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# MULTI-DISCIPLINARY APPROACH TO EVALUATE COMPANIES' PERFORMANCES

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*Dedicated to Professor Jeffrey H. Smith at USC*

Abstract. Effective and objective evaluation of companies' performances based on facts not only is essential information to all potential investors (external users) for wise investment decisions but also an utmost important tool to the management teams in the company (internal users) for strategic planning development and deployment. To compare and evaluate many companies' performances, we apply a multi-disciplinary approach which combines accounting with predictive statistics, multi-attributes utilities model and groups decision making. This is a indeed a very creative and effective approach: the raw data are all from professionally audited financial statements in the latest 3 years (currently 2006-2008), these data are then first analyzed using accounting ratios, these ratios are then used to predict the future years' ratios with predictive statistics tools, the ratios tend to converge to a certain point and these points give the values to the 5 most important criteria in evaluating a company's performance: liquidity, profitability, efficiency, solvency, and size and finally with multi-attribute utilities model and group decision making, we can rank the companies accordingly. To illustrate that more clearly, due to the focus on scrutinized details, a better illustration of this complex multi-disciplinary approach and the time constraint, we only choose five of the biggest companies in computer software industry: Microsoft, Oracle, CA, Intuit, and Red Hat. However, this approach can be applied in evaluating numerous companies' performances within the same or even across various industries all at once.

## 1. **Accounting**

Accounting ratios are very useful to extract information from financial statements and to quantify the 5 most important criteria in evaluating companies' performance. Among many ratios, we only pick the most representative ones to measure liquidity, profitability, efficiency, solvency, and size.

(1) For liquidity, net working capital ratio measures the percentage of net working capital of the total asset and this is best to determine how liquid the company is.
Net working capital ratio = (current assets - current liabilities) / total assets.

(2) For profitability, profit margin measures how much out of every dollar of sales a company actually keeps in earnings and this is very useful to compare different companies regardless their size, or industries.
Profit margin = net income / total revenue

[1]**Please refer to the EXCEL file for more calculation details**

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(3) For efficiency, return on equity (ROE) measures how much profit it is able to generate given resources provided by its stockholders and it tells us how efficient the management is working.
ROE = net income / total equity
(4) For solvency, solvency ratio measures a company's ability to meet long-term obligation and hence suggests how likely a company will continue meeting its debt obligations. As a standard, financially healthy companies have at least 20% solvency ratios.
Solvency ratio = (after tax net profit + depreciation) / total Liabilities.
(5) For size, market capitalization is used as this is the most common valuation of company worth method. Even though it fluctuates very frequently as stock price changes, the magnitude of it still generally stays constant as long as the company is not changing dramatically to bankruptcy.

The first stage in my analysis is to calculate these accounting ratios for all 5 companies using the financial statements in the latest 3 years that are readily available on Yahoo Finance website.

## 2. **Predictive Statistics**

The second stage of this approach is using the data in the first stage to predict companies' future accounting ratios in the next 10 to 20 years. We can statistically analyze the data to see the data distributions and make models like multiple linear regressions or even non-linear regressions to predict future ratios. If we do so, we need to not only look at the annual data like we currently have here, but also the quarterly or even monthly financial statements as our model increases in accuracy and reliability as we increase the number of data. However, due to the complexity of the regression modeling, the huge amount of data we have to gather, and the time given for this mini-project, we alternatively choose "simple moving average" method. Basically, it is just a simple recursive function:

$$Ratio_{n+1} = \frac{(Ratio_{n-2} + Ratio_{n-1} + Ratio_n)}{3}.$$

## 3. **Multi-attributes Utility model (multiplicative case)**

3.1. **Data Gathering and Organization.** First we need the raw data with the alternative choices in the first column and attributes in the first row. In our case, it looks like this:

| Company//Attributes | Liquidity | Profitability | Efficiency | Solvency | Size (Market Cap in $) |
|---|---|---|---|---|---|
| Microsoft | 0.153 | 0.285 | 0.447 | 0.508 | 183,940,000,000 |
| Oracle | 0.148 | 0.241 | 0.241 | 0.176 | 83,190,000,000 |
| CA | -0.023 | 0.075 | 0.084 | 0.099 | 8,260,000,000 |
| Intuit | 0.143 | 0.162 | 0.227 | 0.307 | 7,240,000,000 |
| Red Hat | 0.272 | 0.171 | 0.092 | 0.099 | 1,820,000,000 |

It would be useful to run a preliminary descriptive statistics on this so we have:

| | | | | | |
|---|---|---|---|---|---|
| Min | -0.023 | 0.075 | 0.084 | 0.099 | $ 1,820,000,000 |
| Max | 0.272 | 0.285 | 0.447 | 0.508 | $ 183,940,000,000 |
| Mean | 0.139 | 0.187 | 0.218 | 0.238 | $ 56,890,000,000 |
| Standard Deviation | 0.105 | 0.081 | 0.147 | 0.173 | $ 78,574,959,115 |

3.2. **Utility Assessments for Each Attribute.** Next, we would introduce the utility functions for each of the attributes. For our case, the higher the accounting ratios are and the bigger market cap is, the more preferred they are for the 5 attributes. Therefore, our general utility function for all 5 attributes is:

$$U(x) = \frac{(x - min)}{(max - min)}$$

With this function in place, we convert all the raw data into utility so we have:

| Company//Attributes | Liquidity | Profitability | Efficiency | Solvency | Size |
|---|---|---|---|---|---|
| Microsoft | 0.60 | 1 | 1 | 1 | 1 |
| Oracle | 0.58 | 0.79 | 0.43 | 0.19 | 0.45 |
| CA | 0 | 0 | 0 | 0 | 0.04 |
| Intuit | 0.56 | 0.41 | 0.39 | 0.51 | 0.03 |
| Red Hat | 1 | 0.046 | 0.02 | 0 | 0 |

3.3. **Relative Importance Coefficients Assessments.** Now, we need the data from decision makers to give relative importance coefficients (called $K_n$) for all 5 attributes. Rather than randomly interview people who might not even have a clue about company's performance evaluation, we would characterize both internal and external users (intended audience of this work) who have at least some clues on evaluation of company's performance into 5 groups:

(1) Neutral decision makers. They would view liquidity, profitability, efficiency, solvency, and size being all equally relatively important.
(2) Risk averse decision makers. They would rank the attributes as follow: Solvency > liquidity > efficiency > profitability > size for the reason that they do not want risks and solvency and liquidity solely associate with risk of the company's performance. Efficiency has slightly some correlation to risks as the better the management team is, the higher chance the company will survive in the long run. For the last two attributes, profitability and size seem to have very little correlation to risk. However, profitability is certainly more preferred to size as many potential investors and management teams would care about the profit than the size of the company.
(3) Risk seeking decision makers. They focus the most on profit and are willing to take risks. In contrast to risk averse case, they would generally rank the attributes as follow: profitability > efficiency > size > liquidity > solvency.
(4) Extreme risk averse. They are similar to risk averse group except that they put much more weight on solvency and liquidity than other 3 attributes.
(5) Extreme risk seeking. They are similar to risk seeking group except that they put much more weight on profitability and efficiency than other 3 attributes.

In summary, one possible relative importance coefficients for these 5 groups would be:

| Company//Attributes | Liquidity $K_1$ | Profitability $K_2$ | Efficiency $K_3$ | Solvency $K_4$ | Size $K_5$ |
|---|---|---|---|---|---|
| Risk Neutral | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Risk Averse | 0.4 | 0.2 | 0.3 | 0.5 | 0.1 |
| Risk Seeking | 0.2 | 0.5 | 0.4 | 0.1 | 0.3 |
| Extreme Risk Averse | 0.7 | 0.2 | 0.3 | 0.8 | 0.1 |
| Extreme Risk Seeking | 0.2 | 0.8 | 0.7 | 0.1 | 0.3 |

3.4. **Multi-attributes Utility Determination.** Next we need to find the master constant K for each of these group. The formula is:

$$1 + K = \prod_{n=1}^{n=N} (1 + K * K_n)$$

To find the constant $K$ for each group, since this is a 5th degree polynomial, we don't have an exact solution because we can't explicitly express our solutions. Nevertheless, we can use Newton's approximation method and better yet, we can use MATLAB (professional software that many scientists/engineers/mathematicians use). Interestingly enough, for all 5 groups, their constants $K$ share a lot in commons. The roots for that equation above always contain 2 imaginary and 3 real roots with 0, a real number between -1 and 1, and another real root. For example, for risk neutral group, their master constant $K$ is one of the possible roots: 0, -3.85544.6038i, -8.4831, and -0.6811 but we only choose a none-zero $K$ between -1 and 1 which is -0.6811 in this case.
Furthermore, for each group, we calculate their multi-attribute utility. The multiplicative model for multi-attributes utility model is:

$$U(\vec{x}) = \frac{1}{k} * (\prod_{n=1}^{n=N} (1 + K * K_n * U_n(X_n)) - 1)$$

With EXCEL, we can calculate the multi-utility for all 5 groups and hence determine the ranking of the company's performance and here is a sample for 1 group: (Preferences: liquidity = profitability = efficiency = solvency = size where $K_n = 0.3$ $\forall\ n = 1, 2, ...5$ )

| Company//Attributes | Liquidity | Profitability | Efficiency | Solvency | Size | MAU | Ranking |
|---|---|---|---|---|---|---|---|
| Microsoft | 0.60 | 1 | 1 | 1 | 1 | 0.951 | 1 |
| Oracle | 0.58 | 0.79 | 0.43 | 0.19 | 0.45 | 0.604 | 2 |
| CA | 0 | 0 | 0 | 0 | 0.04 | 0.011 | 5 |
| Intuit | 0.56 | 0.41 | 0.39 | 0.51 | 0.03 | 0.494 | 3 |
| Red Hat | 1 | 0.46 | 0.02 | 0 | 0 | 0.414 | 4 |

Repeating that process 5 times, here is the summary of ranking for all 5 groups:

| Company//Group's Ranking | Risk Neutral | Risk Averse | Risk Seeking | E. Risk Averse | E. Risk Seeking |
|---|---|---|---|---|---|
| Microsoft | 1 | 1 | 1 | 1 | 1 |
| Oracle | 2 | 3 | 2 | 4 | 2 |
| CA | 5 | 5 | 5 | 5 | 5 |
| Intuit | 3 | 2 | 3 | 3 | 3 |
| Red Hat | 4 | 4 | 4 | 2 | 4 |

## 4. Group Decision Making

4.1. **Group Agreement/Disagreement Intensity.** To determine whether all groups agree or disagree with the ranking to a certain degree, we calculate the Kendall's coefficient of concordance W (from 0 (total disagreement) to 1 (complete agreement)).

$$W = \frac{S}{\frac{1}{12}k^2(N^3 - N) - k\sum_{i=1}^{k} T_i}$$

Please refer to the lecture notes for more details.
In our example, W=0.856 (Please refer to Summary & Analysis worksheet in the EXCEL file)
W=0.856 shows that the 5 groups above are very much in agreement especially in ranking Microsoft as best performer and CA as worst performer. To further confirm their agreement, we would conduct a hypothesis testing.

4.2. **Hypothesis Testing on Group's Agreement/Disagreement.** This is also referred to hypothesis testing on S (a parameter in W calculation above)
Ho: $S = S_{critical}$ Ranking is independent (not similar)
Ha: $S > S_{critical}$ Ranking is dependent (similar)
where $\alpha = 0.5$, $k = 5$ (5 groups) and $N = 5$ (5 companies)
Since $S = 214 > S_{critical} = 112.3$ (from Kendall table), we reject Ho.
We conclude that ranking of the groups are in agreement at $\alpha = 0.05$ signficant level.

4.3. **Group Ranking.** Finally, we compute the group ranking for all 5 groups accordingly with different rules and find the following **Summary of Group Ranking**

| Company–//–Group Ranking Rule | Nash | Borda | Additive Utility |
|---|---|---|---|
| Microsoft | 1 | 1 | 1 |
| Oracle | 2 | 2 | 2 |
| CA | 5 | 5 | 5 |
| Intuit | 3 | 3 | 3 |
| Red Hat | 4 | 4 | 4 |

## 5. Possible Improvements

- In the predictive statistics stage, to predict the future accounting ratios more accurately, we should be using more sophisticated tools such as multiple linear regression or even none-linear regression and also gather more data from the past years such as the monthly financial statements in the latest 10 years.
- This approach mainly focuses on *quantitative* analysis with variety of effective methods and consideration many essential factors. Further improvement is to combine it with other *qualitative* analysis such as customer's satisfaction survey, customer perceived value method, quality management of the company...
- We should add more attributes such as employees' retention, potential for future growth, customer's satisfaction...
- This approach can be applied to evaluate not just company's performance but also industry's performance and it can even be applied to portfolio management.