

Application of TOPSIS Technique for Financial Performance Evaluation of Manufacturing Firms in US Market

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Abstract: For over a hundred years, manufacturing firms has been a major sector of the US economy. In today's competitive market, being able to accurately evaluate the firm's financial performance is becoming increasingly important. By appropriately evaluating the financial performance of the company, a firm can better protect their market position and protect their market shares while the financial statement users can better understand the firm's financial position and have better valuation on the company. In this paper, the author utilizes the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method to analyze financial ratios of twenty selected manufacturing firms in the US market. This method enables us to rank these firms according to their financial performance. Although some similar analytics has been done on multiple industries, this article focuses specifically on manufacturing companies and seeks to reach a better understanding of whether this ranking system can explain the overlap between the financial performance and the market value of manufacturing companies.

Keywords: Financial Performance, TOPSIS, Manufacturing sector

1. Introduction

Manufacturing and retail industry have been considered as one of the largest components of the economic. According to the National Institute of Standards and Technology (NIST), the manufacturing industry contributed 2269.2 billion dollars to the Gross Domestic Product (GDP) in US during 2020, which accounted for about 10.8% of total GDP^[1]. With direct and indirect value added, the number increases to 24% of total GDP. The U.S. manufacturing sector plays a central role in the economy, accounting for 20% of U.S. capital investment, 60% of the nation's exports and 70% of business R&D^[2]. The US manufacturing industry is the second largest manufacturing industry in the world, just behind that of China, it also has the largest chemicals and pharmaceutical, Motor vehicles, computer, fabricated metal and paper products production in the world^[1]. Despite the manufacturing industry is more capital intensive and operated stable for the pre Covid-19 period, it still suffered an enormous impact by the pandemic. The manufacturing industry shows a declination of 12.2% on value-adding during 2020 with a 12.4% reduction on employment. During the Covid-19 pandemic period, many smaller factories must shut down due to the health and cost concern.

This study focuses on the financial performance evaluation on the manufacturing business and further contribute to the existing analysis on the industry. Performance evaluation is a useful step to evaluate the efficiency of the management and the accountability for their reports. It can be considered as an action guide from what it is towards what it should be. Evaluating the performance of firms and factories can function as a guideline that paves the way for future decisions, concerning investment, development and most importantly, control and supervision. (Tehrani & Rahanama, 2006)^[3]. The performance evaluation on firm's financial sector is a more focused way to evaluate the overall performance of the company and its position in the industry. According to the CFA institution, financial reporting quality can be thought of as spanning a continuum from the highest (containing information that is relevant, correct, complete, and unbiased) to the lowest (containing information that is not just biased or incomplete but pure fabrication)^[4]. By analyzing the relevance, correctness, completeness, and biasness of the financial report of the company, we can draw a conclusion on the quality of its financial performance.

According to Industry Select, there are 24,034 manufacturing companies in California employing around 1,541,000 workers, which makes it the largest manufacturing state, followed by Texas and Ohio. Electronics is California's largest industrial sector, as most of the top companies such as Google, Apple, Intel, Tesla, and Northrop Grumman based in the state. The scope of this paper will majorly focus on

manufacturing companies in California ^[2]. By analyzing the public manufacturing companies in California, it is possible to draw a conclusion that can extend to other companies in different areas.

2. Literature Review

Multiple studies about financial performance evaluation have been published and addressed various aspects from the evaluation methods to the implementation of models in real life public and private companies. However, there has been few research specifically on the financial performance evaluation on manufacturing companies in United States. By relating this paper to previous studies, we can use manufacturing companies in the United States to address the significance and importance of financial performance evaluation. The following literature review summarized related studies of this paper on financial performance evaluation.

Yidan Liu, Qiuli Wu, Fang Yuan (2020) ^[5] evaluated fifty-six public companies in Anhui province for their financial performance evaluation from the aspect of profitability, development ability, operation ability and solvency including fifteen indicators. Principal component analysis (PCA) was also used for building the qualitative and quantitative index system of the financial performance evaluation.

Patrick Anthony, Babak Behnoee, Malek Hassanpour and Dragan Pamucar (2019) ^[6] investigated 7 Indian companies on their financial performance with ratio analysis, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Complex Proportional Assessment (COPRAS) and Data Envelopment Analysis (DEA) along with weighing systems of equal weighing, Entropy Shannon, and Friedman test. The study results a ranking of the selected companies in three levels based on their financial performance and classified the efficiency of the company based on the ranked values.

Reza Tehrani, Mohammad Reza Mehragan & Mohammad Reza Golkani (2012) ^[7] developed a model for the evaluation of the companies' performance through financial information and data analysis techniques. The author employed the Data Envelopment Analysis (DEA) Model as the core of their study on thirty-six companies. Those companies were ranked based on their efficiency with the model and causes of weaknesses of each company were pointed out using reference units and auxiliary variables. The model was proven as suitable for future evaluation of other companies.

Theodore Syriopoulos, Michael Tsatsaronis and Martha Gorila (2020) ^[8] discussed the financial performance evaluation on the cruise industry. The author identified the critical growth drivers on the cruise industry as well as the evaluates of a set of key financial ratios, metrics, and indicators to assess cruise company financial performance and value creation dynamics. The study provided a filled the research gap in the cruise industry and provided meaningful management suggestions on the industry.

Yujie Gao (2022) ^[9] discussed the incorporation of the entropy weight TOPSIS method on evaluating the financial performance of China Southern Airlines. The author investigated the shortcomings of the current financial performance evaluation on the company and introduced the new entropy weight TOPSIS method to further discuss the weakness of the company and provided valuable suggestions for improvement.

Berna (Kiran) Bulgurcu (2012) ^[10] applied the TOPSIS technique in the performance evaluation of technology firms in Istanbul. The author utilizes the TOPSIS method to evaluate 13 selected firms in Turkey to investigate if they have demonstrated strong ability to maintain their market position and protect their market shares against potential risks. The outcome of the research shows that the ranking results of TOPSIS method is not like the market value of the selected firms and the author concluded that TOPSIS method is not enough to evaluate the financial performance of those newly emerged firms.

3. Research methodology

In this article, the entropy weight Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is used to perform the financial performance evaluation on the selected manufacturing companies in California area. The original data is collected through the U.S. Securities and Exchange Commission (SEC) official website and secondary data came through the analytic procedures.

The TOPSIS method was developed by Hwang and Yoon in 1981 and it has been defined as a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion, and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. The TOPSIS analytical process includes:

(1) create an evaluation matrix consisting of M alternatives and N criteria, with the intersection of each alternative and criteria given as X_{ij} , therefore, we have a matrix $(X_{ij})_{m \times n}$. (2) normalize to form the matrix $R = (r_{ij})_{m \times n}$ using normalization method. (3) Calculate the weighted normalized decision matrix. (4) Determine the worst alternative A_w and the best alternative A_b . (5) Calculate the L^2 distance between the target alternative i and the best and worst condition. (6) Calculate the similarity to the worst condition. (7) Rank the alternatives accordingly.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^m x_{kj}^2}} \quad i = 1, 2, 3 \dots, m, j = 1, 2, 3, \dots, n \quad (1)$$

$t_{ij} = r_{ij} \times w_j, i = 1, 2, 3 \dots, m, j = 1, 2, 3, \dots, n$ where $w_j = \frac{W_j}{\sum_{k=1}^n w_k}, j = 1, 2, 3, \dots, n$ so that $\sum_{k=1}^n w_k = 1$ and W_j is the original weight given to the indicator $v_j, j = 1, 2, 3, \dots, n$ (2)

$$A_w = \{(\max(t_{ij} | i = 1, 2, 3 \dots, m) | j \in J_-), (\min(t_{ij} | i = 1, 2, 3 \dots, m) | j \in J_+)\} \\ \equiv \{t_{wj} | j = 1, 2, 3, \dots, n\}$$

$$A_b = \{(\min(t_{ij} | i = 1, 2, 3 \dots, m) | j \in J_-), (\max(t_{ij} | i = 1, 2, 3 \dots, m) | j \in J_+)\} \\ \equiv \{t_{bj} | j = 1, 2, 3, \dots, n\} \quad (3)$$

$J_+ = (j = 1, 2, 3, \dots, n | j)$ is associated with criteria with positive impact and

$J_- = (j = 1, 2, 3, \dots, n | j)$ is associated with criteria with negative impact (4)

$$d_{iw} = \sqrt{\sum_{j=1}^n (t_{ij} - t_{wj})^2}, i = 1, 2, 3 \dots, m$$

$$d_{ib} = \sqrt{\sum_{j=1}^n (t_{ij} - t_{bj})^2}, i = 1, 2, 3 \dots, m$$

$S_{iw} = \frac{d_{iw}}{(d_{iw} + d_{ib})}, 0 \leq S_{iw} \leq 1, i = 1, 2, 3 \dots, m, S_{iw} = 1$ if and only if the alternative solution has the best condition and $S_{iw} = 0$ if and only if the alternative solution has the worst condition (5)

Financial statement is a valuable resource to evaluate the firm's financial performance, to compare firms with different volumes, 11 financial ratios are selected to perform the analytics. In this article, there are 2 liquidity ratios that measure the company's ability to comply with short-term obligations, 2 efficiency ratios that measure the utilization of resources, 3 leverage ratios that measure the debt level, 3 profitability ratios that measure the company's ability to generate income and 2 market value ratio that measure the reasonableness of the company's stock price. The calculation of those ratios is listed below:

C1	Current Ratio	Current Assets / Current Liabilities
C2	Acid Test Ratio	Quick Assets / Current Liabilities
C3	Total Asset Turnover Ratios	Total Sales / Total Assets
C4	Inventory Turnover Ratios	COGS / Average Inventory
C5	Equity Ratio	Shareholder Equity / Total Assets
C6	Debt Equity Ratio	Total Debts / Shareholder Equity
C7	Debt to Total Capital Ratio	Total Debts / Total Assets
C8	Net Profit Margin	After tax Income / Net Sales
C9	Return on Net Capital	EBIT / Net Capital
C10	Operating Cash Flow Ratio	Cash Flow from Operations / Current Liabilities
C11	Fixed Asset to Net Worth Ratio	Fixed asset / Net Worth
C12	Diluted EPS	taken from the Financial Statement

4. Application

In this paper, twenty public manufacturing companies in California are selected based on their revenue and their representativeness in the industry, data are collected based on the 2021 balance sheet, cash flow statement and income statement, the financial ratios listed above are calculated based on the data collected in Table 1.

Table 1: Original data

Firm	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Apple Inc.	1.07	1.02	1.04	40.03	0.18	1.98	0.36	0.26	1.73	0.83	5.61	0.63
Chevron Corporation	1.26	1.02	0.65	17.91	0.58	0.22	0.13	0.10	0.16	1.09	8.14	1.06
Intel Corporation	2.10	1.71	0.47	3.67	0.57	0.40	0.23	0.25	0.23	1.09	4.86	0.66
HP Inc.	0.76	0.49	1.64	7.21	-0.04	-4.54	0.19	0.10	-4.55	0.22	5.33	-2.27
Cisco Systems, Inc.	1.49	1.43	0.51	12.62	0.42	0.28	0.12	0.21	0.32	0.59	2.50	0.06
Qualcomm Incorporated	1.68	1.41	0.81	4.90	0.24	1.58	0.38	0.27	1.03	0.88	7.87	0.46
Gilead Sciences, Inc.	1.27	1.13	0.40	4.00	0.31	1.27	0.39	0.23	0.39	0.98	4.93	0.24
Nvidia Corporation	6.65	6.05	0.61	4.26	0.60	0.41	0.25	0.36	0.37	2.10	3.85	0.14
Amgen Inc.	1.59	1.26	0.42	1.62	0.11	4.97	0.54	0.23	1.00	0.76	10.28	0.77
Applied Materials, Inc.	2.54	1.86	0.89	2.96	0.47	0.45	0.21	0.26	0.55	0.86	6.40	0.18
Western Digital Corporation	2.00	1.26	0.65	3.71	0.41	0.81	0.33	0.05	0.09	0.39	2.66	0.30
Advanced Micro Devices, Inc.	2.02	1.56	1.32	5.07	0.60	0.04	0.03	0.19	0.49	0.83	2.57	0.14
Lam Research Corporation	3.30	2.54	0.92	3.41	0.38	0.82	0.31	0.27	0.73	1.02	26.90	0.22
KLA Corporation	2.71	1.96	0.67	1.92	0.33	1.02	0.34	0.30	0.70	1.04	13.37	0.23
The Clorox Company	0.89	0.52	1.16	6.87	0.06	6.77	0.44	0.10	2.19	0.62	5.58	3.98
Sanmina Corporation	1.86	1.27	1.61	6.54	0.45	0.18	0.08	0.04	0.16	0.19	4.01	0.28
Agilent Technologies, Inc.	2.22	1.74	0.59	3.76	0.50	0.51	0.25	0.22	0.25	0.87	3.94	0.18
Skechers U.S.A., Inc.	2.33	1.31	0.97	2.56	0.50	0.10	0.05	0.12	0.17	0.15	4.73	0.72
Netapp, Inc.	1.50	1.45	0.63	13.19	0.08	3.15	0.26	0.15	1.31	0.31	4.09	1.07
Intuitive Surgical, Inc.	5.08	4.57	0.42	2.95	0.88	0.00	0.00	0.30	0.16	1.82	4.66	0.16

Using the SPSSAU software, the weight of each indicator can be calculated with the entropy of information and presented in the following Table 2.

Table 2: Weighting table

Firm	Entropy of information	Information utility	weight
Current Ratio	0.9472	0.0528	8.15%
Acid Test Ratio	0.934	0.066	10.19%
Total asset turnover	0.9691	0.0309	4.77%
Inventory Turnover Ratio	0.8593	0.1407	21.71%
Equity Ratio	0.9492	0.0508	7.84%
Debt equity ratio	0.9701	0.0299	4.62%
Debt to total capital ratio	0.9387	0.0613	9.47%
Net profit margin	0.9632	0.0368	5.67%
Return on net capital	0.9812	0.0188	2.90%
operating cash flow ratio	0.944	0.056	8.64%
EPS	0.9244	0.0756	11.67%
Fixed assets to net worth ratio	0.9717	0.0283	4.37%

Based on the previous Table, the weighted data is presented in the following Table 3

Table 3: Weighted normalized table

Firm	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Apple Inc.	0.09	0.10	0.05	8.69	0.01	0.09	0.03	0.01	0.05	0.07	0.65	0.03
Chevron Corporation	0.10	0.10	0.03	3.89	0.05	0.01	0.01	0.01	0.00	0.09	0.95	0.05
Intel Corporation	0.17	0.17	0.02	0.80	0.04	0.02	0.02	0.01	0.01	0.09	0.57	0.03
HP Inc.	0.06	0.05	0.08	1.56	0.00	-0.21	0.02	0.01	-0.13	0.02	0.62	-0.10
Cisco Systems, Inc.	0.12	0.15	0.02	2.74	0.03	0.01	0.01	0.01	0.01	0.05	0.29	0.00
Qualcomm Incorporated	0.14	0.14	0.04	1.06	0.02	0.07	0.04	0.02	0.03	0.08	0.92	0.02
Gilead Sciences, Inc.	0.10	0.12	0.02	0.87	0.02	0.06	0.04	0.01	0.01	0.08	0.58	0.01
Nvidia Corporation	0.54	0.62	0.03	0.92	0.05	0.02	0.02	0.02	0.01	0.18	0.45	0.01
Amgen Inc.	0.13	0.13	0.02	0.35	0.01	0.23	0.05	0.01	0.03	0.07	1.20	0.03
Applied Materials, Inc.	0.21	0.19	0.04	0.64	0.04	0.02	0.02	0.01	0.02	0.07	0.75	0.01
Western Digital Corporation	0.16	0.13	0.03	0.81	0.03	0.04	0.03	0.00	0.00	0.03	0.31	0.01
Advanced Micro Devices, Inc.	0.16	0.16	0.06	1.10	0.05	0.00	0.00	0.01	0.01	0.07	0.30	0.01
Lam Research Corporation	0.27	0.26	0.04	0.74	0.03	0.04	0.03	0.02	0.02	0.09	3.14	0.01
KLA Corporation	0.22	0.20	0.03	0.42	0.03	0.05	0.03	0.02	0.02	0.09	1.56	0.01
The Clorox Company	0.07	0.05	0.06	1.49	0.01	0.31	0.04	0.01	0.06	0.05	0.65	0.17
Sanmina Corporation	0.15	0.13	0.08	1.42	0.03	0.01	0.01	0.00	0.00	0.02	0.47	0.01
Agilent Technologies, Inc.	0.18	0.18	0.03	0.82	0.04	0.02	0.02	0.01	0.01	0.08	0.46	0.01
Skechers U.S.A., Inc.	0.19	0.13	0.05	0.56	0.04	0.00	0.00	0.01	0.01	0.01	0.55	0.03
Netapp, Inc.	0.12	0.15	0.03	2.86	0.01	0.15	0.02	0.01	0.04	0.03	0.48	0.05
Intuitive Surgical, Inc.	0.41	0.47	0.02	0.64	0.07	0.00	0.00	0.02	0.00	0.16	0.54	0.01

The positive and negative ideal solution are determined by the maximum and minimum value for each indicator from weighted table and presented in the following Table 4

Table 4: Ideal solution

	Positive ideal solution A	Negative ideal solution A-
C1	0.542	0.062
C2	0.617	0.05
C3	0.078	0.019
C4	8.689	0.351
C5	0.073	0.001
C6	0.523	0
C7	0.053	0.001
C8	0.021	0.002
C9	0.196	0
C10	0.182	0.013
C11	3.139	0.292
C12	0.273	0

Finally, relative closeness calculation to ideal solutions on those selected manufacturing firms is determined using formulars in the TOPSIS calculation. The calculation shows a ranking of those selected firms as presented in the following Table 5.

Table 5: Company ranking and relative closeness

	Distance to positive ideal solutions	Distance to negative ideal solution	Relative closeness	Ranking
Apple Inc.	2.594	8.355	0.763	1
Chevron Corporation	5.331	3.611	0.404	2
Intel Corporation	8.329	0.631	0.07	17
HP Inc.	7.62	1.259	0.142	7
Cisco Systems, Inc.	6.637	2.408	0.266	5
Qualcomm Incorporated	7.973	1.02	0.113	10
Gilead Sciences, Inc.	8.264	0.682	0.076	15
Nvidia Corporation	8.224	1.01	0.109	11
Amgen Inc.	8.587	1.038	0.108	12

Applied Materials, Inc.	8.42	0.652	0.072	16
Western Digital Corporation	8.406	0.564	0.063	19
Advanced Micro Devices, Inc.	8.132	0.819	0.091	13
Lam Research Corporation	7.969	2.907	0.267	4
KLA Corporation	8.444	1.33	0.136	8
The Clorox Company	7.652	1.349	0.15	6
Sanmina Corporation	7.78	1.127	0.126	9
Agilent Technologies, Inc.	8.344	0.605	0.068	18
Skechers U.S.A., Inc.	8.564	0.466	0.052	20
Netapp, Inc.	6.441	2.557	0.284	3
Intuitive Surgical, Inc.	8.468	0.738	0.08	14

The relative closeness measures the distance from the positive ideal solution and the negative ideal solution. Higher value indicates the distance is closer to the positive ideal solution and further from the negative ideal solution which results in higher ranking. In this evaluation, Apple Inc. has the highest ranking while Skechers U.S.A Inc. has the lowest.

The following Table 6 presents the rank of companies and their market value in billions dated September 10, 2022.

Table 6: Company ranking and market value

	Rank	Market value
Apple Inc.	1	2529.0
Nvidia Corporation	11	358.5
Chevron Corporation	2	305.3
Cisco Systems, Inc.	5	189.5
Qualcomm Incorporated	10	144.7
Advanced Micro Devices, Inc.	13	137.9
Amgen Inc.	12	131.3
Intel Corporation	17	129.2
Gilead Sciences, Inc.	15	81.8
Applied Materials, Inc.	16	80.7
Intuitive Surgical, Inc.	14	79.0
Lam Research Corporation	4	61.7
KLA Corporation	8	49.8
Agilent Technologies, Inc.	18	40.7
HP Inc.	7	29.2
The Clorox Company	6	18.2
Netapp, Inc.	3	15.9
Western Digital Corporation	19	13.7
Skechers U.S.A., Inc.	20	5.9
Sanmina Corporation	9	2.8

5. Conclusion

This article provides analyze on US manufacturing firms in California with the TOPSIS method. The TOPSIS method ranked the selected companies is based on the financial ratio analysis shows the difference between the financial performance and the market value. Apple. Inc has the highest rank in both the financial performance evaluation, sales revenue, and market value, but a significant difference in ranking the financial performance, sales and market value can be observed for the rest of the selected firms, indicating that the TOPSIS method is not enough to fully evaluate those firms. One probable reason is the difference in production and the nature of the manufactured goods. In the future studies, other methods can be incorporated to evaluate the financial performance of those firms while the TOPSIS

method can also be applied to evaluate companies in other areas. With the combination of different evaluation methods, a more refined financial performance evaluation can be done.

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