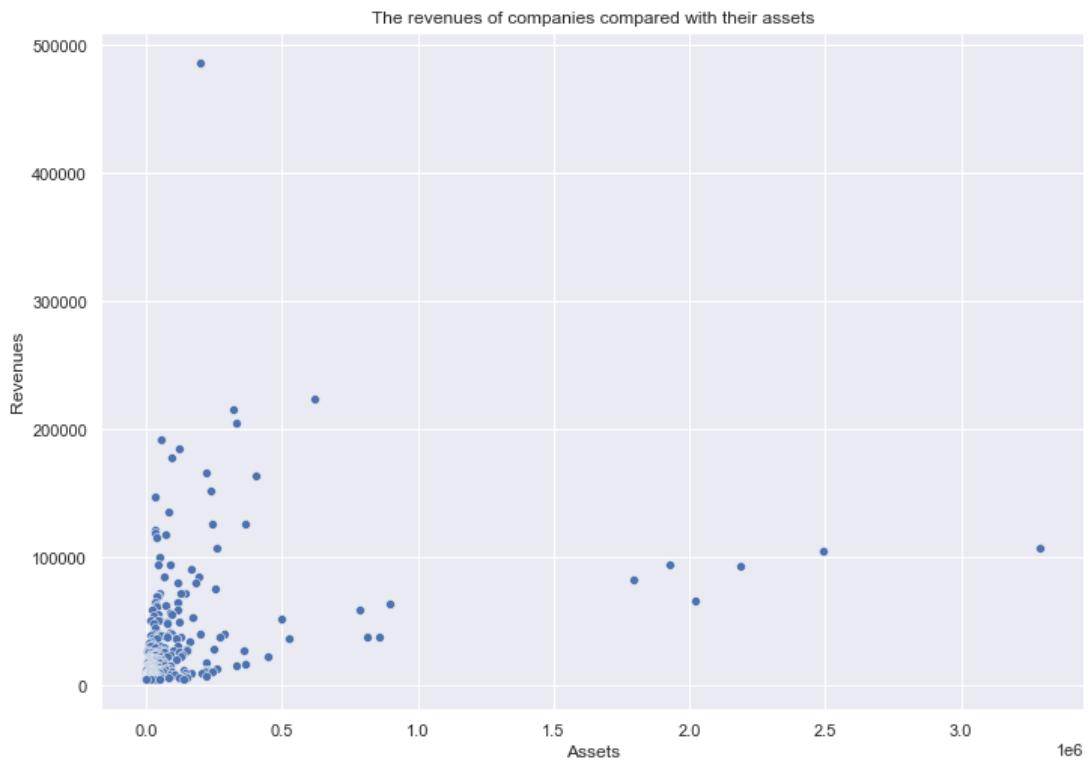


There are 2 outliers identified from the scatter plot above, one with significantly higher profits (Apple) and the other with significantly higher revenue (Walmart). In an attempt to discern a clearer pattern a graph without these outliers will be plotted

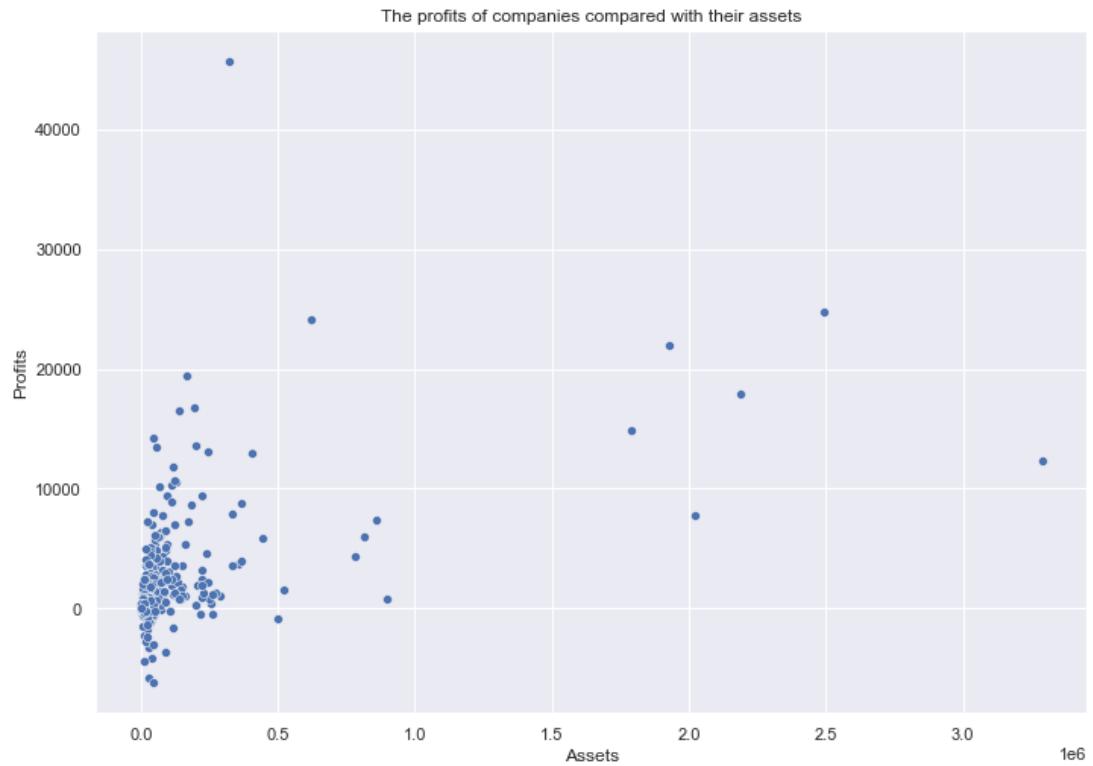
```
[279]: walmart_removed_df = df.drop(0)
apple_walmart_removed_df = walmart_removed_df.drop(1)
ax = sns.scatterplot(y = 'Profits', x = 'Revenues', data = apple_walmart_removed_df, cmap="crest")
plt.title("The profits of companies compared with their revenue")
plt.show()
```



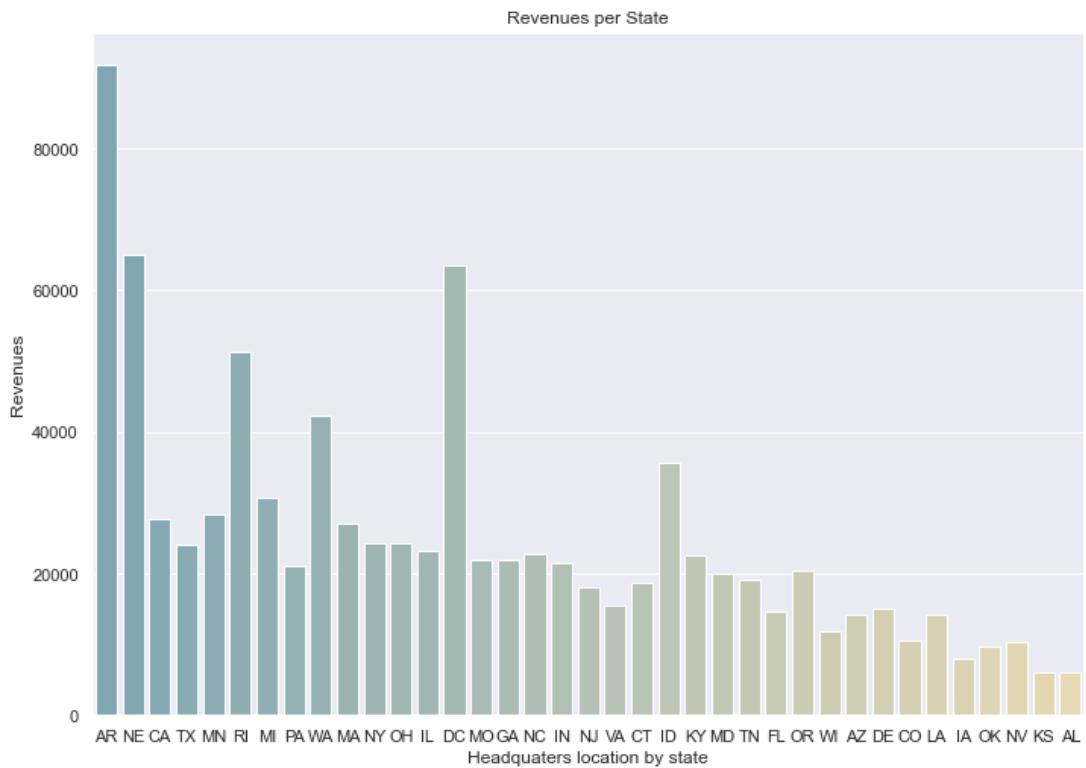
```
[280]: ax = sns.scatterplot(y ='Revenues', x = 'Assets', data = df, cmap="crest")
plt.title("The revenues of companies compared with their assets")
plt.show()
```



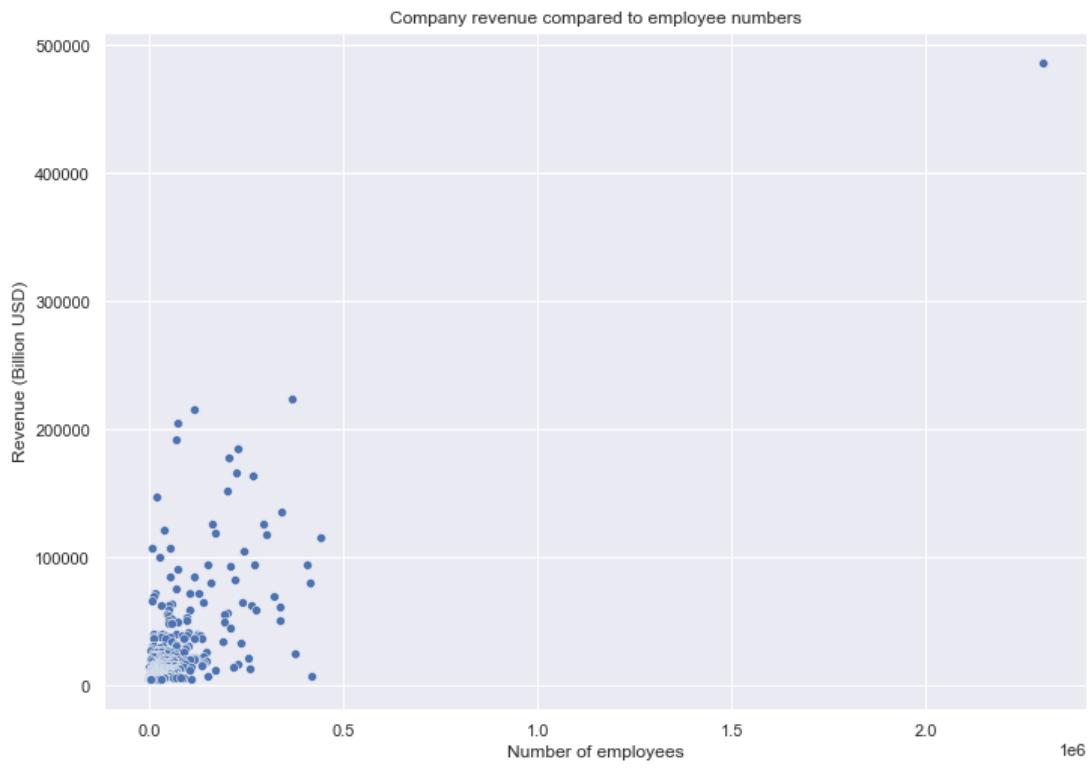
```
[209]: ax = sns.scatterplot(y ='Profits', x = 'Assets', data = df, cmap="crest")
plt.title("The profits of companies compared with their assets")
plt.show()
```



```
[210]: ax = sns.barplot(y ='Revenues', x = 'Hqstate', data = df, ci=None, palette =  
    ↪'blend:#7AB,#EDA')  
plt.title("Revenues per State")  
plt.xlabel("Headquarters location by state")  
plt.show()
```

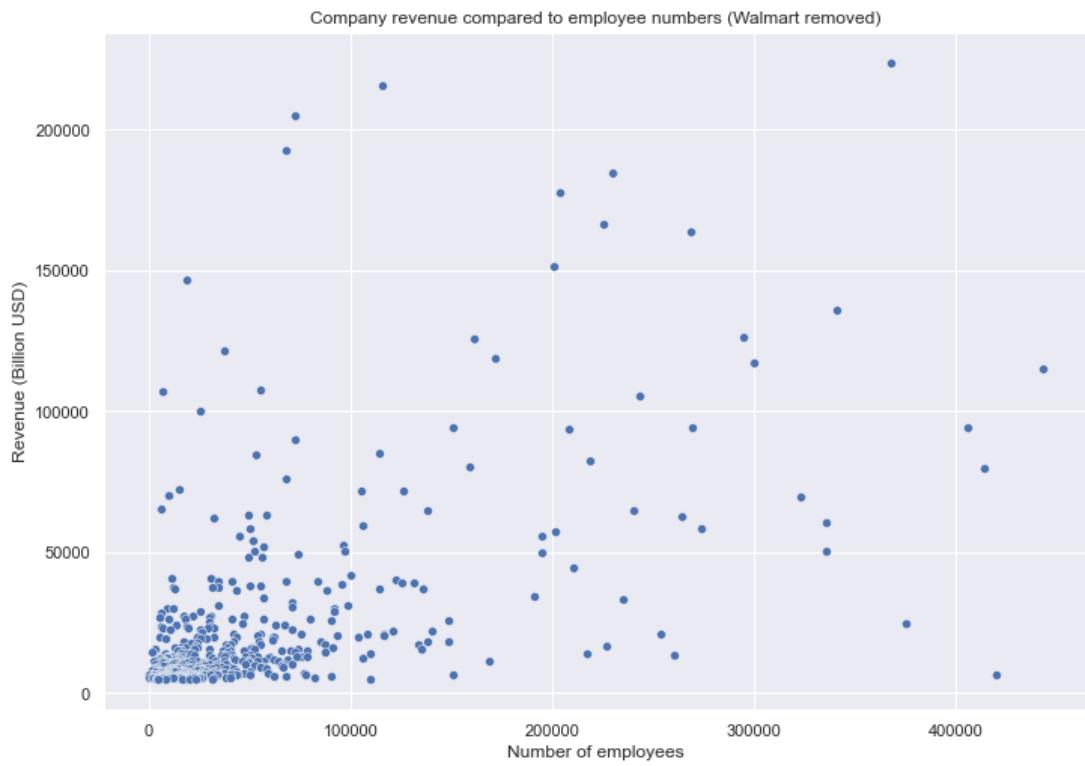


```
[211]: sns.scatterplot(data=df, x='Employees', y='Revenues', cmap="crest")
plt.title("Company revenue compared to employee numbers")
plt.xlabel("Number of employees")
plt.ylabel("Revenue (Billion USD)")
plt.ticklabel_format(style='plain', axis='y')
plt.show()
```



This graph may be more helpful with walamart removed as it has been identified as an outlier in both of these categories and is changing the scale.

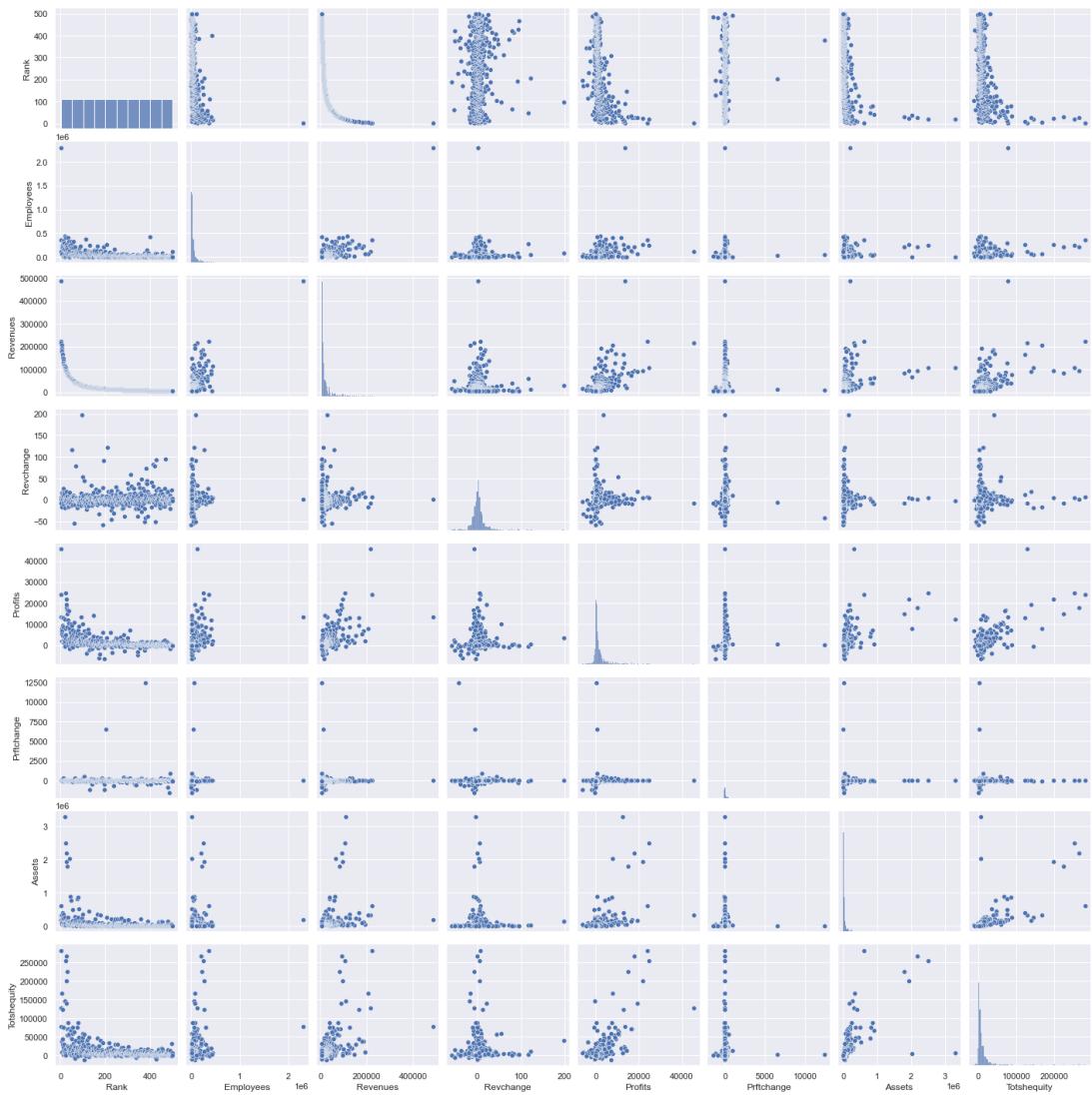
```
[212]: sns.scatterplot(data=walmart_removed_df, x='Employees', y='Revenues',  
                     cmap="crest")  
plt.title("Company revenue compared to employee numbers (Walmart removed)")  
plt.xlabel("Number of employees")  
plt.ylabel("Revenue (Billion USD)")  
plt.ticklabel_format(style='plain', axis='y')  
plt.show()
```



2.1.11 Pair plot showing the relationship between all linear variables.

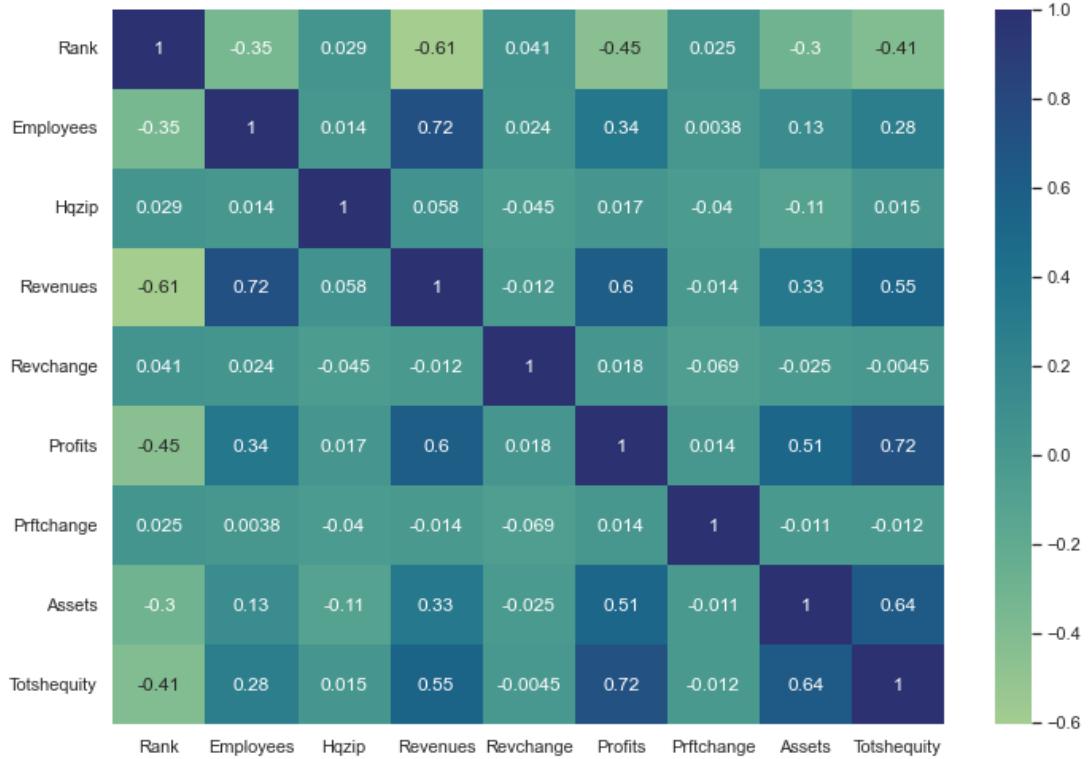
Pair plots are a good method to identify trends for follow-up analysis. Seeing the relationships between all the numerical values unearth some patterns previously unspotted in the data.

```
[1071]: sns.pairplot(df, diag_kind='hist')
plt.show()
```



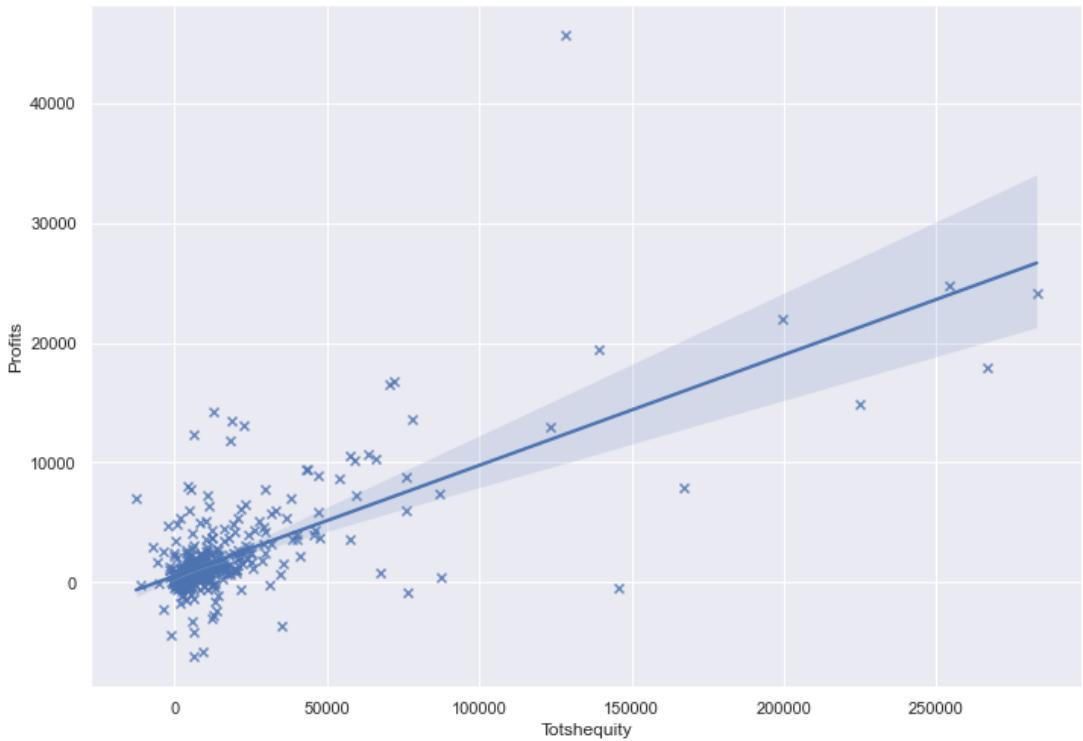
Correlation heatmaps show the strength of the relationship between each of the values. The higher the number the stronger the correlation. Negative numbers have inverse correlation (as one goes up the other goes down).

```
[222]: corr = df.corr()
        heatmap = sns.heatmap(corr, annot=True, cmap="crest")
        plt.show()
```



By looking at the Profit row correlation between other variables can be determined. There seems to be a good correlation between Totshequity, Revenues, Assets and Employees. The features selected by the model will be decided by an algorithm but this map gives a clue as to what they may be.

```
[1209]: sns.regplot(y=df.Profits, x=df.Totshequity, marker="x")
plt.show()
```



3 Section 2: Machine Learning Models

Now that the dataset has been explored, cleaned of extra features and outliers have been identified, it is time to begin training some models.

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3.1 Model 1 - Multiple Linear Regression

This model uses multiple variables to predict a target feature. It is similar to linear regression which is a simpler form which only takes 1 variable to predict a target feature. Each feature is weighted using a coefficient based on their impact.

```
[865]: #Importing models needed to perform Multiple regression.
from sklearn import linear_model
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.metrics import accuracy_score
from sklearn.datasets import make_regression
from sklearn.model_selection import train_test_split
```

```

from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import f_regression
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_absolute_error

```

3.1.1 Model 1.1

Firstly, the model will be constructed using features identified as having a good correlation with the target value profits. The dataset including outliers like Walmart, Apple and Fannie Mae who have higher Revenues, Profits and Assets respectively. The features will not be scaled in this model to get a base line to see if standardisation improves the predictions. The predicted results will be plotted against the true profits and the mean squared error will be calculated.

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```

[1061]: # feature selection: This function selects the best 4 features to use to
#predict profits based of the statistical method that takes the best k features
#where k is defined as a function.
def select_features(X_train, y_train, X_test):
    # configure to select a subset of features
    fs = SelectKBest(score_func=f_regression, k=4)
    # learn relationship from training data
    fs.fit(X_train, y_train)
    # transform train input data
    X_train_fs = fs.transform(X_train)
    # transform test input data
    X_test_fs = fs.transform(X_test)
    return X_train_fs, X_test_fs, fs

```

```

[871]: #Setting X as the variables Employees, Revenues, Assets, Total Shared Equity
#and Profit Change to predict y.
#Setting y as the target value to predict Profit.
X1 = df[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange']]
y1 = df['Profits']
print(X1)
print('-----')
print(y1)
print('-----')

```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	2300000	485873	198825	77798.0	0.8	-7.2
1	367700	223604	620854	283001.0	6.1	0.0
2	116000	215639	321686	128249.0	-7.7	-14.4
3	72700	205004	330314	167325.0	-16.7	-51.5
4	68000	192487	56563	8924.0	6.2	53.0
..
495	31000	5197	2148	-1698.0	5.8	4.2

```

496      4200      5170     9737     4229.0      23.9      5.2
497      8500      5169    48083    31049.0       4.0      5.2
498      4431      5164   15167     6597.0       4.0      5.2
499    110000      5145    2281      974.0      -2.8     -25.0

```

[500 rows x 6 columns]

```

0      13643.0
1      24074.0
2      45687.0
3      7840.0
4      2258.0
...
495     378.2
496     382.1
497    -214.3
498    -214.3
499      57.2
Name: Profits, Length: 500, dtype: float64

```

A solution to overfitting is a procedure called cross-validation (CV for short). K-fold CV, the training set is split into k smaller sets. A procedure is then carried out on all k training sets:

A model is trained using $k - 1$ of the folds as training data;

the resulting model is validated on the remaining part of the data (i.e., it is used as a test set to compute a performance measure such as accuracy).

The performance measure reported by k-fold cross-validation is then the average of the values computed in the loop.

```
[872]: #K Fold validation splits the data into multiple sets and tests the models
#accuracy to avoid selecting an overfitted model
cv = KFold(n_splits=8, random_state=1, shuffle=True)
```

Data is split into testing and training data, 30% is testing data and the other 70% is training data. This is done using the skit-learn package.

```
[982]: x1_train, x1_test, y1_train, y1_test = train_test_split(X1 , y1, test_size = 0.
                                                               ↪3)
x1_train_fs, x1_test_fs, fs = select_features(x1_train, y1_train, x1_test)
```

A linear regression model is fit to the training data and the negative root mean squared error for the k fold cross validation is calculated.

```
[1062]: regr = linear_model.LinearRegression()
regr.fit(x1_train_fs, y1_train)
scores1 = cross_val_score(regr, x1_test_fs, y1_test, cv=cv, scoring = ↪
                           'neg_root_mean_squared_error')
```

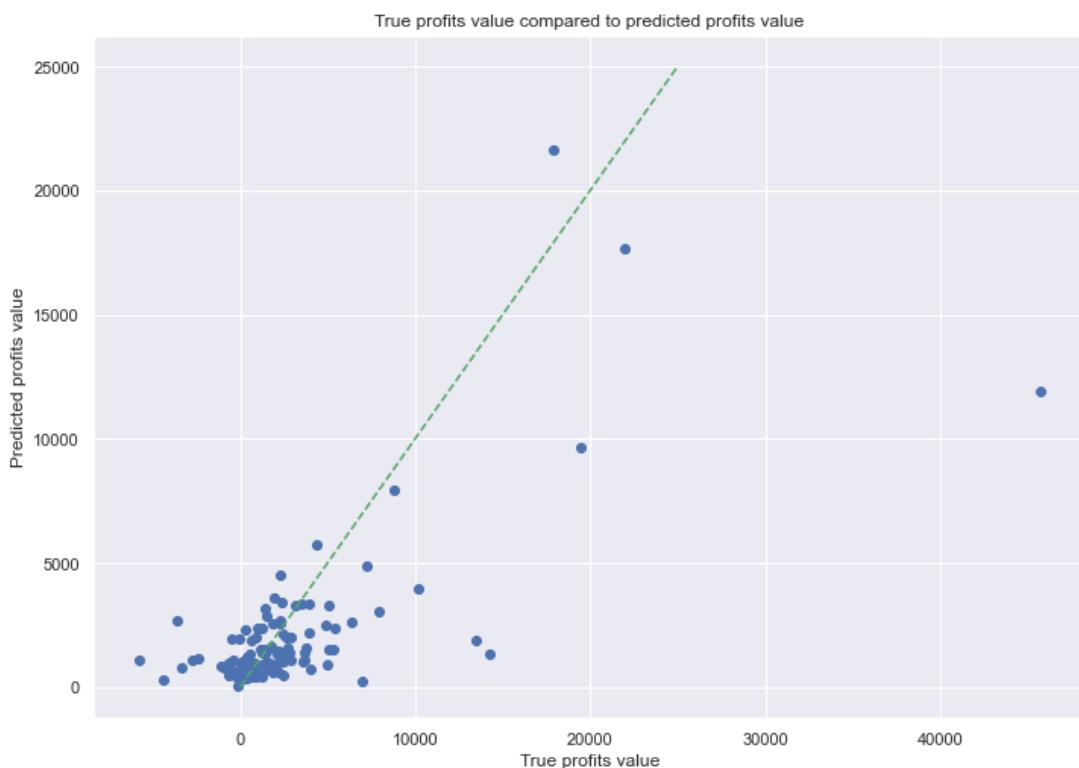
The coefficients show how much the factor impacts the prediction. If a coefficient is larger than others then it has a bigger impact. Totshequity had the largest coefficient and Employees the smallest.

```
[1063]: predictions = regr.predict(x1_test_fs)
pd.DataFrame(regr.coef_, ['Employees', "Revenues", "Assets", "Totshequity"],  
             columns = ['Coefficient'])
```

	Coefficient
Employees	0.001907
Revenues	0.018877
Assets	0.002524
Totshequity	0.051798

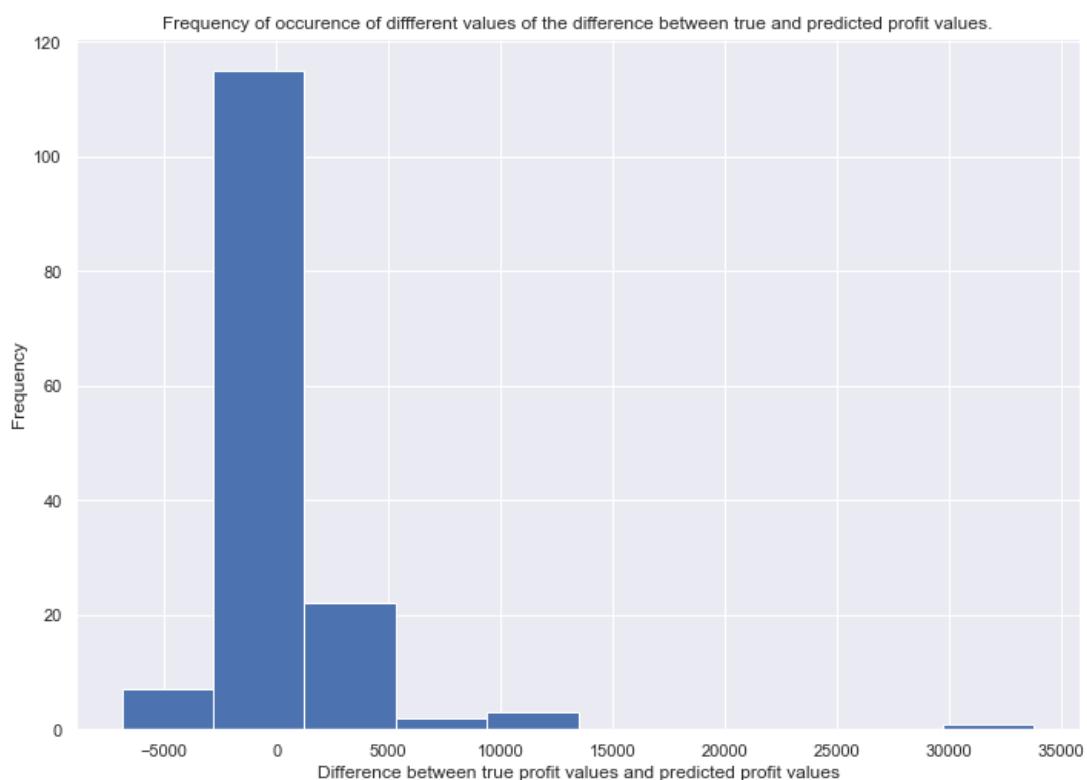
A good way to analysis the sucess of each model is to visualise the data. The graph below shows the predicted profit values against the true profit values. A completely accurate prediction will fall on the green dotted line $x=y$.

```
[1065]: plt.scatter(y1_test, predictions)
plt.plot([0,10000,25000],[0, 10000,25000], color = 'g', linestyle='dashed',  
         label= "Line to show where predicted profits equal actual profits")
plt.title('True profits value compared to predicted profits value')
plt.xlabel('True profits value')
plt.ylabel('Predicted profits value')
plt.show()
```



This histogram shows the frequency of different bands of error. A successful model will have a very large band around 0 and very little anywhere else.

```
[986]: plt.hist(y1_test - predictions)
plt.title('Frequency of occurrence of different values of the difference between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()
```



This graph plots Predicted profits against true profits, it highlights that the model has difficulty predicting negative profits.

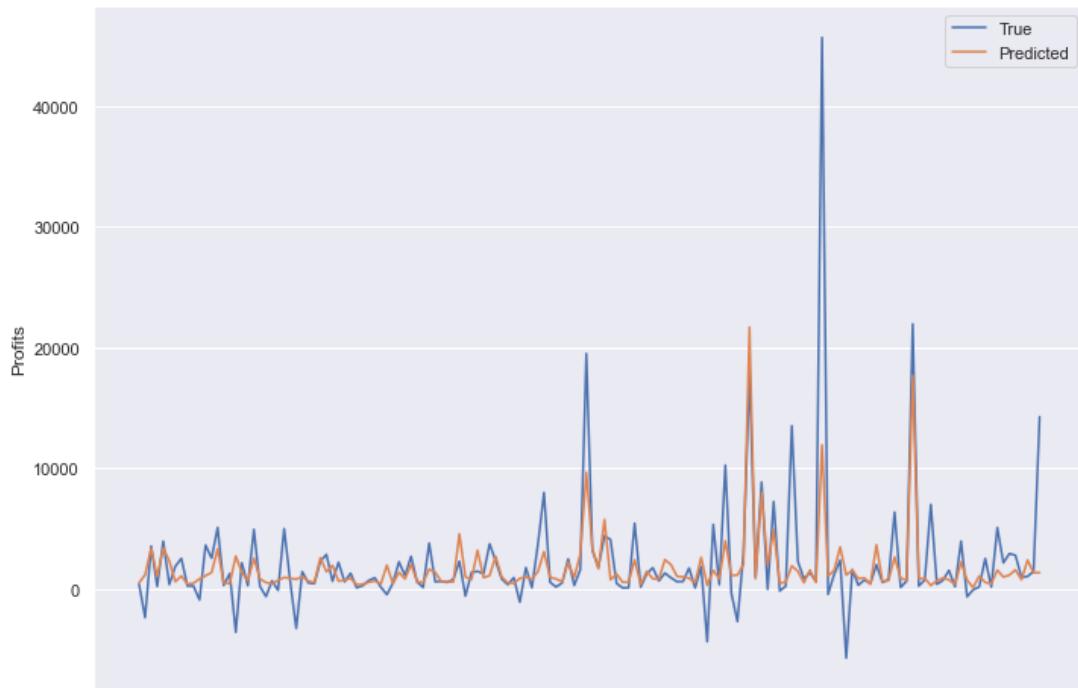
```
[1072]: pred1_df = pd.DataFrame(predictions)
x1_df = pd.DataFrame(x1_test.iloc[:,0])

plt.plot(range(len(y1_test)), y1_test)
plt.plot(range(len(predictions)), predictions)
plt.ylabel('Profits')
plt.legend(['True', 'Predicted'])
```

```

plt.xticks(())
plt.show()

```



There are multiple possible metrics to measure the performance of the model. The selected metrics are explained below.

Negative Root Mean Squared Error (NRMSE) is the negative root average of the difference between the Original Values and the Predicted Values on the cross validated set. An accurate model will minimise the Negative Root Mean Squared Error.

Given by the equation below:

$$NRMSE = -\sqrt{\frac{\sum_{j=1}^N (y_j - \hat{y}_j)^2}{N}}$$

R-Squared is a statistical measure of fit that indicates how much variation of a dependent variable is explained by the independent variable(s) in a regression model.

Mean Absolute Error (MAE) is the average of the difference between the Original Values and the Predicted Values. An accurate model will minimise the mean absolute error.

Given by the equation:

$$MAE = \frac{1}{N} \sum_{j=1}^N |y_j - \hat{y}_j|$$

Mean Squared Error takes the average of the square of the difference between the original values and the predicted values. An accurate model will minimise the mean squared error.

Given by the equation:

$$MSE = \frac{1}{N} \sum_{j=1}^N (y_j - \hat{y}_j)^2$$

MAE gives an idea of how far away predictions are from the true values, it is sensitive to results with opposite signs as negative results can cancel out positive results. MSE does not have this problem as all values are positive. It is sensitive to outliers as large numbers get much bigger when squared than normal numbers.

All of these metrics will be calculated to give a holistic look at how accurate the model is.

```
[1082]: #Using sklearn's metric package mean absolute error and mean squared error can
    ↪be calculated.
mae = metrics.mean_absolute_error(y1_test, predictions)
mse = metrics.mean_squared_error(y1_test, predictions)
r2 = metrics.r2_score(y1_test, predictions)
print('-----')
print(f"Negegative root mean squared error : mean: {scores1.mean()} standard_
    ↪deviation: {scores1.std()}")
print('-----')
print('R2 score = ', (r2))
print('-----')
print('Mean absolute error = ', (mae))
print('-----')
print('Mean squared error = ', (mse))
print('-----')
```

3.1.2 Model 1.2

This model will be the same as the previous model other than the fact all features will be standardised using the StandardScaler method in sklearn. Feautures are scales so that they can be compared if they have different units. The standard score of a sample x is calculated as:

$$z = (x - u) / s$$

where u is the mean of the training samples, and s is the standard deviation of the training samples.

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```
[1123]: # StandardScaler is used on the 4 hyperparameters and the target value, this means all the hyperparameters have a
df_scaled = df[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange', 'Profits']]
df_scaled = StandardScaler().fit_transform(df_scaled.to_numpy())
df_scaled = pd.DataFrame(df_scaled, columns=['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange', 'Profits'])
X2 = df_scaled[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange']]
y2 = df_scaled['Profits']
print(X2)
print('-----')
print(y2)
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	18.192467	12.056745	0.438399	2.104046	-0.148289	-0.052097
1	2.524557	5.208811	2.000571	8.833642	0.117408	-0.040993
2	0.483666	5.000843	0.893178	3.758577	-0.574408	-0.063202
3	0.132572	4.723159	0.925115	5.040068	-1.025592	-0.120421
4	0.094462	4.396336	-0.088195	-0.154665	0.122421	0.040749
..
495	-0.205550	-0.493871	-0.289616	-0.503012	0.102369	-0.034515
496	-0.422855	-0.494576	-0.261525	-0.308637	1.009750	-0.032973
497	-0.387989	-0.494602	-0.119584	0.570920	0.012132	-0.032973
498	-0.420982	-0.494732	-0.241426	-0.230979	0.012132	-0.032973
499	0.435016	-0.495228	-0.289124	-0.415384	-0.328763	-0.079550

[500 rows x 6 columns]

```
-----
0      3.015930
1      5.667686
2     11.162118
3      1.540698
4      0.121649
      ...
495    -0.356232
496    -0.355240
497    -0.506856
498    -0.506856
499    -0.437836
Name: Profits, Length: 500, dtype: float64
-----
```

```
[1124]: cv = KFold(n_splits=5, random_state=1, shuffle=True)
```

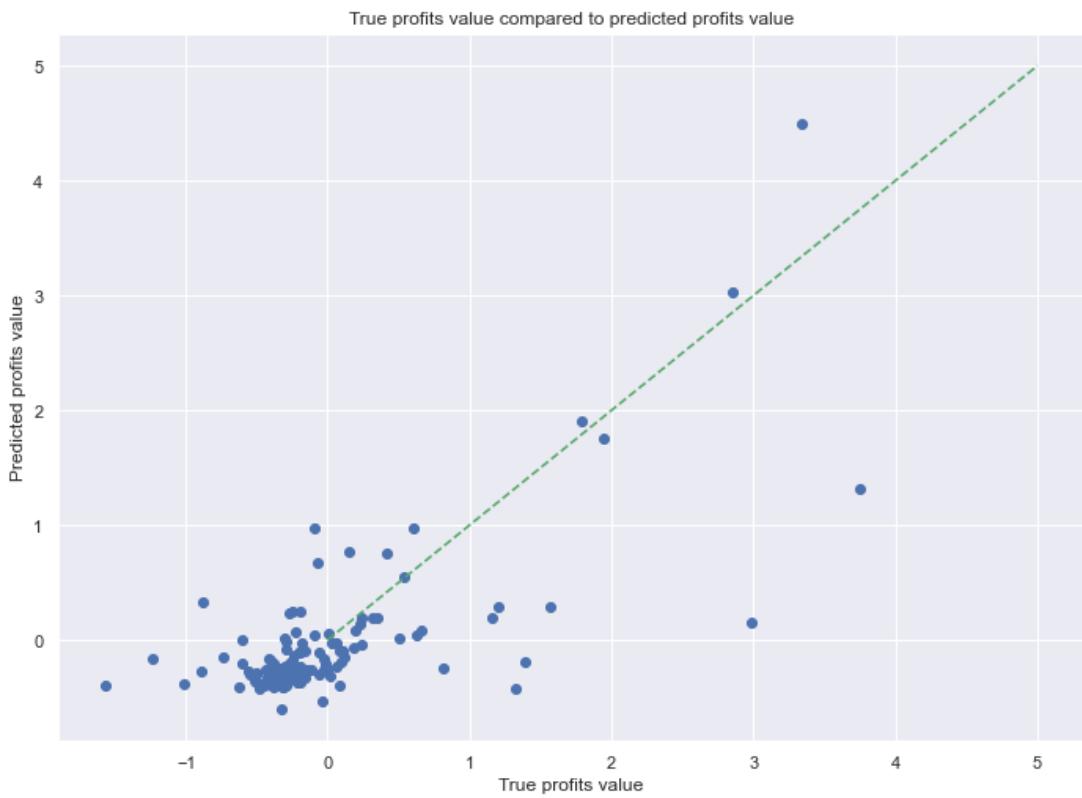
```
[1125]: X2_train, X2_test, y2_train, y2_test = train_test_split(X2 , y2, test_size = 0.  
    ↪3)  
X2_train_fs, X2_test_fs, fs = select_features(X2_train, y2_train, X2_test)
```

```
[1167]: regr = linear_model.LinearRegression()  
regr.fit(X2_train_fs, y2_train)  
scores2 = cross_val_score(regr, X2_test, y2_test, cv=cv, scoring =  
    ↪'neg_root_mean_squared_error')
```

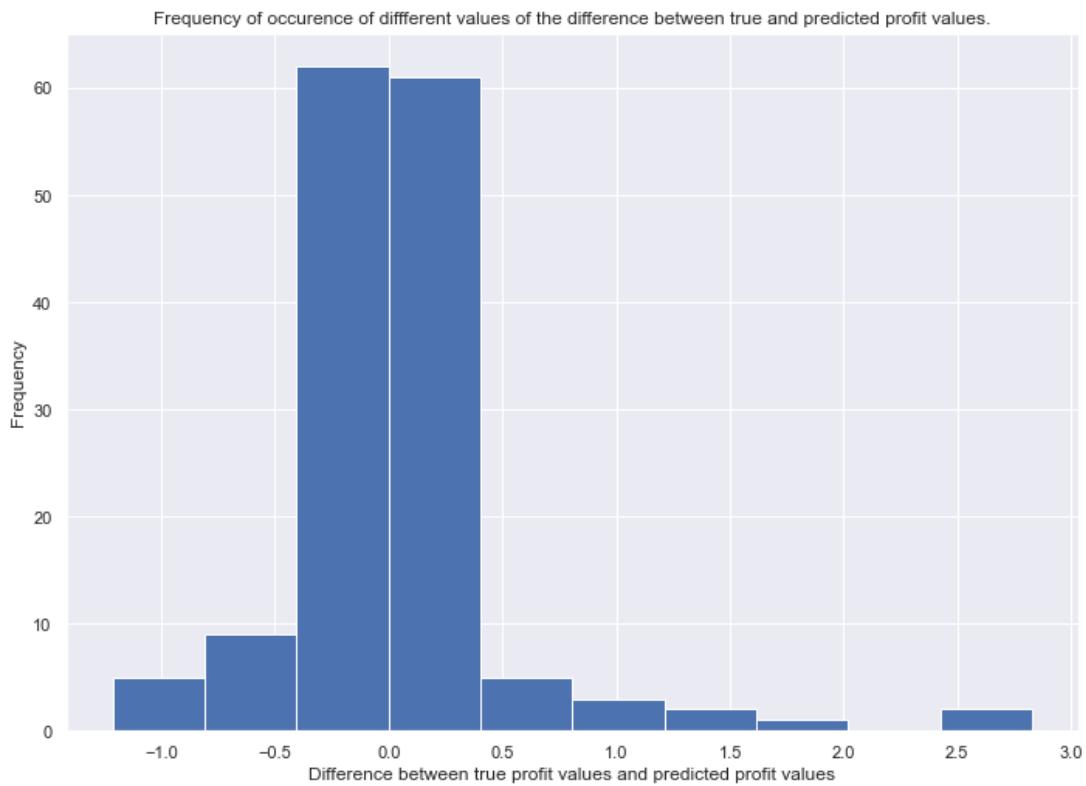
```
[1127]: predictions2 = regr.predict(X2_test_fs)  
pd.DataFrame(regr.coef_, ['Employees', 'Revenues', "Assets", "Totshequity"],  
    ↪columns = ['Coefficient'])
```

```
[1127]:           Coefficient  
Employees      -0.074261  
Revenues        0.360205  
Assets          0.119924  
Totshequity     0.474350
```

```
[1128]: plt.scatter(y2_test, predictions2)  
plt.plot([0,1,5],[0, 1,5], color = 'g', linestyle='dashed', label= "Line to  
    ↪show where predicted profits equal actual profits")  
plt.title('True profits value compared to predicted profits value')  
plt.xlabel('True profits value')  
plt.ylabel('Predicted profits value')  
plt.show()
```



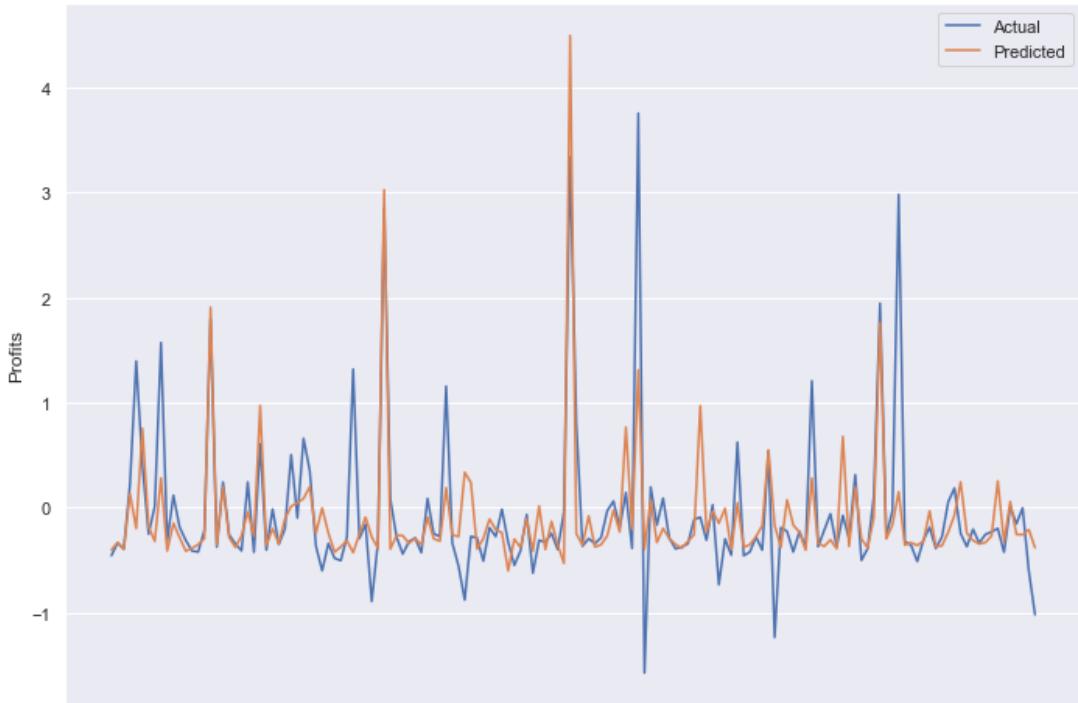
```
[1129]: plt.hist(y2_test - predictions2)
plt.title('Frequency of occurrence of different values of the difference between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()
```



```
[1130]: pred2_df = pd.DataFrame(predictions2)
x2_df = pd.DataFrame(X2_test.iloc[:,0])

plt.plot(range(len(y2_test)), y2_test)
plt.plot(range(len(predictions2)), predictions2)
plt.ylabel('Profits')
plt.legend(['Actual', 'Predicted'])
plt.xticks(())

plt.show()
```



[1132]: #Using sklearns metric package mean absolute error and mean squared error can be calculated.

```

mae2 = metrics.mean_absolute_error(y2_test, predictions2)
mse2 = metrics.mean_squared_error(y2_test, predictions2)
r2_2 = metrics.r2_score(y2_test, predictions2)
print('-----')
print(f"Negative root mean squared error: mean: {scores2.mean()} standard deviation: {scores2.std()}")
print('-----')
print('R2 score = ',(r2))
print('-----')
print('Mean absolute error = ',(mae))
print('-----')
print('Mean squared error = ',(mse))
print('-----')

```

Negative root mean squared error: mean: -0.6299711990022783 standard deviation: 0.4322145670772607

R2 score = 0.5264293469574413

Mean absolute error = 0.27009261092725895

```
Mean squared error =  0.2520722214947627
```

3.1.3 Model 1.3

This model will remove companies that are outliers in multiple categories in the features and predicted values. The data is not scaled for this model.

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```
[997]: df_no_out = df.drop([1, 2, 20, 24, 25, 26, 0, 3, 8, 29])
df_no_out.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 490 entries, 4 to 499
Data columns (total 13 columns):
 #   Column      Non-Null Count  Dtype  
--- 
 0   Rank        490 non-null    int64  
 1   Title       490 non-null    object  
 2   Employees   490 non-null    int64  
 3   Sector      490 non-null    object  
 4   Industry    490 non-null    object  
 5   Hqcity      490 non-null    object  
 6   Hqstate     490 non-null    object  
 7   Revenues    490 non-null    int64  
 8   Revchange   490 non-null    float64 
 9   Profits     490 non-null    float64 
 10  Prftchange  490 non-null    float64 
 11  Assets      490 non-null    int64  
 12  Totshequity 490 non-null    float64 
dtypes: float64(4), int64(4), object(5)
memory usage: 53.6+ KB
```

```
[998]: #Setting X as the variables Employees, Revenues, Assets, Total Shared Equity and Profit Change to predict y.
#Setting y as the target value to predict Profit.
X3 = df_no_out[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange']]
y3 = df_no_out['Profits']
print(X3)
print('-----')
print(y3)
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
4	68000	192487	56563	8924.0	6.2	53.0
5	230000	184840	122810	38274.0	17.7	20.7
6	204000	177526	94462	36830.0	15.8	1.5

```

7      225000    166380   221690      43836.0      9.2     -2.7
9      201000    151800   237951      29170.0      1.5    -37.7
...
495     ...       ...       ...       ...       ...
495      31000    5197    2148     -1698.0      5.8      4.2
496      4200    5170    9737     4229.0     23.9      5.2
497      8500    5169   48083    31049.0      4.0      5.2
498     4431    5164   15167     6597.0      4.0      5.2
499    110000    5145   2281      974.0     -2.8    -25.0

[490 rows x 6 columns]
-----
4      2258.0
5      7017.0
6      5317.0
7      9427.0
9      4596.0
...
495     378.2
496     382.1
497    -214.3
498    -214.3
499     57.2
Name: Profits, Length: 490, dtype: float64
-----
```

```
[999]: cv = KFold(n_splits=5, random_state=1, shuffle=True)
```

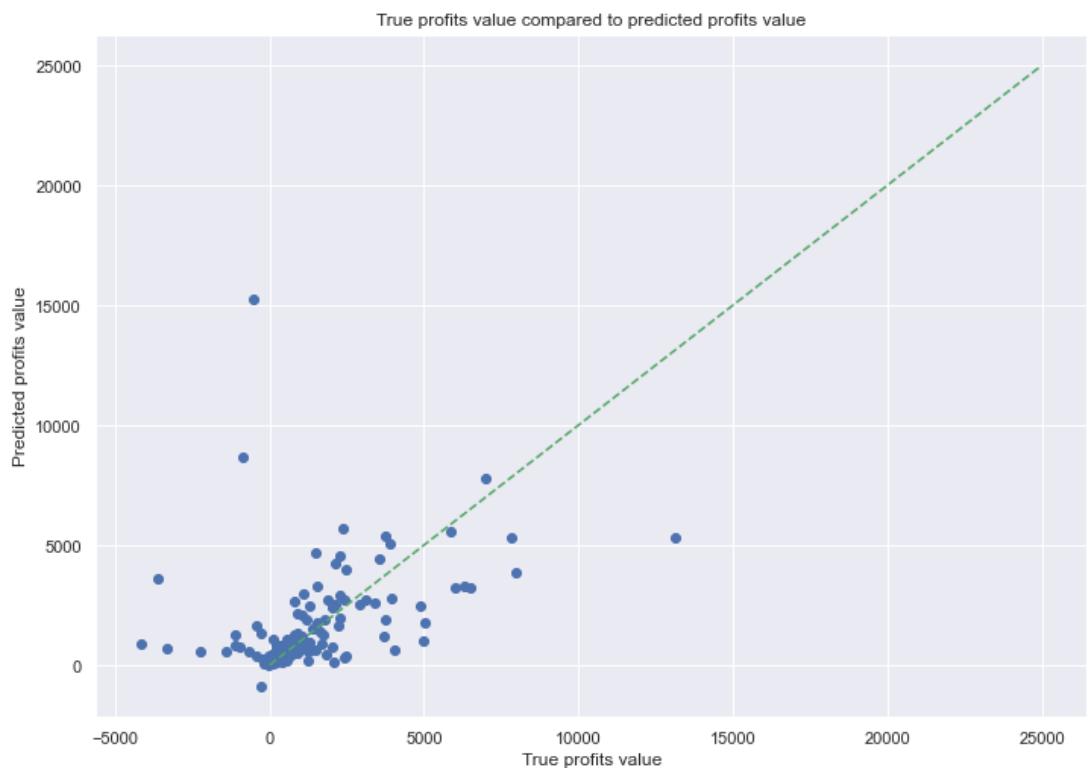
```
[1001]: X3_train, X3_test, y3_train, y3_test = train_test_split(X3 , y3, test_size = 0.
                                                               ↪3)
#Selecting the best 4 features to use
X3_train_fs, X3_test_fs, fs = select_features(X3_train, y3_train, X3_test)
```

```
[1243]: regr = linear_model.LinearRegression()
regr.fit(X3_train_fs, y3_train)
scores3 = cross_val_score(regr, X3_test_fs, y3_test, cv=cv, scoring = ↪
                           ↪'neg_root_mean_squared_error')
```

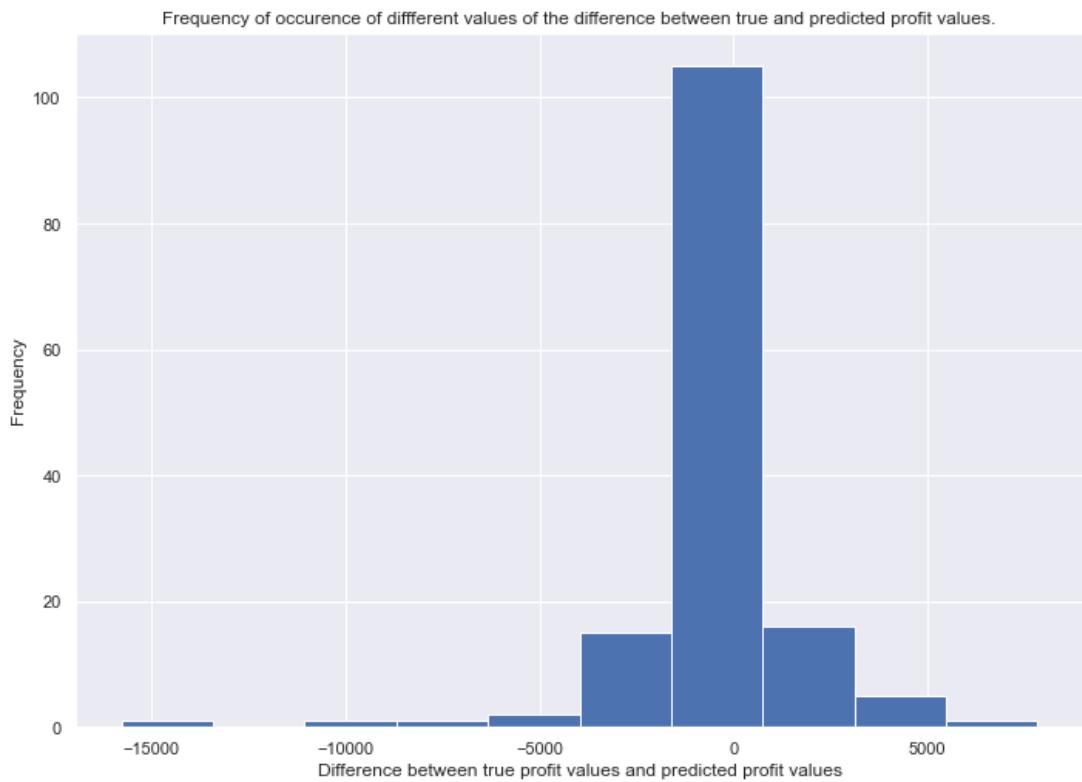
```
[1244]: predictions3 = regr.predict(X3_test_fs)
pd.DataFrame(regr.coef_, ['Employees' , 'Revenues' , 'Assets' , 'Totshequity'], ↪
                           ↪columns = ['Coefficient'])
```

```
[1244]:          Coefficient
Employees      0.004448
Revenues       0.018087
Assets         0.001869
Totshequity    0.087521
```

```
[1245]: plt.scatter(y3_test, predictions3)
plt.plot([0,10000,25000],[0, 10000,25000], color = 'g', linestyle='dashed',_
         label= "Line to show where predicted profits equal actual profits")
plt.title('True profits value compared to predicted profits value')
plt.xlabel('True profits value')
plt.ylabel('Predicted profits value')
plt.show()
```



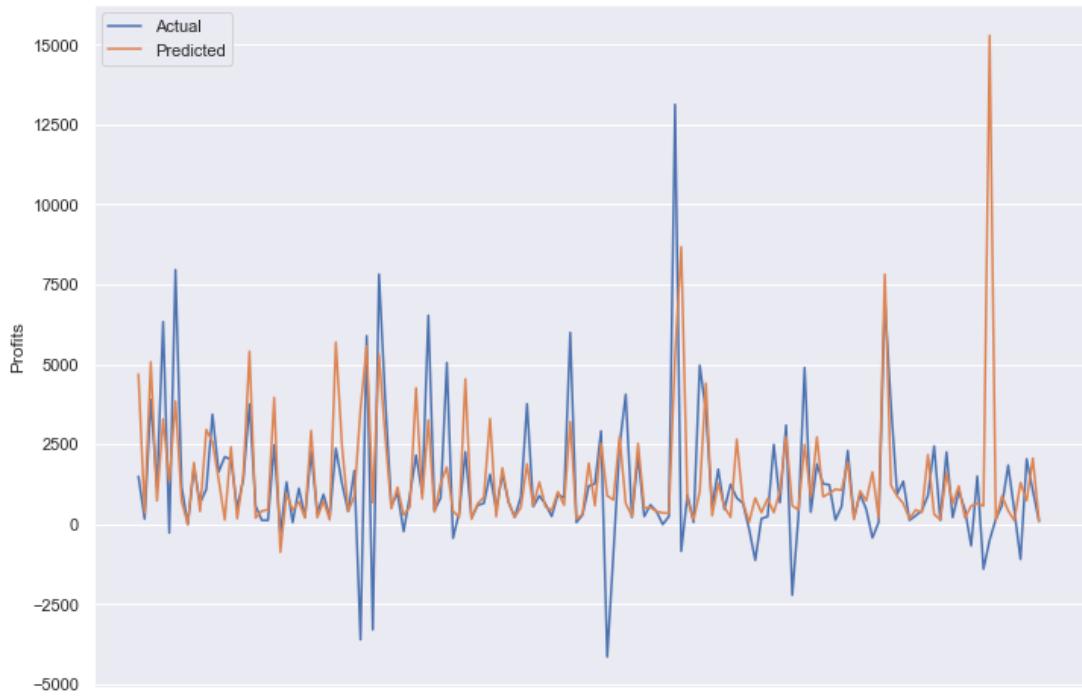
```
[1246]: plt.hist(y3_test - predictions3)
plt.title('Frequency of occurrence of different values of the difference_'
           'between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()
```



```
[1247]: pred3_df = pd.DataFrame(predictions3)
x3_df = pd.DataFrame(X3_test.iloc[:,0])

plt.plot(range(len(y3_test)), y3_test)
plt.plot(range(len(predictions3)), predictions3)
plt.ylabel('Profits')
plt.legend(['Actual', 'Predicted'])
plt.xticks(())

plt.show()
```



```
[1006]: mae = metrics.mean_absolute_error(y3_test, predictions3)
mse = metrics.mean_squared_error(y3_test, predictions3)
r2 = metrics.r2_score(y3_test, predictions3)
print('-----')
print(f"Negative Root Mean squared error: mean: {scores3.mean()} standard deviation: {scores3.std()}")
print('-----')
print('R2 score = ',(r2))
print('-----')
print('Mean absolute error = ',(mae))
print('-----')
print('Mean squared error = ',(mse))
print('-----')
```

Negative Root Mean squared error: mean: -1828.0764190904802 standard deviation:
447.4077844669261

R2 score = -0.08334878618751551

Mean absolute error = 1109.5690675450041

Mean squared error = 4869886.615090279

3.1.4 Model 1.4

This model will have the same outliers removed as Model 1.3 and it will be scaled using StandardScaler.

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```
[1274]: df_no_out = df.drop([1, 2, 20, 24, 25, 26, 0, 3, 8, 29])
df_no_out.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 490 entries, 4 to 499
Data columns (total 13 columns):
 #   Column      Non-Null Count  Dtype  
---  --  
 0   Rank        490 non-null    int64  
 1   Title       490 non-null    object 
 2   Employees   490 non-null    int64  
 3   Sector      490 non-null    object 
 4   Industry    490 non-null    object 
 5   Hqcity      490 non-null    object 
 6   Hqstate     490 non-null    object 
 7   Revenues    490 non-null    int64  
 8   Revchange   490 non-null    float64 
 9   Profits     490 non-null    float64 
 10  Prftchange  490 non-null    float64 
 11  Assets      490 non-null    int64  
 12  Totshequity 490 non-null    float64 
dtypes: float64(4), int64(4), object(5)
memory usage: 53.6+ KB
```

```
[1275]: df_scaled = df_no_out[['Employees', 'Revenues', 'Assets', 'Totshequity',
                             ↪ 'Revchange', 'Prftchange', 'Profits']]
df_scaled = StandardScaler().fit_transform(df_scaled.to_numpy())
df_scaled = pd.DataFrame(df_scaled, columns=['Employees', 'Revenues', 'Assets',
                                             ↪ 'Totshequity', 'Revchange', 'Prftchange', 'Profits'])
X4 = df_scaled[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange',
                 ↪ 'Prftchange']]
y4 = df_scaled['Profits']
print(X4)
print('-----')
print(y4)
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	0.278342	6.303331	-0.021002	-0.077202	0.119465	0.039323
1	2.658880	6.022231	0.314013	1.827107	0.691657	-0.009994
2	2.276819	5.753372	0.170656	1.733417	0.597121	-0.039309
3	2.585407	5.343650	0.814055	2.187985	0.268732	-0.045722

```

4      2.232735  4.807697  0.896288      1.236414  -0.114388  -0.099161
..
485   -0.265362 -0.581360 -0.296181     -0.766387   0.099562  -0.035186
486   -0.659179 -0.582352 -0.257803     -0.381827   1.000143  -0.033660
487   -0.595992 -0.582389 -0.063885      1.358329   0.010002  -0.033660
488   -0.655785 -0.582573 -0.230344     -0.228185   0.010002  -0.033660
489    0.895518 -0.583271 -0.295509     -0.593021  -0.328338  -0.079770

```

[490 rows x 6 columns]

```

0      0.332215
1      2.177311
2      1.518209
3      3.111684
4      1.238673
...
485   -0.396596
486   -0.395084
487   -0.626312
488   -0.626312
489   -0.521050
Name: Profits, Length: 490, dtype: float64

```

[1276]: `cv = KFold(n_splits=5, random_state=1, shuffle=True)`

[1277]: `X4_train, X4_test, y4_train, y4_test = train_test_split(X4 , y4, test_size = 0.
 ↪3)
X4_train_fs, X4_test_fs, fs = select_features(X4_train, y4_train, X4_test)`

[1278]: `regr = linear_model.LinearRegression()
regr.fit(X4_train_fs, y4_train)
scores4 = cross_val_score(regr, X4_test_fs, y4_test, cv=cv, scoring =
 ↪'neg_root_mean_squared_error')`

[1279]: `predictions4 = regr.predict(X4_test_fs)
pd.DataFrame(regr.coef_, ['Employees', "Revenues", 'Assets', "Totshequity"],
 ↪columns = ['Coefficient'])`

[1279]:

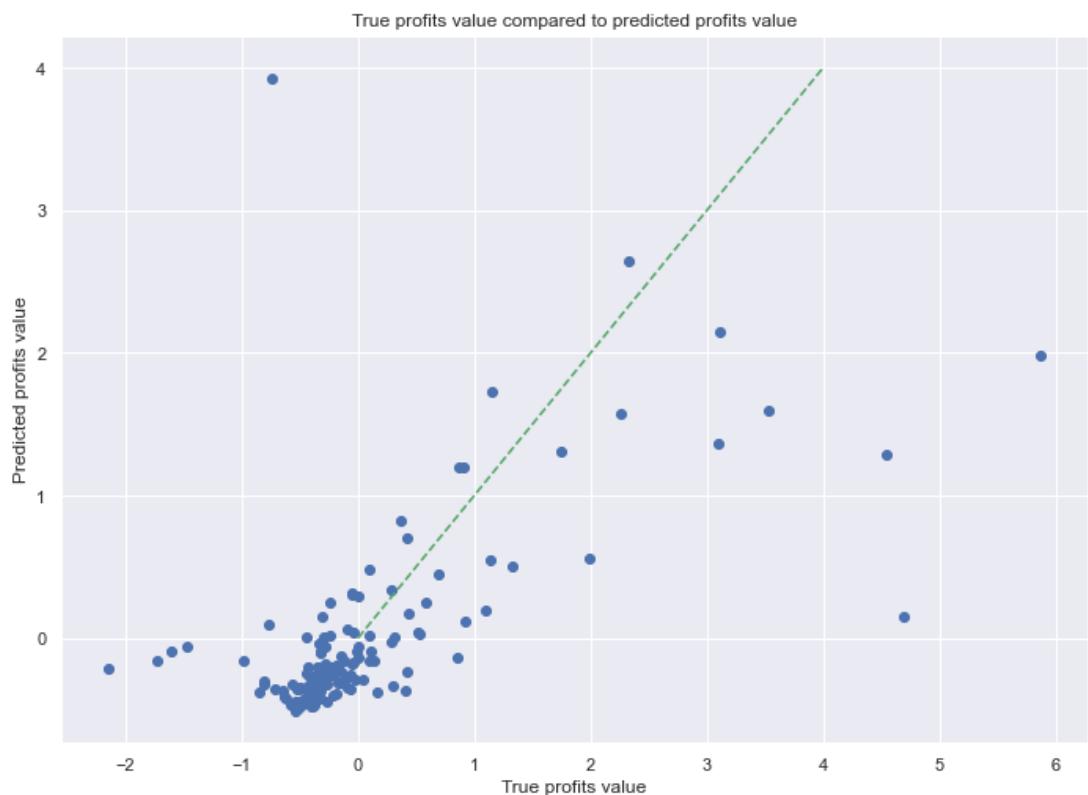
	Coefficient
Employees	0.168161
Revenues	0.142384
Assets	0.184460
Totshequity	0.373581

[1280]: `plt.scatter(y4_test, predictions4)`

```

plt.plot([0,1,4],[0, 1,4], color = 'g', linestyle='dashed', label= "Line to show where predicted profits equal actual profits")
plt.title('True profits value compared to predicted profits value')
plt.xlabel('True profits value')
plt.ylabel('Predicted profits value')
plt.show()

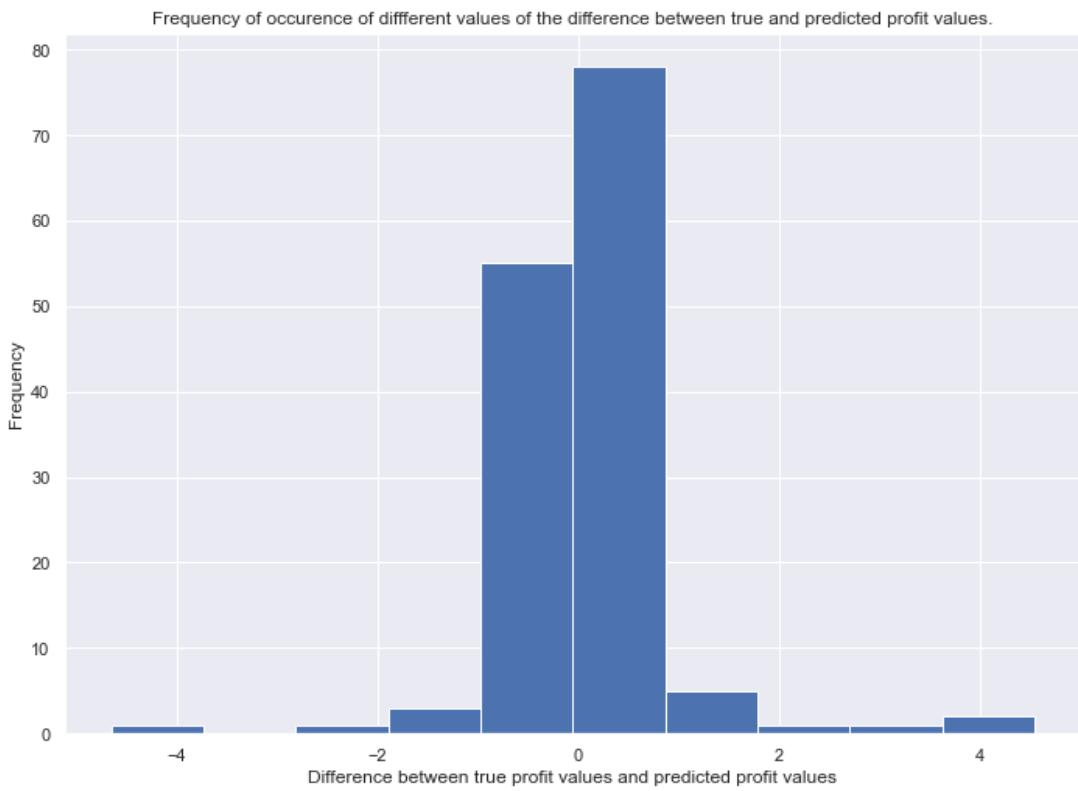
```



```

[1281]: plt.hist(y4_test - predictions4)
plt.title('Frequency of occurrence of different values of the difference between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()

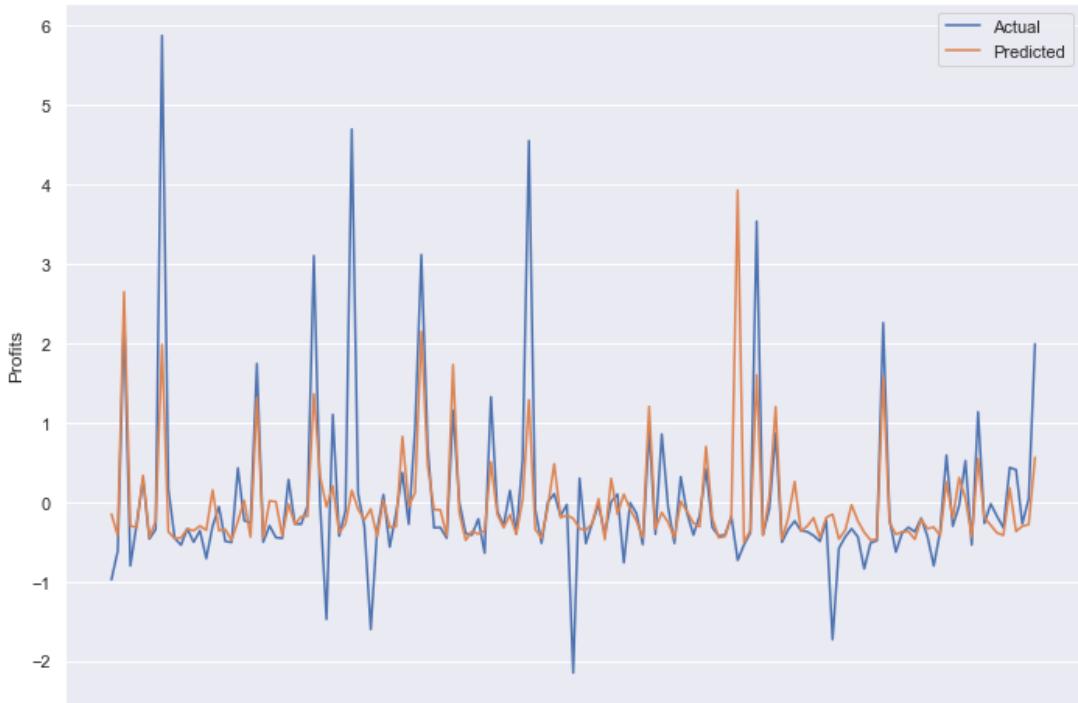
```



```
[1282]: pred4_df = pd.DataFrame(predictions4)
x4_df = pd.DataFrame(X4_test.iloc[:,0])

plt.plot(range(len(y4_test)), y4_test)
plt.plot(range(len(predictions4)), predictions4)
plt.ylabel('Profits')
plt.legend(['Actual', 'Predicted'])
plt.xticks(())

plt.show()
```



```
[1283]: mae = metrics.mean_absolute_error(y4_test, predictions4)
mse = metrics.mean_squared_error(y4_test, predictions4)
r2 = metrics.r2_score(y4_test, predictions4)
print('-----')
print(f"Negative root mean squared error: mean: {scores4.mean()} standard deviation: {scores4.std()}")
print('-----')
print('R2 score = ',(r2))
print('-----')
print('Mean absolute error = ',(mae))
print('-----')
print('Mean squared error = ',(mse))
print('-----')
```

Negative root mean squared error: mean: -0.9416822197882263 standard deviation:
0.45010117016273726

R2 score = 0.3956895910189271

Mean absolute error = 0.3962522091871683

Mean squared error = 0.6896081713494023

3.1.5 Model 1.5

Trying 6 features instead of 4 to see if they produce more accurate results. Data is not scaled for this attempt.

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```
[1284]: #Setting X as the variables Employees, Revenues, Assets, Total Shared Equity and Profit Change to predict y.  
#Setting y as the target value to predict Profit.  
X5 = df[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange',  
         'Prftchange']]  
y5 = df['Profits']  
print(X5)  
print('-----')  
print(y5)  
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	2300000	485873	198825	77798.0	0.8	-7.2
1	367700	223604	620854	283001.0	6.1	0.0
2	116000	215639	321686	128249.0	-7.7	-14.4
3	72700	205004	330314	167325.0	-16.7	-51.5
4	68000	192487	56563	8924.0	6.2	53.0
..
495	31000	5197	2148	-1698.0	5.8	4.2
496	4200	5170	9737	4229.0	23.9	5.2
497	8500	5169	48083	31049.0	4.0	5.2
498	4431	5164	15167	6597.0	4.0	5.2
499	110000	5145	2281	974.0	-2.8	-25.0

[500 rows x 6 columns]

```
-----  
0    13643.0  
1    24074.0  
2    45687.0  
3    7840.0  
4    2258.0  
...  
495   378.2  
496   382.1  
497   -214.3  
498   -214.3  
499   57.2  
Name: Profits, Length: 500, dtype: float64
```

```
[1285]: cv = KFold(n_splits=5, random_state=1, shuffle=True)
```

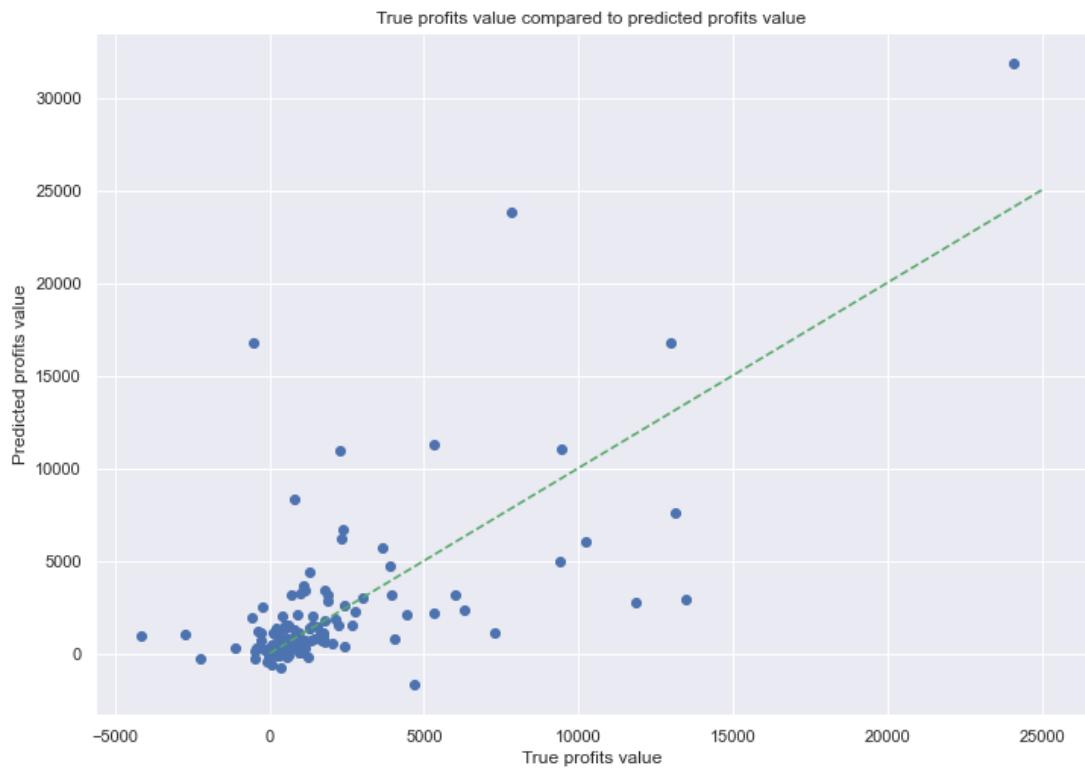
```
[1286]: x5_train, x5_test, y5_train, y5_test = train_test_split(X5 , y5, test_size = 0.  
↪3)
```

```
[1287]: regr = linear_model.LinearRegression()  
regr.fit(x5_train, y5_train)  
scores5 = cross_val_score(regr, x5_test, y5_test, cv=cv, scoring =  
↪'neg_root_mean_squared_error')
```

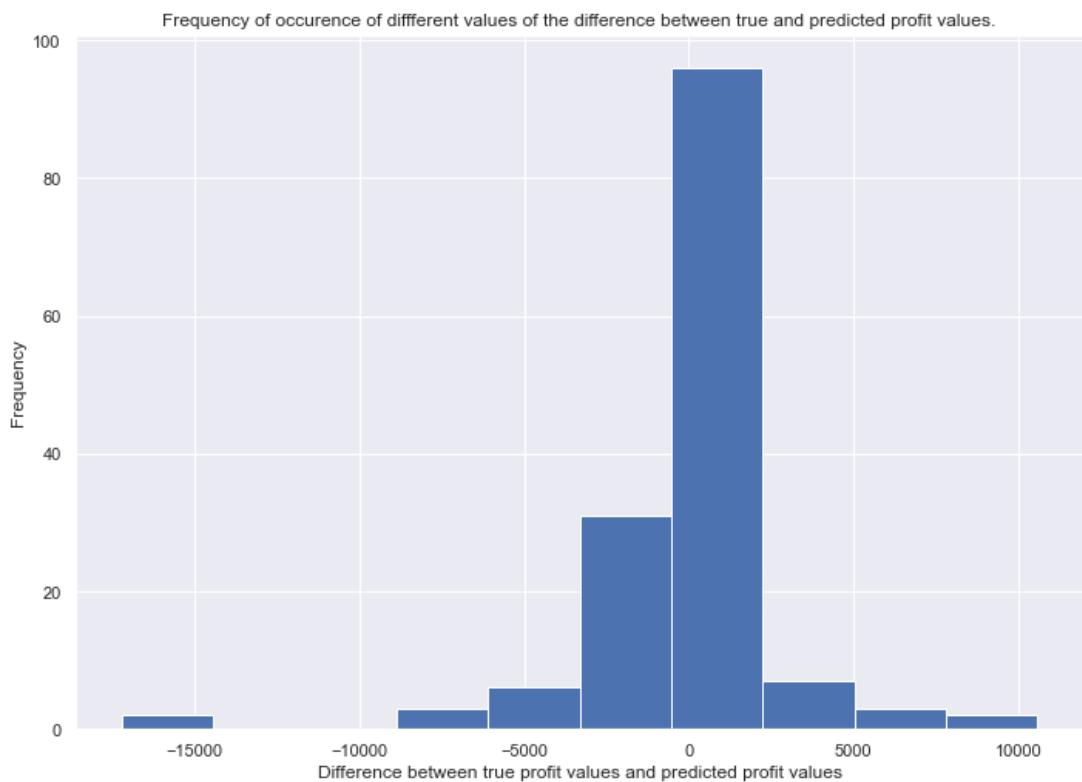
```
[1288]: predictions5 = regr.predict(x5_test)  
pd.DataFrame(regr.coef_, ["Employees", "Revenues", "Assets", "Totshequity",  
↪'Revchange', 'Prftchange'], columns = ['Coefficient'])
```

```
[1288]:          Coefficient  
Employees      -0.007177  
Revenues        0.056462  
Assets           0.000229  
Totshequity     0.077262  
Revchange        3.121790  
Prftchange       0.162452
```

```
[1289]: plt.scatter(y5_test, predictions5)  
plt.plot([0,10000,25000],[0, 10000,25000], color = 'g', linestyle='dashed',  
↪label= "Line to show where predicted profits equal actual profits")  
plt.title('True profits value compared to predicted profits value')  
plt.xlabel('True profits value')  
plt.ylabel('Predicted profits value')  
plt.show()
```



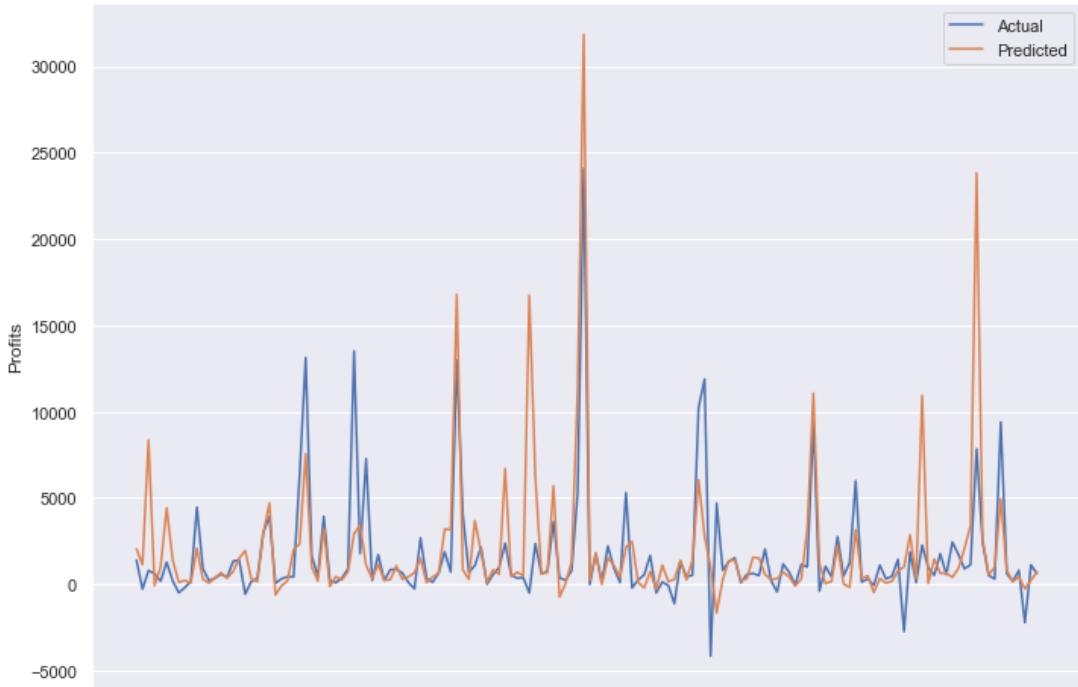
```
[1290]: plt.hist(y5_test - predictions5)
plt.title('Frequency of occurrence of different values of the difference between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()
```



```
[1291]: pred5_df = pd.DataFrame(predictions5)
x5_df = pd.DataFrame(x5_test.iloc[:,0])

plt.plot(range(len(y5_test)), y5_test)
plt.plot(range(len(predictions5)), predictions5)
plt.ylabel('Profits')
plt.legend(['Actual', 'Predicted'])
plt.xticks(())

plt.show()
```



```
[1292]: mae = metrics.mean_absolute_error(y5_test, predictions5)
mse = metrics.mean_squared_error(y5_test, predictions5)
r2 = metrics.r2_score(y5_test, predictions5)
print('-----')
print(f"Negative root mean squared error': mean: {scores5.mean()} standard deviation: {scores5.std()}")
print('-----')
print('R2 score = ',(r2))
print('-----')
print('Mean absolute error = ',(mae))
print('-----')
print('Mean squared error = ',(mse))
print('-----')
```

Negative root mean squared error': mean: -2356.243479016056 standard deviation: 1028.1659833275326

R2 score = 0.1589730686396591

Mean absolute error = 1521.4940748974266

Mean squared error = 9128909.32741839

3.1.6 Model 1.6

Model where outliers have been removed, data is scaled and there are 6 features used.

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```
[1264]: df_no_out = df.drop([1, 2, 20, 24, 25, 26, 0, 3, 8, 29])
df_no_out.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 490 entries, 4 to 499
Data columns (total 13 columns):
 #   Column      Non-Null Count  Dtype  
--- 
 0   Rank         490 non-null    int64  
 1   Title        490 non-null    object  
 2   Employees    490 non-null    int64  
 3   Sector       490 non-null    object  
 4   Industry     490 non-null    object  
 5   Hqcity       490 non-null    object  
 6   Hqstate      490 non-null    object  
 7   Revenues     490 non-null    int64  
 8   Revchange    490 non-null    float64 
 9   Profits      490 non-null    float64 
 10  Prftchange   490 non-null    float64 
 11  Assets       490 non-null    int64  
 12  Totshequity 490 non-null    float64 
dtypes: float64(4), int64(4), object(5)
memory usage: 53.6+ KB
```

```
[1265]: df_scaled = df_no_out[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange', 'Profits']]
df_scaled = StandardScaler().fit_transform(df_scaled.to_numpy())
df_scaled = pd.DataFrame(df_scaled, columns=['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange', 'Profits'])
X6= df_scaled[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange']]
y6 = df_scaled['Profits']
print(X6)
print('-----')
print(y6)
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	0.278342	6.303331	-0.021002	-0.077202	0.119465	0.039323
1	2.658880	6.022231	0.314013	1.827107	0.691657	-0.009994
2	2.276819	5.753372	0.170656	1.733417	0.597121	-0.039309
3	2.585407	5.343650	0.814055	2.187985	0.268732	-0.045722
4	2.232735	4.807697	0.896288	1.236414	-0.114388	-0.099161

```
..      ..      ..      ..      ..      ..      ..  
485 -0.265362 -0.581360 -0.296181 -0.766387 0.099562 -0.035186  
486 -0.659179 -0.582352 -0.257803 -0.381827 1.000143 -0.033660  
487 -0.595992 -0.582389 -0.063885 1.358329 0.010002 -0.033660  
488 -0.655785 -0.582573 -0.230344 -0.228185 0.010002 -0.033660  
489  0.895518 -0.583271 -0.295509 -0.593021 -0.328338 -0.079770
```

```
[490 rows x 6 columns]
```

```
-----  
0      0.332215  
1      2.177311  
2      1.518209  
3      3.111684  
4      1.238673  
...  
485 -0.396596  
486 -0.395084  
487 -0.626312  
488 -0.626312  
489 -0.521050  
Name: Profits, Length: 490, dtype: float64
```

```
[1266]: cv = KFold(n_splits=6, random_state=1, shuffle=True)
```

```
[1267]: x6_train, x6_test, y6_train, y6_test = train_test_split(X6 , y6, test_size = 0.  
    ↪3)
```

```
[1268]: regr = linear_model.LinearRegression()  
regr.fit(x6_train, y6_train)  
scores6 = cross_val_score(regr, x6_test, y6_test, cv=cv, scoring =  
    ↪'neg_root_mean_squared_error')
```

```
[1269]: predictions6 = regr.predict(x6_test)  
pd.DataFrame(regr.coef_, ['Employees', 'Revenues', 'Assets', 'Totshequity',  
    ↪'Revchange', 'Prftchange'], columns = ['Coefficient'])
```

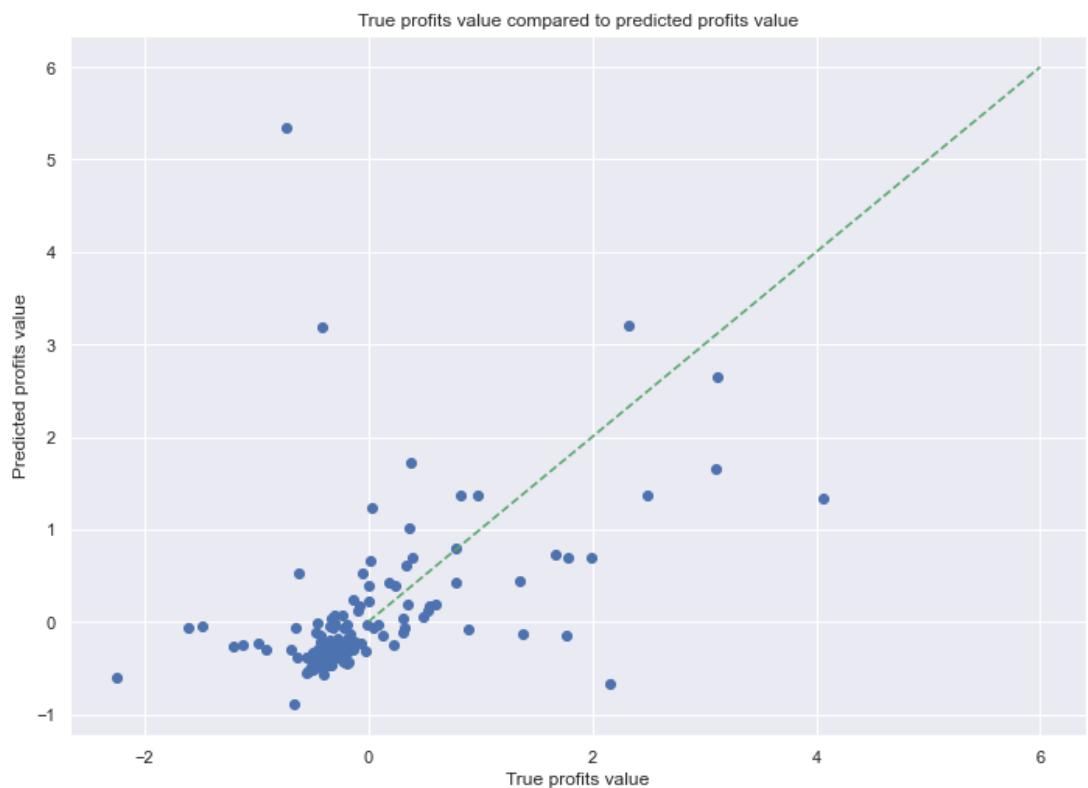
```
[1269]:          Coefficient  
Employees      0.105571  
Revenues       0.210018  
Assets         0.125407  
Totshequity   0.517453  
Revchange      0.017005  
Prftchange     0.033607
```

```
[1270]: plt.scatter(y6_test, predictions6)
```

```

plt.plot([0,1,6],[0, 1,6], color = 'g', linestyle='dashed', label= "Line to show where predicted profits equal actual profits")
plt.title('True profits value compared to predicted profits value')
plt.xlabel('True profits value')
plt.ylabel('Predicted profits value')
plt.show()

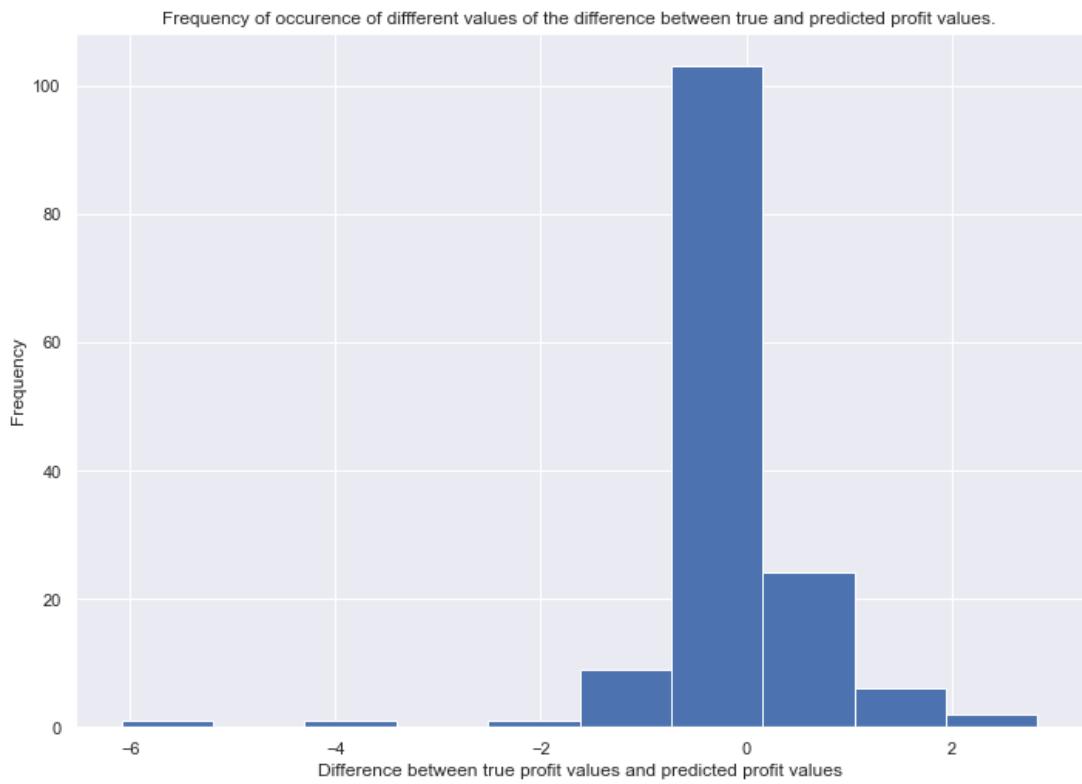
```



```

[1271]: plt.hist(y6_test - predictions6)
plt.title('Frequency of occurrence of different values of the difference between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()

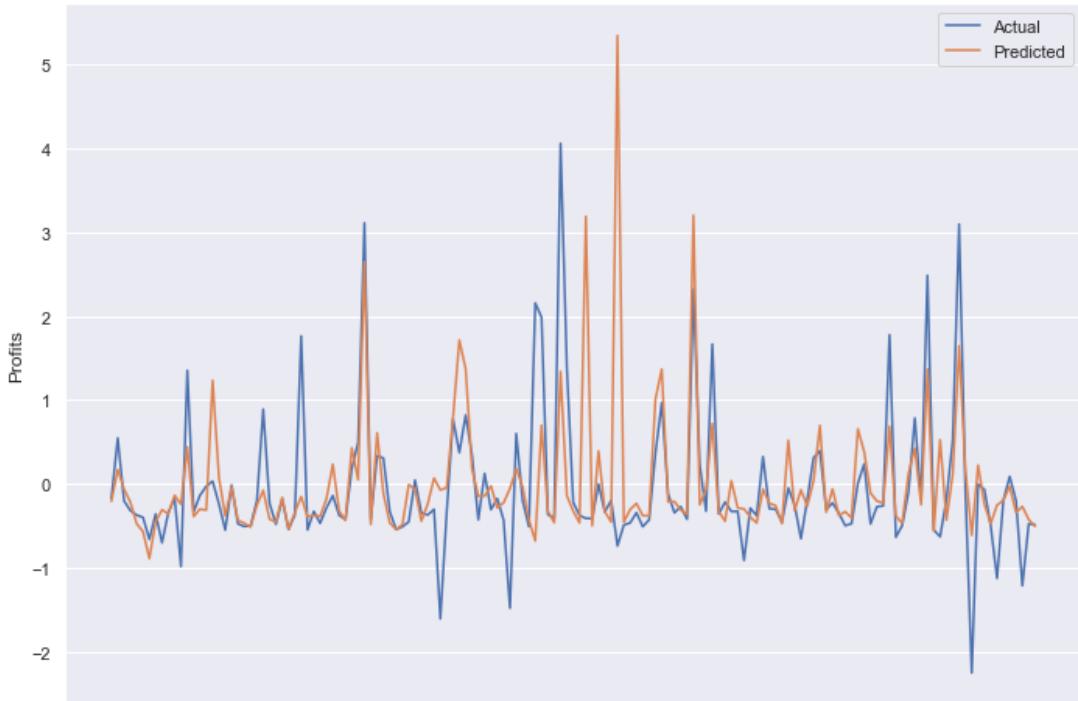
```



```
[1272]: pred6_df = pd.DataFrame(predictions6)
x6_df = pd.DataFrame(x6_test.iloc[:,0])

plt.plot(range(len(y6_test)), y6_test)
plt.plot(range(len(predictions6)), predictions6)
plt.ylabel('Profits')
plt.legend(['Actual', 'Predicted'])
plt.xticks(())

plt.show()
```



```
[1293]: mae = metrics.mean_absolute_error(y6_test, predictions6)
mse = metrics.mean_squared_error(y6_test, predictions6)
r2 = metrics.r2_score(y6_test, predictions6)
print('-----')
print(f"Negative root mean squared error: mean: {scores6.mean()} standard deviation: {scores6.std()}")
print('-----')
print('R2 score = ',(r2))
print('-----')
print('Mean absolute error = ',(mae))
print('-----')
print('Mean squared error = ',(mse))
print('-----')
```

Negative root mean squared error: mean: -0.9281187505784315 standard deviation: 0.4084233211446156

R2 score = 0.01567909031619108

Mean absolute error = 0.4074979955550994

Mean squared error = 0.692359542782294

3.2 Model 2 - Multi-layer Perceptron

Multi-layer Perceptrons are a type of neural network inspired by the neurons in the brain, using nodes to calculate and combine results with others through shared connections . A Multi-layer Perceptron model is made up of multiple layers of Perceptrons. Each Perceptron takes inputs, multiplies them by a weight and sums them together and adds a bias coefficient. The sum is passed to an activation function, such as a threshold function . To begin with, the weights are random but after some training, the model adjusts the weights using Stochastic Gradient Decent, so it minimizes incorrect classifications. It contains hidden layers of Perceptrons stacked together. This allows the model to take any arbitrary activation function, unlike a single Perceptron which must take a linear activation function. This means it can handle more complex regression problems, which require more flexible decision boundaries. The process of taking an output of one Perceptron and using it as the input for the next Perceptron in the hidden layer describes a feedforward algorithm. However, to learn and improve the weights needed to maximise correct classification the algorithm must backpropagate. Backpropagation iteratively modifies the weights using Stochastic Gradient Descent, as mentioned above. First, a loss function, such as Mean Squared Error, is computed for all input and output sets. Then the weights of the first hidden layer are adjusted to the value produced by the algorithm. The process of adjusting the weights for each input-output layer continues until the loss is minimised which means the algorithm has converged over some defined threshold.

```
[1294]: #Importing packages needed for the model
from sklearn.neural_network import MLPRegressor
from sklearn.model_selection import GridSearchCV
```

3.2.1 Model 2.1

Multilayer Perceptron using 6 features on unscaled data.

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```
[1177]: #Setting X as the variables Employees, Revenues, Assets, Total Shared Equity
         ↵and Profit Change to predict y.
#Setting y as the target value to predict Profit.
X7 = df[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', ↵
          ↵'Prftchange']]
y7 = df['Profits']
print(X7)
print('-----')
print(y7)
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	2300000	485873	198825	77798.0	0.8	-7.2
1	367700	223604	620854	283001.0	6.1	0.0
2	116000	215639	321686	128249.0	-7.7	-14.4
3	72700	205004	330314	167325.0	-16.7	-51.5
4	68000	192487	56563	8924.0	6.2	53.0
..

```

495      31000      5197     2148    -1698.0      5.8      4.2
496      4200       5170     9737    4229.0     23.9      5.2
497      8500       5169    48083   31049.0      4.0      5.2
498     4431       5164    15167   6597.0      4.0      5.2
499    110000      5145    2281     974.0     -2.8     -25.0

```

[500 rows x 6 columns]

```

0      13643.0
1      24074.0
2      45687.0
3      7840.0
4      2258.0
...
495     378.2
496     382.1
497    -214.3
498    -214.3
499      57.2
Name: Profits, Length: 500, dtype: float64

```

```

[1178]: X7_train,X7_test,Y7_train,Y7_test = train_test_split(X7,y7,test_size=0.3)
print('Training Data: ')
print(X7_train)
print('350 rows')
print('-----')
print('Testing Data: ')
print(X7_test)
print('150 rows')

```

Training Data:

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
204	260200	13487	14262	10728.0	8.6	-4.3
304	27000	9071	8835	3218.3	13.1	-80.6
141	24000	20143	8861	1751.0	4.0	5.2
198	8516	13982	6948	1046.0	7.6	5.3
449	14000	5779	5777	1760.0	0.6	2.9
..
454	16487	5722	123449	16487.0	14.5	21.8
250	48950	11361	12057	4575.0	-10.6	-20.3
306	12380	9061	4360	1229.0	-4.6	117.4
295	36000	9480	19155	1075.0	-10.0	-279.9
150	148400	18558	9901	3057.0	1.9	30.8

[350 rows x 6 columns]

350 rows

Testing Data:

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
151	138000	18353	10323	2438.0	2.5	-10.5
370	20500	7405	6213	3744.0	-2.8	-43.6
238	13195	11735	139821	6292.0	-3.8	-15.9
335	12600	8172	24888	10917.0	-0.7	-80.3
387	44360	6896	4285	-106.0	-38.7	-428.2
..
96	5646	28799	250441	20226.0	2.4	0.4
66	122300	40180	51274	3785.0	-2.0	-64.8
382	30025	7000	22664	4753.0	73.0	10.7
346	7695	7777	6424	2927.0	2.4	99.7
297	40700	9390	27899	17893.0	3.1	176.0

[150 rows x 6 columns]

150 rows

```
[1193]: # each combination of parameters will be tested and the most accurate will be printed.
mlp = MLPRegressor()
param_grid = {
    'hidden_layer_sizes': [(200,), (150,), (120,), (100,)],
    'max_iter': [500, 1000],
    'activation': ['tanh', 'relu'],
    'solver': ['sgd', 'adam'],
    'alpha': [0.0001, 0.05],
    'learning_rate': ['constant','adaptive'],
}
grid = GridSearchCV(mlp, param_grid, n_jobs= -1, cv=5)
grid.fit(X7_train, Y7_train)

print(grid.best_params_)
predictions7 = grid.predict(X7_test)
scores7 = cross_val_score(mlp, X7_test, Y7_test, cv=6, scoring = 'neg_root_mean_squared_error')
mae7 = metrics.mean_absolute_error(Y7_test, predictions7)
mse7 = metrics.mean_squared_error(Y7_test, predictions7)
r2_7 = metrics.r2_score(Y7_test, predictions7)
print('-----')
print(f"Negative root mean squared error: mean: {scores7.mean()} standard deviation: {scores7.std()}")
print('-----')
print('R2 score = ',(r2_7))
print('-----')
print('Mean absolute error = ',(mae7))
print('-----')
print('Mean squared error = ',(mse7))
```

```

print('-----')
plt.scatter(Y7_test, predictions7)
plt.plot([0,10000,25000],[0, 10000,25000], color = 'g', linestyle='dashed',_
         label= "Line to show where predicted profits equal actual profits")
plt.title('True profits value compared to predicted profits value')
plt.xlabel('True profits value')
plt.ylabel('Predicted profits value')
plt.show()
plt.hist(Y7_test - predictions7)
plt.title('Frequency of occurrence of different values of the difference_'
           'between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()

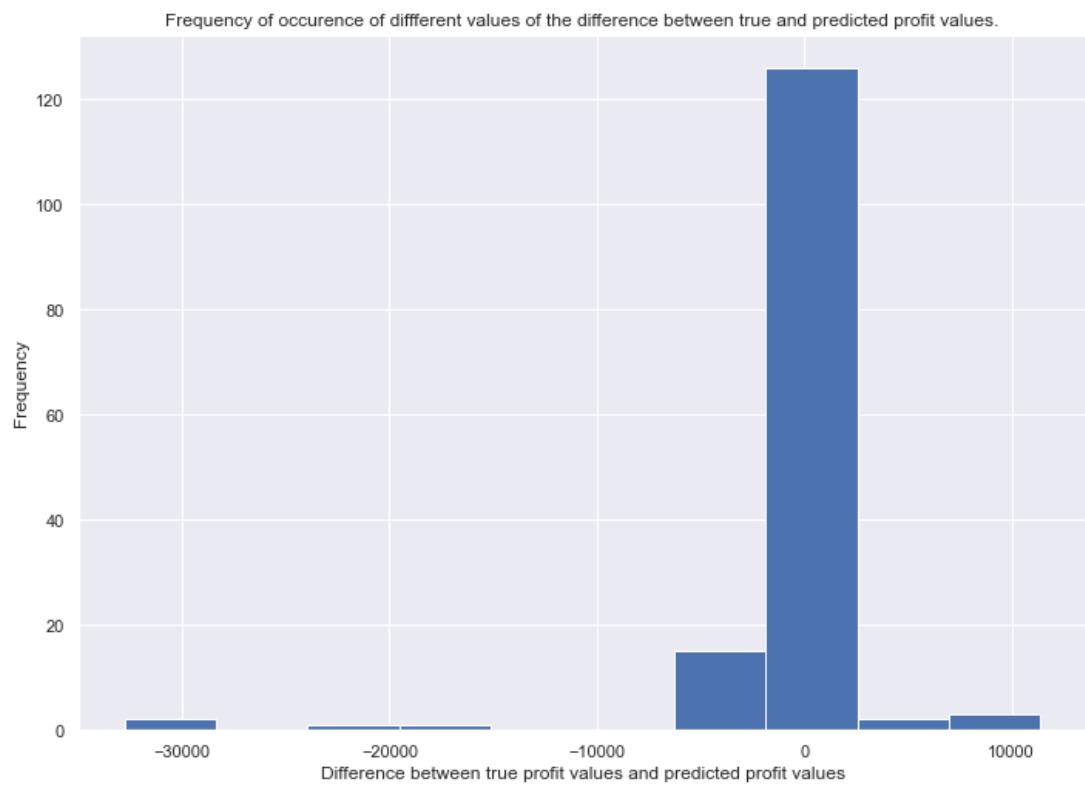
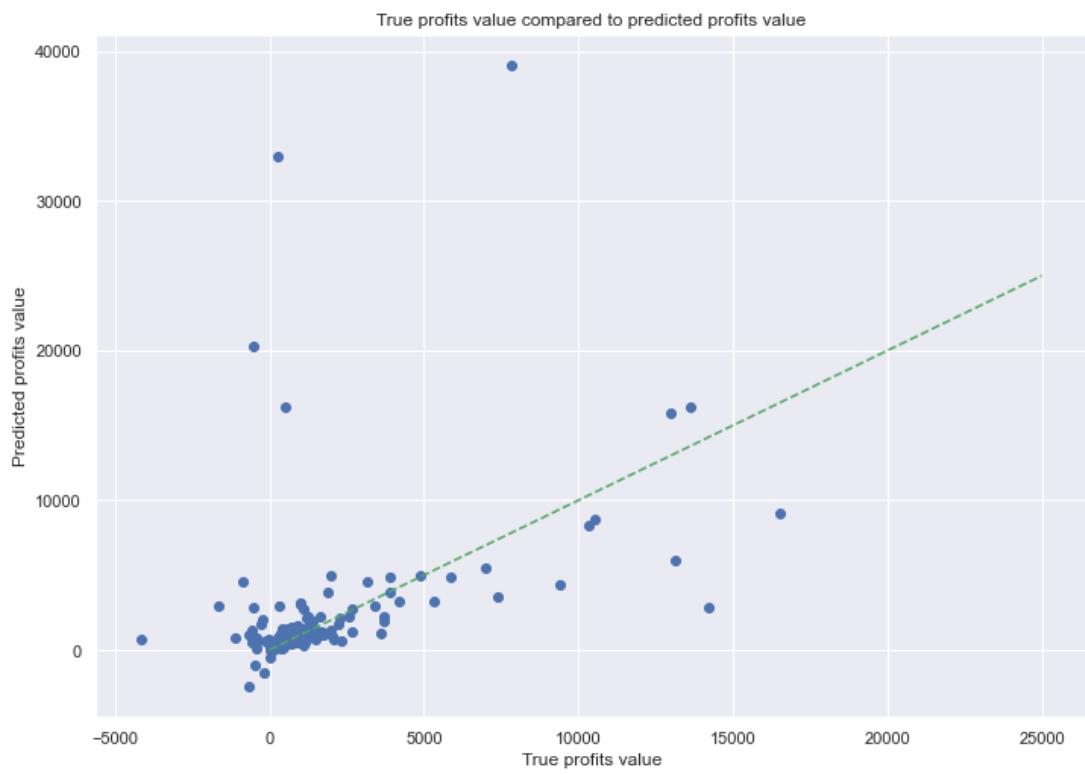
```

```

/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(

```

```
packages/sklearn/neural_network/_multilayer_perceptron.py:692:  
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and  
the optimization hasn't converged yet.  
    warnings.warn(  
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-  
packages/sklearn/neural_network/_multilayer_perceptron.py:692:  
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and  
the optimization hasn't converged yet.  
    warnings.warn(  
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-  
packages/sklearn/neural_network/_multilayer_perceptron.py:692:  
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and  
the optimization hasn't converged yet.  
    warnings.warn(  
{'activation': 'relu', 'alpha': 0.05, 'hidden_layer_sizes': (200,),  
'learning_rate': 'constant', 'max_iter': 500, 'solver': 'adam'}  
-----  
Negative root mean squared error: mean: -5160.583710304484 standard deviation:  
4291.039814336105  
-----  
R2 score = -1.2911044670834162  
-----  
Mean absolute error = 1655.1458100258606  
-----  
Mean squared error = 21479072.054986943  
-----
```



3.2.2 Model 2.2

Multilayer Perceptron with 6 features and scaled data.

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```
[1152]: df_scaled = df[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange',  
                     'Prftchange', 'Profits']]  
df_scaled = StandardScaler().fit_transform(df_scaled.to_numpy())  
df_scaled = pd.DataFrame(df_scaled, columns=['Employees', 'Revenues', 'Assets',  
                                             'Totshequity', 'Revchange', 'Prftchange', 'Profits'])  
X8= df_scaled[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange',  
               'Prftchange']]  
y8 = df_scaled['Profits']  
print(X8)  
print('-----')  
print(y8)  
print('-----')
```

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
0	18.192467	12.056745	0.438399	2.104046	-0.148289	-0.052097
1	2.524557	5.208811	2.000571	8.833642	0.117408	-0.040993
2	0.483666	5.000843	0.893178	3.758577	-0.574408	-0.063202
3	0.132572	4.723159	0.925115	5.040068	-1.025592	-0.120421
4	0.094462	4.396336	-0.088195	-0.154665	0.122421	0.040749
..
495	-0.205550	-0.493871	-0.289616	-0.503012	0.102369	-0.034515
496	-0.422855	-0.494576	-0.261525	-0.308637	1.009750	-0.032973
497	-0.387989	-0.494602	-0.119584	0.570920	0.012132	-0.032973
498	-0.420982	-0.494732	-0.241426	-0.230979	0.012132	-0.032973
499	0.435016	-0.495228	-0.289124	-0.415384	-0.328763	-0.079550

[500 rows x 6 columns]

```
-----  
0      3.015930  
1      5.667686  
2     11.162118  
3     1.540698  
4     0.121649  
      ...  
495    -0.356232  
496    -0.355240  
497    -0.506856  
498    -0.506856  
499    -0.437836  
Name: Profits, Length: 500, dtype: float64
```

```
[1153]: X8_train,X8_test,Y8_train,Y8_test = train_test_split(X8,y8,test_size=0.3)
print('Training Data: ')
print(X8_train)
print('350 rows')
print('-----')
print('Testing Data: ')
print(X8_test)
print('150 rows')
```

Training Data:

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
369	-0.296405	-0.436062	-0.271034	-0.356288	-0.228500	-0.102530
27	0.467450	1.598169	0.419406	1.913803	-0.629552	0.017306
280	-0.067706	-0.364207	-0.240023	-0.175457	-0.088131	0.595818
178	0.179601	-0.227023	-0.211820	-0.376424	-0.093144	-0.033281
9	1.172883	3.333984	0.583227	0.509299	-0.113197	-0.099137
..
356	-0.325554	-0.429979	0.529302	0.091198	0.693921	0.006047
379	-0.156899	-0.445018	-0.274055	-0.393116	-0.153302	0.023475
146	-0.254200	-0.122320	-0.172798	0.083196	0.678882	0.244022
91	-0.383935	0.163927	-0.086663	0.172070	-0.534302	-0.080167
188	-0.445040	-0.244308	-0.275539	-0.433093	-3.070961	-0.043769

[350 rows x 6 columns]

350 rows

Testing Data:

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
181	-0.159332	-0.232819	-0.252693	-0.455295	-0.449079	0.076838
336	-0.365286	-0.417785	-0.276642	-0.621073	-1.191026	-0.164839
157	-0.148791	-0.171878	-0.281391	-0.461789	-0.268605	-0.052252
486	-0.403395	-0.489380	-0.289557	-0.421713	-0.183381	0.086246
247	-0.396908	-0.330629	-0.212886	-0.049197	0.132448	-0.034207
..
304	-0.237983	-0.392719	-0.264864	-0.341783	0.468329	-0.165301
367	-0.391443	-0.434470	-0.186065	-0.154468	1.120040	0.031649
418	-0.394071	-0.462486	-0.217532	-0.307850	-0.233513	-0.032664
70	0.222218	0.405422	-0.107821	-0.044376	-0.318737	-0.046237
114	-0.349069	0.006482	0.034731	0.699640	-1.256197	-0.024645

[150 rows x 6 columns]

150 rows

```
[1194]: # each combination of parameters will be tested and the most accurate will be
        ↪printed.
```

```

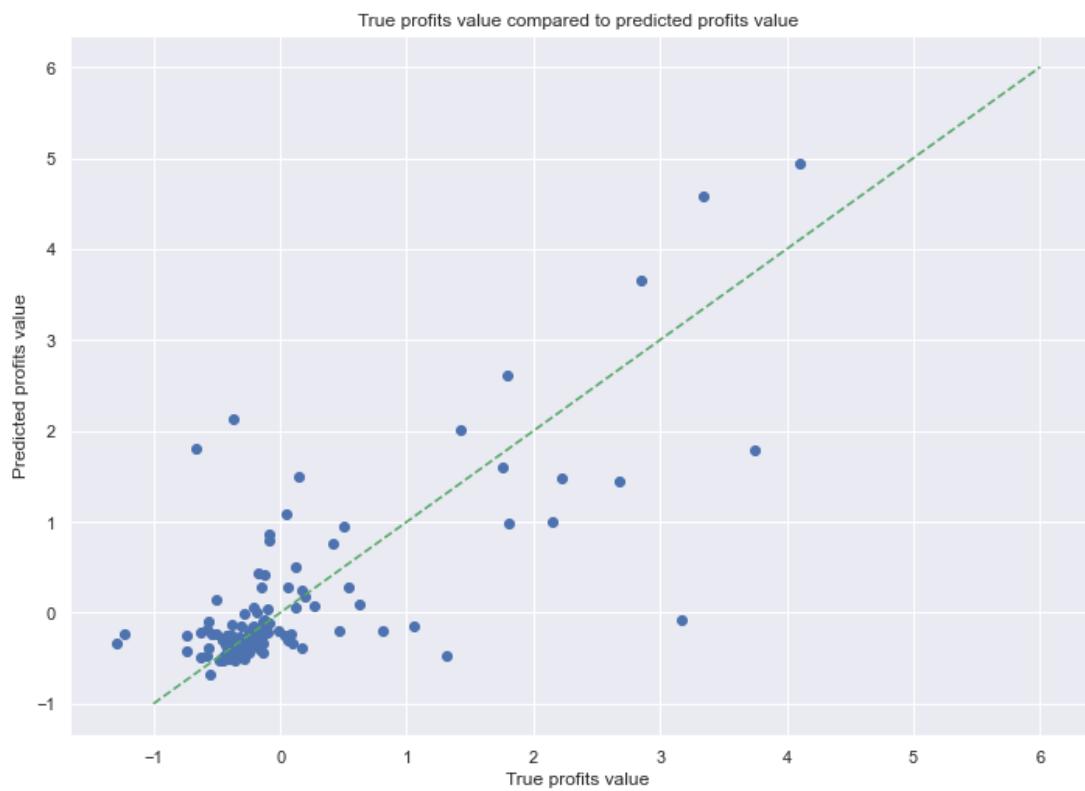
warnings.filterwarnings("ignore")
mlp = MLPRegressor()
param_grid = {
    'hidden_layer_sizes': [(200,), (150,), (120,), (100,)],
    'max_iter': [500, 1000],
    'activation': ['tanh', 'relu'],
    'solver': ['sgd', 'adam'],
    'alpha': [0.0001, 0.05],
    'learning_rate': ['constant','adaptive'],
}
grid = GridSearchCV(mlp, param_grid, n_jobs= -1, cv=5)
grid.fit(X8_train, Y8_train)

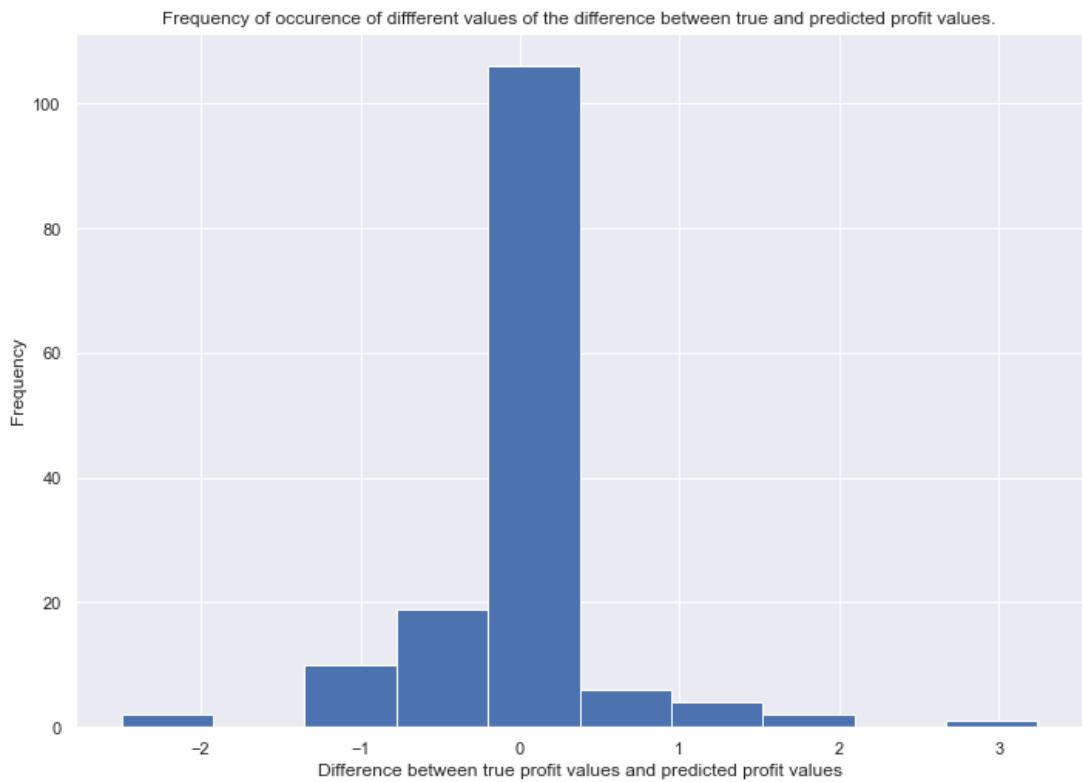
print(grid.best_params_)
predictions8 = grid.predict(X8_test)
scores8 = cross_val_score(mlp, X8_test, Y8_test, cv=6, scoring = "neg_root_mean_squared_error")
mae8 = metrics.mean_absolute_error(Y8_test, predictions8)
mse8 = metrics.mean_squared_error(Y8_test, predictions8)
r2_8= metrics.r2_score(Y8_test, predictions8)
print('-----')
print(f"Negative root mean squared error: mean: {scores8.mean()} standard deviation: {scores8.std()}")
print('-----')
print('R2 score = ',(r2_8))
print('-----')
print('Mean absolute error = ',(mae8))
print('-----')
print('Mean squared error = ',(mse8))
print('-----')
plt.scatter(Y8_test, predictions8)
plt.plot([-1,1,6],[-1, 1,6], color = 'g', linestyle='dashed', label= "Line to show where predicted profits equal actual profits")
plt.title('True profits value compared to predicted profits value')
plt.xlabel('True profits value')
plt.ylabel('Predicted profits value')
plt.savefig('mlp_lin.png')
plt.show()
plt.hist(Y8_test - predictions8)
plt.title('Frequency of occurrence of different values of the difference between true and predicted profit values.')
plt.xlabel('Difference between true profit values and predicted profit values')
plt.ylabel('Frequency')
plt.show()

```

/Users/ursulamenear/opt/anaconda3/lib/python3.9/site-packages/sklearn/neural_network/_multilayer_perceptron.py:692:

```
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (1000) reached and
the optimization hasn't converged yet.
    warnings.warn(
/Users/ursulamennear/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (1000) reached and
the optimization hasn't converged yet.
    warnings.warn(
['activation': 'tanh', 'alpha': 0.05, 'hidden_layer_sizes': (200,), 
'learning_rate': 'constant', 'max_iter': 1000, 'solver': 'sgd'}-----Negative root mean squared error: mean: -0.537390331937597 standard deviation:
0.19320494164125837-----R2 score = 0.529307843494091-----Mean absolute error = 0.3215306169790056-----Mean squared error = 0.3514439880164748-----
```

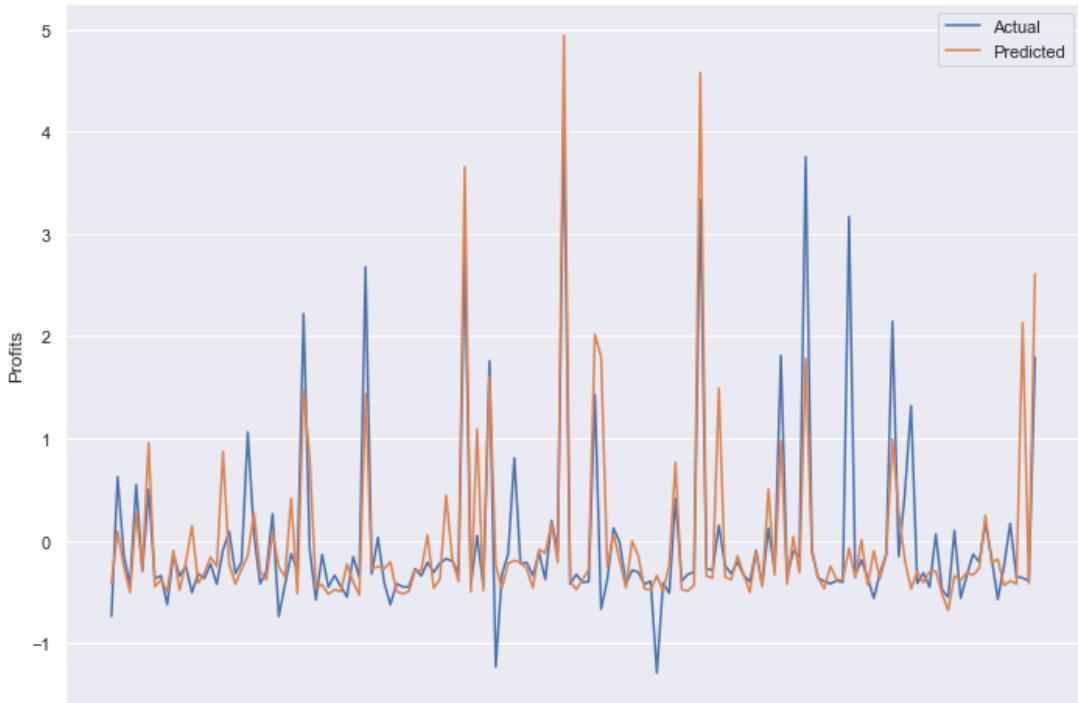




```
[1237]: pred8_df = pd.DataFrame(predictions8)
x8_df = pd.DataFrame(X8_test.iloc[:,0])

plt.plot(range(len(Y8_test)), Y8_test)
plt.plot(range(len(predictions8)), predictions8)
plt.ylabel('Profits')
plt.legend(['Actual', 'Predicted'])
plt.xticks(())

plt.show()
```



4 Section 3: Comparing results

Comparing the most successful model of each type.

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The most successful linear regression model was Model 1.2, because it has a small negative root mean squared error over cross validation and the R squared score was over 0.5 on almost all runs. The highest r squared score recorded was 0.87.

```
[1238]: mae2 = metrics.mean_absolute_error(y2_test, predictions2)
mse2 = metrics.mean_squared_error(y2_test, predictions2)
r2_2 = metrics.r2_score(y2_test, predictions2)
print('-----')
print("Linear Regression Model 1.2: 4 features with scaled data.")
print('-----')
print(f"Negative root mean squared error: mean: {scores2.mean()} standard deviation: {scores2.std()}")
print('-----')
print('R2 score = ',(r2_2))
print('-----')
print('Mean absolute error = ',(mae2))
print('-----')
print('Mean squared error = ',(mse2))
```

```
print('-----')
```

```
-----  
Linear Regression Model 1.2: 4 features with scaled data.  
-----  
Negative root mean squared error: mean: -0.6299711990022783 standard deviation:  
0.4322145670772607  
-----  
R2 score = 0.5264293469574413  
-----  
Mean absolute error = 0.27009261092725895  
-----  
Mean squared error = 0.2520722214947627  
-----
```

The most successful multilayer perceptron model was Model 2.2 with hyperparameters {‘activation’: ‘tanh’, ‘alpha’: 0.05, ‘hidden_layer_sizes’: (200,), ‘learning_rate’: ‘constant’, ‘max_iter’: 1000, ‘solver’: ‘sgd’} because it had a low negative root mean squared error with a low standard deviation and a R squared score above 0.5.

```
[1239]: scores8 = cross_val_score(mlp, X8_test, Y8_test, cv=6, scoring ='neg_root_mean_squared_error')  
mae8 = metrics.mean_absolute_error(Y8_test, predictions8)  
mse8 = metrics.mean_squared_error(Y8_test, predictions8)  
r2_8= metrics.r2_score(Y8_test, predictions8)  
print('-----')  
print("Multi-layer Perceptron Model 2.2: 6 features with scaled data.")  
print('-----')  
print(f"Negative root mean squared error: mean: {scores8.mean()} standard deviation: {scores8.std()}")  
print('-----')  
print('R2 score = ',(r2_8))  
print('-----')  
print('Mean absolute error = ',(mae8))  
print('-----')  
print('Mean squared error = ',(mse8))  
print('-----')
```

```
-----  
Multi-layer Perceptron Model 2.2: 6 features with scaled data.  
-----  
Negative root mean squared error: mean: -0.4963260837012858 standard deviation:  
0.20301934478099304  
-----  
R2 score = 0.529307843494091  
-----  
Mean absolute error = 0.3215306169790056  
-----
```

```
Mean squared error =  0.3514439880164748
```

```
[1242]: print('-----')
print("Model 1.2 Scores - Model 2.2 Scores")
print('-----')
print(f"Negative root mean squared error difference: mean: {scores2.mean() - scores8.mean()} standard deviation: {scores2.std() - scores8.std()}")
print('-----')
print('R2 score difference = ',(r2_2 - r2_8))
print('-----')
print('Mean absolute error difference = ',(mae2 - mae8))
print('-----')
print('Mean squared error difference = ',(mse2 - mse8))
print('-----')
```

```
-----  
Model 1.2 Scores - Model 2.2 Scores  
-----
```

```
Negative root mean squared error difference: mean: -0.1336451153009925 standard deviation: 0.22919522229626765
```

```
-----  
R2 score difference = -0.002878496536649733  
-----
```

```
Mean absolute error difference = -0.05143800605174664
```

```
-----  
Mean squared error difference = -0.08135137708921586  
-----
```

This shows that the Multilayer perceptron performed better across cross validation as it had a smaller Negative root mean squared error mean and standard deviation so was more consistent. However the linear model had a higher R squared score and a slightly lower mean squared error and mean absolute error.

```
[1200]: df_scaled = df[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange', 'Profits']]
df_scaled = StandardScaler().fit_transform(df_scaled.to_numpy())
df_scaled = pd.DataFrame(df_scaled, columns=['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange', 'Profits'])
X9= df_scaled[['Employees', 'Revenues', 'Assets', 'Totshequity', 'Revchange', 'Prftchange']]
y9 = df_scaled['Profits']
print(X9)
print('-----')
print(y9)
print('-----')
```

```
Employees    Revenues    Assets    Totshequity    Revchange    Prftchange
```

```

0    18.192467  12.056745  0.438399    2.104046  -0.148289  -0.052097
1    2.524557   5.208811  2.000571    8.833642   0.117408  -0.040993
2    0.483666   5.000843  0.893178    3.758577  -0.574408  -0.063202
3    0.132572   4.723159  0.925115    5.040068  -1.025592  -0.120421
4    0.094462   4.396336  -0.088195   -0.154665  0.122421   0.040749
...
495   -0.205550  -0.493871  -0.289616   -0.503012  0.102369  -0.034515
496   -0.422855  -0.494576  -0.261525   -0.308637  1.009750  -0.032973
497   -0.387989  -0.494602  -0.119584    0.570920  0.012132  -0.032973
498   -0.420982  -0.494732  -0.241426   -0.230979  0.012132  -0.032973
499   0.435016   -0.495228  -0.289124   -0.415384  -0.328763  -0.079550

[500 rows x 6 columns]
-----
0      3.015930
1      5.667686
2     11.162118
3     1.540698
4     0.121649
...
495   -0.356232
496   -0.355240
497   -0.506856
498   -0.506856
499   -0.437836
Name: Profits, Length: 500, dtype: float64
-----
```

```
[1201]: X9_train,X9_test,Y9_train,Y9_test = train_test_split(X8,y8,test_size=0.3)
print('Training Data: ')
print(X9_train)
print('350 rows')
print('-----')
print('Testing Data: ')
print(X9_test)
print('150 rows')
```

Training Data:

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
186	-0.341771	-0.235770	-0.060537	0.632017	0.247750	-0.049167
312	-0.227183	-0.397288	-0.190173	-0.299126	2.794435	0.026405
33	-0.336906	1.260718	-0.106370	0.286950	-1.035618	-0.138465
333	-0.442559	-0.414417	-0.288076	-0.434438	-1.196039	-0.901281
323	-0.294742	-0.405722	-0.274695	-0.340153	-0.424013	0.048151
..
171	-0.431248	-0.213889	-0.269354	-0.380917	0.879408	-0.015237
479	-0.446159	-0.488205	-0.286518	-0.414794	-0.489184	-1.417177
17	3.135121	2.381923	-0.162441	-0.227666	0.062263	-0.045774

```
167  0.280794 -0.202714 -0.174175    -0.376686   0.162527   -0.149261
81   0.467450  0.333410 -0.214752    -0.132234   -0.734829   0.028256
```

[350 rows x 6 columns]

350 rows

Testing Data:

	Employees	Revenues	Assets	Totshequity	Revchange	Prftchange
482	-0.439251	-0.488622	-0.135324	-0.279941	-0.148289	-0.113789
77	-0.177981	0.355107	2.886399	2.402315	-0.378895	-0.007679
374	-0.161894	-0.440240	-0.219316	0.009834	-2.740092	-0.091888
109	0.745569	0.043506	-0.224087	-0.305554	-0.429026	-0.106232
389	-0.051490	-0.449979	-0.219064	-0.164209	0.809224	-0.149416
..
471	-0.455127	-0.486272	-0.255340	-0.217959	-0.093144	0.015455
146	-0.254200	-0.122320	-0.172798	0.083196	0.678882	0.244022
299	-0.343393	-0.386270	-0.235599	-0.261904	-0.038000	-0.069217
370	-0.290688	-0.436219	-0.274569	-0.324542	-0.328763	-0.108237
433	-0.310959	-0.472800	-0.251009	-0.297192	0.232711	-0.066595

[150 rows x 6 columns]

150 rows

```
[1204]: X9_lin_train = X9_train.drop(columns=['Revchange' , 'Prftchange'])
X9_lin_test = X9_test.drop(columns=['Revchange' , 'Prftchange'])
print('Training Data: ')
print(X9_lin_train)
```

Training Data:

	Employees	Revenues	Assets	Totshequity
186	-0.341771	-0.235770	-0.060537	0.632017
312	-0.227183	-0.397288	-0.190173	-0.299126
33	-0.336906	1.260718	-0.106370	0.286950
333	-0.442559	-0.414417	-0.288076	-0.434438
323	-0.294742	-0.405722	-0.274695	-0.340153
..
171	-0.431248	-0.213889	-0.269354	-0.380917
479	-0.446159	-0.488205	-0.286518	-0.414794
17	3.135121	2.381923	-0.162441	-0.227666
167	0.280794	-0.202714	-0.174175	-0.376686
81	0.467450	0.333410	-0.214752	-0.132234

[350 rows x 4 columns]

```
[1205]: predictions9_mlp = grid.predict(X9_test)
predictions9_lin = regr.predict(X9_lin_test)
```

Using the same testing data the models were compared, the orange dotted line is the MLP model

and the green dotted line is the MLR model.

```
[1206]: pred9mlp_df = pd.DataFrame(predictions9_mlp)
pred9lin_df = pd.DataFrame(predictions9_lin)
x9_df = pd.DataFrame(X9_test.iloc[:,0])

plt.plot(range(len(Y9_test)), Y9_test)
plt.plot(range(len(predictions9_mlp)), predictions9_mlp, linestyle='dashed')
plt.plot(range(len(predictions9_lin)), predictions9_lin, linestyle='dashed')
plt.ylabel('Profits')
plt.legend(['Actual', 'MLP Predicted' , 'MLR Predicted'])
plt.xticks(())

plt.show()
```

