Evaluation of Company Performance and its Relation to Stock Price

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***Abstract*—Benjamin Graham stated, "The stock market is like a voting machine in the short run, but a weighing machine in the long run". The vicissitudes of the market in the short run can result in financial loss for individuals who get carried away by market swings. Therefore, it is important to understand whether a company's stock price is increasing due to improved performance and not hype. To do this, we evaluate the key factors affecting company performance and how this in turn affects price.**

Keywords—earnings per share, price variation, finance

I. Introduction

Financial markets globally are reaching new milestones day by day. A battery of valuation tests performed by Goldman Sachs show record high levels on almost all measures [1]. However, we are amid a global pandemic! Millions of lives have been affected, countless jobs lost, and yet, we see stock prices surge to historic highs. As evidenced by job loss, it is certain that some companies are not performing at a level that is reflected by these high prices. On the contrary, the pandemic has forced companies to become more dynamic and efficient. Therefore, it is necessary to distinguish between the two. To do so, a sufficient metric will be required to measure company performance. Once completed, we can distinguish companies whose price increase are a result of good performance and not hype.

This research will gauge company performance by looking at Earnings per Share (EPS). Our primary aim will be to examine the extent to which various factors affect EPS. Why is this important? It will help ascertain whether an increase in a company's share price is validated. Significant wealth can be lost - and has been - by individuals buying into fads. The internet and airline stock booms (with their subsequent busts) are evidence of this.

Once EPS has been evaluated, our secondary aim is to measure the extent to which it impacts stock price. Additionally, we will create tranches of companies according to their performance and price variation. For example, a company facing negative sentiment (price decrease) may be performing well (positive EPS), and identification of these companies can be useful to the investor - this negative sentiment may be temporary and provide a worthy investment opportunity.

II. Analytical Questions and Data

To reiterate, the primary objective of this research is to examine the key factors influencing company performance – as measured by Earnings per Share (EPS). Knowledge of these features will aid an investor in making appropriate investment decisions when performing analysis on a company. A high EPS value for a company is insufficient to justify good performance. It is important to understand what is *driving* that performance. The dataset used contains 225 financial parameters (including EPS) for companies in the US stock market in the year 2018 – providing great scope for analysis. To limit this scope, this research will focus solely on financial and healthcare companies. This brings us to our first research question:

- What are the primary determinants of earnings for financial and healthcare companies in the US stock market and to what extent do these factors determine Earnings per Share (EPS)?

The second objective is to measure the relationship between EPS and price variation. The dataset contains a target variable named "Class" corresponding to the values 0 and 1 - 1 indicating that a company's stock price has increased over the year, and 0 indicating a decrease. Segmenting the dataset according to these classes and evaluating the differences in EPS will provide valuable information to an investor. For example, if a company's price has increased, but EPS is negative, it is a good indication to sell (or stay away from) the stock – given that the company is underperforming but valued high. This brings us to the second research question:

- To what extent does EPS affect price variation and how can companies be segmented according to the relationship between the two?

III. Data Materials

The original dataset consisted of 4392 companies and 225 attributes. The companies belonged to all sectors of the market. To limit the scope of this project, focus was placed on financial and healthcare companies – these were the two most populated industries in the dataset. Initial considerations were to use just financial companies. However, the healthcare sector was incorporated to facilitate comparison. The resultant dataset consisted of 1515

companies – 824 and 691 for financial and healthcare sectors respectively.

There were three target variables relevant to this study: Earnings per Share (**EPS**), Class and Price Variation (**Price_Var**). The former two have been explained previously. Price Variation measures the percentage change in a company's stock price over the year 2018. Correlations between this variable and EPS were examined to determine the relationship between the two – yielding interesting results.

The feature space consisted of 223 variables – including 2 categorical variables and 221 continuous features. One of these categorical variables corresponded to company name and was dropped. It would not be useful in relevance to either research question. The continuous variables included financial metrics commonly found on a company's annual report and financial statements. They contain valuable information required by investors wishing to perform any kind of rigorous analysis. The various patterns between these features in relation to the target variables will prove to be immensely useful in reference to the research questions of this study.

IV. Analysis

A. *Data Preparation*

a) Segmenting Feature Space

Analysis of the feature space showed that variables could be segmented into the following categories:

- **Balance sheet** – further segmented into **assets**, **liabilities**, and **equity**
- **Income statement** – further segmented into **income** and **expenses**
- **Cash Flow Statement**
- **Ratios**
- **Per Share statistics**
- **Growth statistics**
- **Other**

This separation of the feature space allowed investigation to be conducted by segment, greatly simplifying the proposed analytical tasks. The patterns and relationships between the constituents of these individual segments and EPS were codified and accumulated to provide answers for our first research question. These relationships were measured using the Spearman's rank correlation coefficient – which is robust to outliers.

b) Missing Value Treatment

Missing values were treated using two methods:

1) Features with more than 20% missing values were dropped. Using an alternative method like imputation to treat these features may significantly skew results [2]. Interpretation of correlation measures between the features and EPS would be severely impeded.

2) The remaining missing values were treated using KNN imputation. In a comparative study, [2] shows how this method outperforms both mean and median imputation as well as case deletion.

c) Outliers

Outlier treatment was performed on the two continuous target variables – EPS and Price Variation. These outliers were identified using summary statistics and visualizations. Given that we could not go back to the data source to correct these values, they were dropped [3]. Data loss was minimal due to the low occurrence of these outliers. Fig 1 shows the results of outlier cleaning on the Price Variation target variable for healthcare companies.

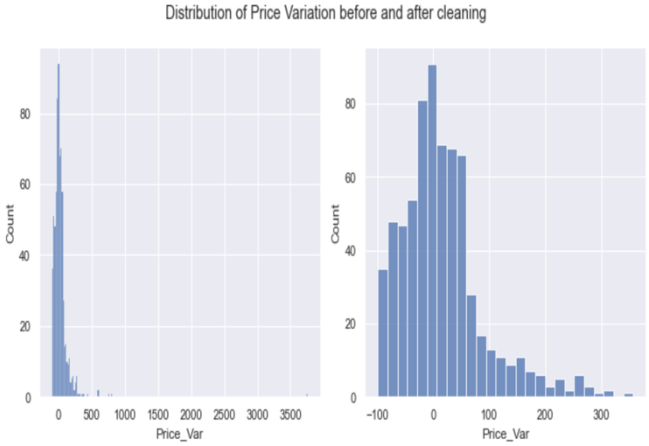

Fig 1. Histograms of Price Variation before *(left)* and after *(right)* outlier treatment for healthcare companies

The feature space contained numerous extreme values. However, these could be explained by company size. Larger companies would have significantly higher values (in the order of billions) compared to smaller ones. Scaling was employed to improve model performance but there were negligible differences noted. Therefore, the feature space was left as it was.

d) Duplicate columns

Once the feature space was separated into segments, the existence of duplicate columns was discovered. For example, there were columns named "ROE" and "returnonEquity". These columns were not exact duplicates due to the occurrence of missing values. Therefore, a special function was created to calculate "similarity" measures between the features. The first elements of the pairs of highly similar features were dropped, significantly reducing the cardinality of the feature space. Keeping these variables would lead to collinearity and obscure model results when trying to determine the key determinants of EPS for the first research question.

e) Feature selection

Features were selected by examining the Spearman's correlation coefficient between variables and EPS. This statistic is robust to extreme values in the data – of which we have many. This was performed by the segments mentioned in a). Variables exhibiting moderate/strong correlation with EPS were selected and collated. We further segmented these variables by removing collinear features to ensure that model performance was not harmed. Fig 2 below shows a heatmap illustrating the Spearman's rank correlation coefficient between the key features and EPS for financial and healthcare companies.

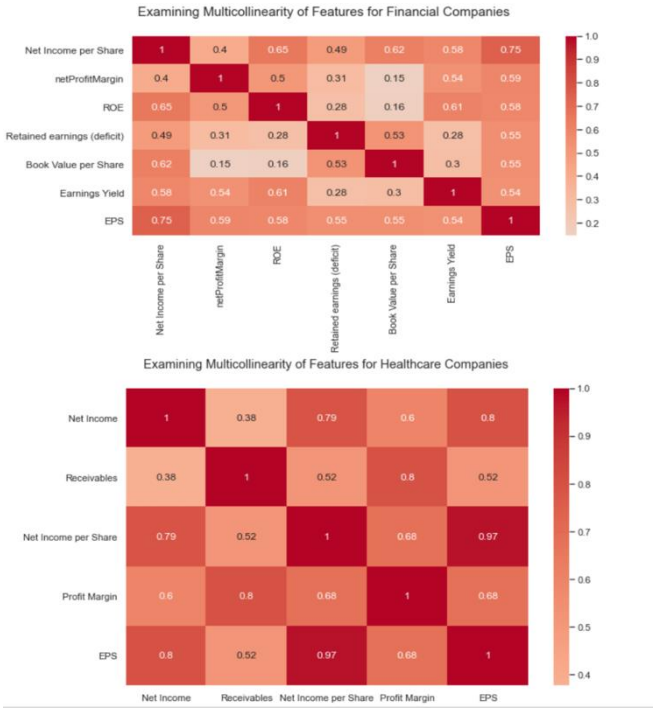

Fig 2. Heatmaps showing Spearman's rank correlation coefficient for important features and EPS for financial *(above)* and healthcare *(below)* companies

B. Data Derivation

The second research question examines the extent to which EPS affects price variation. Once this was determined, companies were segmented into tranches based on these relationships. These segmentations were encapsulated in a new variable named "Tier" labelled 1-4 which corresponded to the following:

1 – "Class" = 0 and "EPS" <= 0. This implies that the company's stock price and earnings decreased during the year. This is to be expected. An investor can either sell this stock or hold in hope for a rebound.

2 – "Class" = 1 and "EPS" > 0. This implies that the company's stock price and earnings increased during the year. This is to be expected. An investor would ideally hold this stock due to its high performance or sell to collect profits.

3 – "Class" = 1 and "EPS" <= 0. This implies that the company's stock price increased while its earnings decreased. An investor would either sell this stock if contained in their portfolio or stay away – given that the increase in its price is not validated by strong company performance.

4 – "Class" = 0 and "EPS" > 0. This implies that a company's price has decreased while its earnings increased. This can turn out to be very profitable for investors as they can capitalize on low price to enter a well performing company. Further investigation must be conducted however to ensure that the decrease in stock price is only temporary.

C. Construction of Models

To investigate the effects of various financial indicators on EPS, random forest models were built. These ensemble models are particularly powerful machine learning algorithms that employ numerous decision trees to find patterns in the data.

The library used to build the random forests was sklearn. Evaluation of model performance in this library is done by calculating the coefficient of determination of the model. This indicates the percentage variance of the dependent variable that can be explained by the combination of independent variables fed to the model. Using this metric can allow us to ascertain the extent to which these independent variables explain EPS – which will be valuable for the first research question.

D. Validation of results

Model results were validated using cross-validation. The hyperparameters tuned were the number of estimators and maximum number of features (to be considered for each split). The GridSearchCV class was used – which employs 5-fold cross validation by default.

The feature selection process included using the coefficient of determination to identify important features. One issue with this is the correlation vs causality problem – evidence of the former does not prove the latter. However, investigation of the features selected do imply an arrow of causality. Some of the features included **Net Income per Share** and **Retained earnings (deficit)**. These values clearly influence a company's earnings and validate results.

V. Findings, Reflection and Further Work

A. Research Question 1

TABLE I.

Industry	*Key Features*	*Score (coefficient of determination)*
Finance	Net Income per Share, Net Profit Margin, Return on Equity, Retained earnings (deficit), Earnings Yield	0.57
Healthcare	Net Income, Receivables, Net Income per Share, Profit Margin	0.87

Fig 3. Table showing important features and random forest model results for financial and healthcare companies

Fig 3 shows the key determinants of earnings per share – satisfying the first part the research question. The second part questioned the extent to which these determinants effected EPS. The coefficient of determination illustrates this. As mentioned earlier, this does not imply causation. However, these features are related to company earnings and income – which have a causal relationship with EPS.

Identifying the key determinants of EPS will provide investors with key information when making investment decisions. A positive EPS is insufficient evidence to purchase a stock. However, if this purchase decision is informed by the key features driving earnings, it will lead to better results and be conducive to thorough analysis.

Investigation of the coefficients of determination for the models constructed can aid investors in the weightage given to the key factors of EPS. The lower value for financial companies (0.57) indicates that investigation of these factors may be insufficient to fully justify a purchase decision.

One limitation of this study is that it is limited to the financial and healthcare industries. While this was intentionally done to limit the scope of this research, further work could include all industries. This would enable further comparison and deeper analysis.

B. Research Question 2

The first part of the research question focuses on the relationship between EPS and Price Variation. Fig 4 shows the relationship between the two for financial and healthcare companies using scatterplots.

The scatterplots suggest that there is no relationship between EPS and Price Variation. This was investigated further by segmenting the companies according to Class. The Cohen's d was calculated between the EPS for each Class to determine the effect size of EPS on price. Remember, a value of 0 and 1 for the Class target variable correspond to price decrease and increase, respectively. For financial companies, Cohen's d was 0.13, indicating little to no effect of EPS on price. This can protect investors by making them stop and think before buying into financial stocks whose prices are rising sharply – given their knowledge that this may not be driven by healthy company performance. For healthcare companies, Cohen's d was 0.52, indicating a moderate effect size of EPS on price.

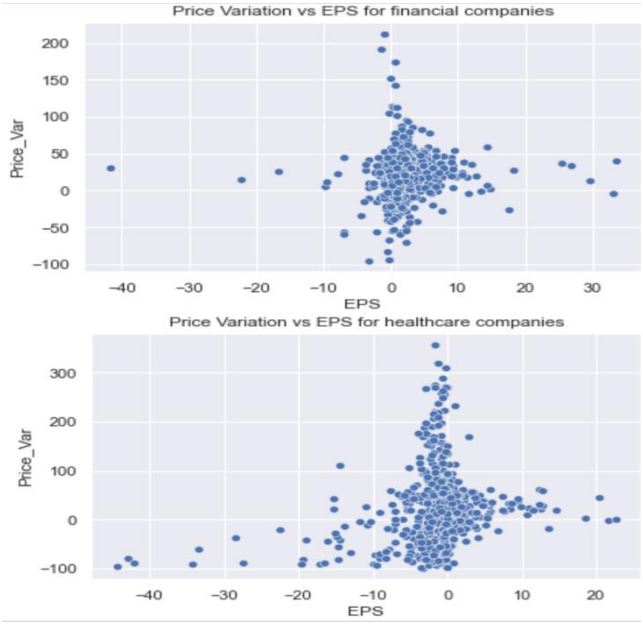

Fig 4. Scatterplots showing Price_Var vs EPS for financial *(above)* and healthcare *(below)* companies

This will be useful to investors as an increase in price can indicate good company performance and a good buying opportunity – if the price is favorable.

The companies were segmented into tranches discussed in the *Data Derivation* section. The distribution of the companies across these tranches is shown in Fig 5 below:

TABLE II.

	Tier			
Industry	***1***	***2***	***3***	***4***
Finance	**0.04**	**0.74**	**0.12**	**0.10**
Healthcare	**0.40**	**0.20**	**0.33**	**0.07**

Fig 5. Table showing the percentage of companies per sector belonging to each tier

The main companies to note are those in Tier 4. These correspond to companies whose stock prices have reduced despite good performance. This will be helpful to investors as identifying these companies gives them the opportunity to purchase them at a fair price.

Another key finding is companies in Tier 3 for the healthcare industry. This tier corresponds to companies whose prices have increased despite poor performance. This identification will help investors stay away from these companies and not get drawn in by the hype surrounding their increasing prices.

One limitation of these findings is that they do not consider the magnitude of EPS and price varation – just that they are negative or positive. For further work, this could be considered.

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WORD COUNT

[1] Introduction – 279 words
[2] Analytical questions and data – 273 words
[3] Data Materials – 231 words
[4] Analysis – 970 words
[5] Findings, reflections and further work – 590 words