Evaluation of Chinese Semiconductor Companies' Stock Based on Factor Analysis and Cluster Analysis

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Abstract. The stock market has always played a very important role in the economy which could help to study the development and status of companies and even countries. With the continuous development of science and technology and the new prosperity of computing, telecommunication, banking, security, and manufacturing, the demand for semiconductor products is increasing, especially in China, which has become the world's largest regional market. Due to some objective reasons like national policy support, large market space, the emergence of new industry types, the subdivision of the industrial chain, and the M&A wave, China's semiconductor industry prospects are very good. Therefore, this paper aims to provide some suggestions for different types of investors by dividing the stocks into different categories and summarizing their characteristics through the research on semiconductor stocks. This article selects 60 different stocks and 18 various indicators for research and adopts factor and cluster methods to analyse. Finally, it is found that these 60 stocks can be roughly divided into 4 groups and each category has its characteristics.

Keywords: stock market, semiconductor industry, factor analysis, cluster analysis.

1. Introduction

Public stock markets exert a significant impact on today's globalized economy. They provide the chance to several exchanges in which shares of publicly held companies are bought and sold. Furthermore, stock markets enable companies to finance their development and expand operations by offering stock shares and corporate bonds and allow investors and traders to participate in the economic success of public companies by being the part owners to make profits from capital gains and earn income from dividends. Scientific reports show that stock markets have played an important role in both advanced economy growth and the emerging market and helped to predict the future economy [1-3]. Therefore, the performance of the country's stock markets is regarded as the best indicator of how well that economy is doing. Compared with other countries, China's stock market boomed relatively late. However, with the popular tendency for the stock market and huge progress of the market of the financial industry, the stock has emerged from the financial industry, becoming the mainstay of China's economic markets [4,5]. Therefore, it is still valuable and practical to have a stock investment analysis to study the development prospects of one industry in China.

In recent years, the adoption of digital technologies has been given a particular boost due to the worldwide disruption caused by the COVID-19 pandemic, since electronic devices showed the importance of connecting businesses and people remotely. Therefore, with the high demand from the customers, the semiconductor industry has been developing rapidly and its economic profitability has recovered relative better to other industries. The semiconductor industry grew quickly following the invention of the transistor in 1956 [6]. However, in the early 2000s, many companies generated returns that were less than the output of capital because the profit margins were relatively low. The semiconductor industry's economic profit has substantially increased over the past two decades. High improvement cloud usage, the rapid advance in technology, and the huge demand for microchips make the industry promise great benefits in the future [7]. Following the development of the times, China is now vigorously expanding the semiconductor industry. China's semiconductor industry started in 1988 and during its 40-year development, it has overcome various difficulties [8,9]. Today, China has become the world's largest regional market, accounting for 34.6%; the year-on-year increase is 27.1%, ranking third in the world [10]. Therefore, the investment prospects of the semiconductor industry are substantial and have extremely significant investment value. Furthermore,

there are other factors like the subdivision of the industrial chain which has weakened technical and financial barriers, and the M&A wave which offers experience and opportunities for domestic enterprises. All the factors provide many opportunities for China's semiconductor industry development as well as for the investors more chance to participate in the financial businesses of semiconductor companies.

Therefore, to help investors choose suitable stocks for themselves in the face of the semiconductor industry with better prospects, it is necessary to study in detail the features of different stocks by considering price indicators and companies' absolute value indicators. In the author's opinion, different investors have different risk preferences. Some investors are stable, some are aggressive, and some investors have more liquidity. The purpose of this article is to focus on several semiconductor stocks and to provide some suggestions for different types of investors by dividing stocks into different categories and summarizing their characteristics. This paper classifies stocks by cluster analysis and factor analysis.

2. Methodology

This research analyzes and studies the data of companies in China's semiconductor industry which comes from the financial big data terminal of the website called east money. Selected were the top 65 companies in the semiconductor industry from all the companies ranking at the top in debt asset ratio since 2022, due to the lack of some indicators, after removing the missing values, 60 stocks were finally selected for subsequent analysis. A total of 18 indicators are calculated to classify and analyze to make an effective and thorough evaluation of the performance of the stocks, including 8 market indicators and 10 company fundamental indicators, as Table 1 and 2 showing.

Market indicators contain the highest price, amplitude, turnover rate, and other indicators that reveal stock trading conditions. Because the market indicators are in a state of fluctuation at any time, this research finally selected the daily market indicators from August 1st to August 5th and figured out the average value as the value of each market indicator. In addition, the value range of the turnover rate is 1.25 to 66.05, which shows that the overall trading of the semiconductor companies is particularly active, and the trading style is relatively sharp.

Table 1. Market indicators description.

No.	Indicator	Description of Indicator
1	Price–earnings ratio	Share Price/Earnings per Share
2	Ratio of Price Spread	Value of Price Spread/Yesterday's Closing Price*100%
3	Amplitude	(Highest Price – Lowest Price)/ Closing Price *100%
4	Turnover Rate	the percentage of employees who left a company over a certain period.
5	Highest Price	the highest transaction price generated during the transaction.
6	Lowest Price	the lowest transaction price generated during the transaction.
7	Opening Price	the first price at which a stock trades during a regular trading session.
8	Closing Price	the last price at which a stock trades during a regular trading session.

The company's fundamental indicators include return on total assets (ROTA), current ratio, return on equity (ROE), and other common indicators that reflect the company's financial and operating conditions. To obtain the newest information, in this paper, the reporting period corresponds to the company's fundamental indicators in the first quarter of 2022.

Among them, return on total assets and return on equity measure how much profit a company can make with its extant capital. Gross margin on sales and net profit margin on sales show how much profit can be generated by a company's main business. The current ratio, quick ratio, and debt asset ratio can all be regarded as liabilities divided by assets, which judge a company's solvency. The total assets growth rate and net assets growth rate are equivalent to the proportion of assets added during the reporting period to the original assets which are used to weigh the expansion of a company's assets. The inventory turnover ratio measures the turnover speed of the inventory.

To recommend stocks for different investors, the clustering model is considered in this case. However, due to the high correlation between variables, it is not suitable to direct cluster. Therefore, factor analysis is used to reduce the dimensionality of the data before clustering. In this research, SPSS [11,12] is the tool to analyze the factor analysis [13,14] and cluster analysis [15,16] of those samples.

Table 2. Company fundamental indicators description.

No	Indicator	Description of Indicator
1	Return on total assets	EBIT /Average Total Assets
2	Return on equity	Net Earnings / Shareholders' Equity * 100%
3	Gross margin	(Revenue – COGS) / Revenue * 100%
4	Net profit margin	Net Profits / Net Sales * 100%
5	Debt asset ratio	Total Debt / Total Assets * 100%
6	Quick ratio	(Current Assets - Inventories - Prepaid Expenses) / Current Liabilities
7	Current ratio	Current Assets / Current Liabilities * 100%
8	Total assets growth rate	Growth in total assets this year/total assets at the beginning of the year * 100%
9	Net assets growth rate	increase in net assets in the current period/ total net assets of the previous period
10	Inventory turnover ratio	COGS/Average Value of Inventory

3. Result And Discussion

3.1 Factor Analysis

Factor analysis is considered a method to work with a dimensional reduction in statistical analysis, seeking the hidden factors among variables that would interpret the common ground of variances, which summarizes the interrelationships among the variables in a succinct but accurate manner to aid in conceptualization. The first step to perform factor analysis is to necessarily check if the dataset is available for factor analysis according to the judgment of KMO and Bartlett's test. Applying the 60 semiconductor companies' stock's 18 indicators and after standardizing the data, the Bartlett test could be approached, and its significance indicator, the p-value, is less than 0.0001, showing that the data can be subjected to factor analysis usefully. Furthermore, the value of the KMO of sampling is 0.693, indicating that there is indeed a certain correlation between the variables, and common factors can be extracted by factor analysis. It also represents that some latent factors may cause or interpret the proportion of variance in applied variables, which means that the variability of the stock data for the chosen indicators may result in 69.3% of the selected indicators. The next step is to find the commonalities analysis. All the indicators are 0.497 or above which is larger than 0.4 which means that there is a strong correlation between research items and factors, thereby factors can effectively extract information.

The data had been verified to be suitable and fit well for factor analysis, next step is to determine how many complex factors can be obtained from selected 18 indicators of the semiconductor companies' stock. Therefore, using the scree plot to obtain the optimal number of factors, and apply the eigenvalue of each factor to draw a screen diagram (figure 1). It can be seen from the diagram that there are a total of six complex factors whose eigenvalue is greater or equal to 1, so the number of factors initially selected is 6. Besides, after the rotated component matrix (Varimax rotation), it is clear to see that when six complex factors are selected, the cumulative proportion of variance reaches 81.84% which is a very high value for the indicator, indicating that the selection of the number of factors has certain rationality.

As Table 3 shows, complex factor 1 was named as price factor, which explains 24.47% of the variance of the semiconductor companies' stocks and this complex factor groups the largest number of indicators-4 or 22% of the total number. Complex factor 1 has a high load on price variables such as the highest price, the lowest price, the opening price, and the closing price, and all are positive, which can reflect the performance of the price stock.

Complex factor 2 was called profit factor, which explains 15.86% of the variance of the semiconductor companies' stocks and this complex factor groups the largest number of indicators-4 or 22% of the total number. Com-plex factor 2 has higher loadings on return on total assets, return on equity, gross margin, and net profit on sales. The return on total assets and return on equity positively reveal the company's profitability on assets, and the net profit margin on sales positively shows the company's profitability on sales. The higher the gross margin, the more capital the company retains, which it can then use to cover other costs or pay down debt.

Table 3. Factor analysis result of 60 semiconductor companies' stock indicators

Items	Factor loading						Communalities
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
Ratio of Price Spread	-0.318	-0.198	-0.229	-0.334	0.430	0.090	0.497
Amplitude	0.026	-0.108	-0.032	0.933	0.029	-0.092	0.894
Turnover Rate	-0.105	-0.010	-0.072	0.953	0.014	0.024	0.926
Highest Price	0.970	0.173	-0.107	0.021	-0.065	0.052	0.990
Lowest Price	0.968	0.188	-0.103	-0.025	-0.063	0.056	0.990
Opening Price	0.968	0.186	-0.106	-0.004	-0.064	0.054	0.989
Closing Price	0.965	0.190	-0.104	-0.060	-0.068	0.058	0.990
Gross margin	0.413	0.548	0.349	-0.170	0.069	-0.143	0.647
Debt asset ratio	0.271	-0.197	-0.827	-0.057	-0.163	0.044	0.827
Return on total assets	0.234	0.867	0.172	0.016	-0.023	0.045	0.839
Return on equity	0.411	0.840	-0.012	0.021	-0.045	0.092	0.886
Net profit margin	0.038	0.886	0.211	-0.085	-0.031	-0.020	0.840
Current ratio	-0.027	0.137	0.950	0.000	-0.117	-0.016	0.936
Quick ratio	-0.100	0.122	0.946	-0.135	-0.057	-0.004	0.942
Inventory turnover ratio	-0.072	-0.129	0.055	-0.055	0.756	-0.040	0.601
Total assets growth rate	0.239	0.107	-0.078	-0.154	0.040	0.661	0.537
Net assets growth rate	-0.073	-0.066	0.023	0.063	0.019	0.851	0.739

Table 3. Factor analysis result of 60 semiconductor companies' stock indicators

Items	Factor loading						Communalities
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
Price–earnings ratio	-0.014	0.146	-0.035	0.142	0.783	0.079	0.662

Complex factor 3 was entitled to the debt repayment factor which explains 15.51% of the variance of the semiconductor companies' stocks and this complex factor groups the second largest number of indicators-3 or 17% of the total number. Complex factor 3 has a higher load on the current ratio, quick ratio, and debt asset ratio which is taken as the absolute value. The current ratio and speed ratio can reflect the company's solvency in the short term, and the debt asset ratio can represent the company's solvency in the long run.

Complex factor 4 was concluded as the trading factor, which explains 11.14% of the variance of the semiconductor companies' stocks, and this complex factor groups the smallest number of indicators-2 or 11% of the total number. Complex factor 4 has a higher load on turnover and amplitude. The turnover rate positively reveals the performance of the stock in trading, and the amplitude also has a certain correlation with the trading performance.

Complex factor 5 was reported as the flow factor, which explains 8.07% of the variance of the semiconductor companies' stocks, and this complex factor groups the second largest number of indicators-3 or 17% of the total number. Complex factor 5 has a higher load on the inventory turnover ratio, price-earnings ratio, and ratio of price spread. The inventory turnover ratio could represent the efficiency of a company that has sold and replenished its inventory over a specific amount of time.

Complex factor 6 was regarded as the growth factor, which explains 6.84% of the variance of the semiconductor companies' stocks, and this complex factor groups the smallest number of indicators-2 or 11% of the total number. Complex factor 6 has a higher load on the total assets growth rate and the net assets growth rate. The total assets growth rate and the net assets growth rate both positively show the company's performance in terms of growth.

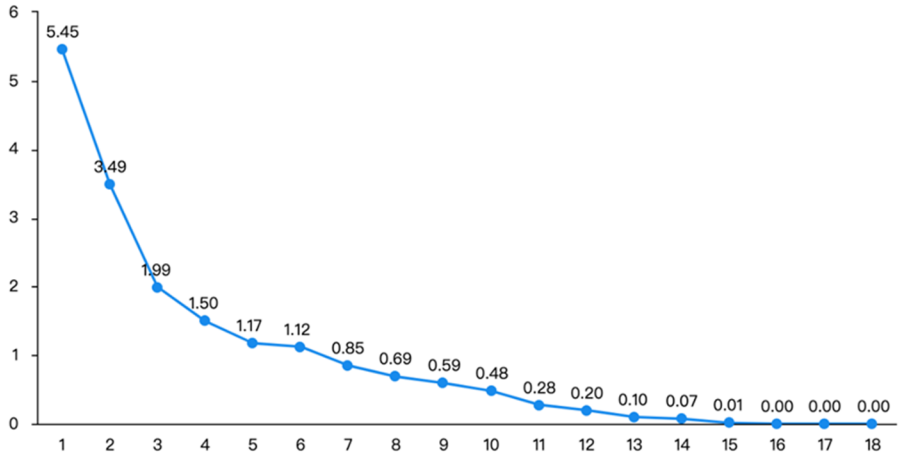

Figure 1. Scree Plot.

As Figure 1 shows, the scree plot is used to assist in judging the number of factors to be extracted. When the stitches are suddenly changed from steep to stable, the number of factors corresponding to the steepness to the stable is the number of reference extraction factors. Therefore, 18 indicators in this analysis were grouped into 6 complex factors, and their factor loads are presented in Table 3. According to the positive and negative values of the factor loadings, their name could be defined.

3.2 Cluster analysis

Cluster analysis is an approach to sorting different samples or data points into groups in a manner, and the degree of association between two objects is high if they belong to the same group and low if they belong to different groups. After the factor scores for each stock were normalized to remove dimensional effects, a K-means cluster analysis was performed. This research uses the sum of squared distances (SSE) from the sample points in each cluster to the centroid of the cluster as a performance measure. The smaller the value, the more convergent each cluster is. Then according to the elbow rule, the 60 semiconductor companies' stocks were divided into 4 clusters. To explore the specific characteristics of each cluster, the analysis of variance is used to study the differences between each category group. Using ANOVA to explore the different characteristics of each category, factor 5 was found that shows no significance, thereby in the later analysis, factor 5 was deleted, as Table 4 shows.

Table 4. Cluster Centers.

Items	Initial Cluster Centers				Final Cluster Centers			
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Growth Factor	3.450	-1.705	1.486	1.989	0.805	-0.237	0.478	-0.249
Trading Factor	0.283	-1.487	-1.453	3.792	-0.131	-0.094	-0.157	6.710
Debt Repayment Factor	1.470	2.246	1.550	-0.261	-1.149	-0.234	0.705	-0.312
Profit factor	0.928	0.998	0.796	2.300	1.254	0.355	-0.973	-0.167
Price factor	3.797	0.297	1.445	0.276	3.396	-0.341	0.391	0.184

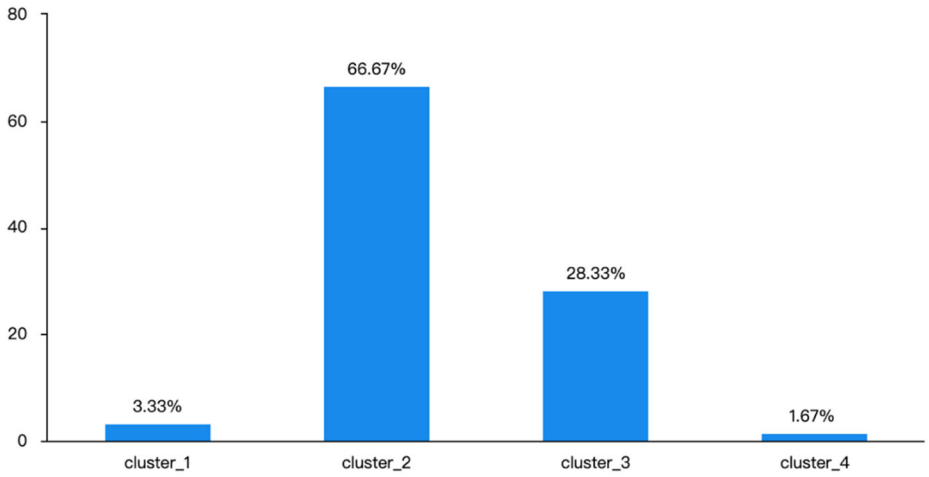

Figure 2. Cluster Diagram.

As can be seen from Figure 2, the price factors of cluster 1 are significantly higher than other stocks, and its profit factor and growth factor are also ranked first, showing that this type of stock has a high price, and strong profitability, and powerful growth ability. Cluster 2 performs equally in all factors. It is more common and has no features. Cluster 3 shows significantly better than the debt repayment factor. Other categories of stocks perform better in growth and price factors, indicating that they have strong solvency and that the company's operations are relatively stable and sustainable. Cluster 4 presents the best trading factor and well in price factor, representing they have strong profitability ability and active trading.

4. Conclusion

There are only 2 stocks in cluster 1. From the above results, it is clear to see that the price factor, profit factor, and growth factor under this cluster have higher scores, while the debt repayment factor and trading factor have lower scores. In terms of the price factor, the highest price of such stocks is 404.63 yuan, much higher than the average price of 83.06 yuan on the other semiconductor companies' stocks. In terms of profitability factors, the return on total assets and return on equity of such stocks were 5.67% and 12.45% respectively, much higher than the 2.23% and 3.18% of the overall 60 stocks, showing strong profitability. However, the debt repayment factor of this type of stock ranks last, indicating the solvency performance is not satisfactory. These kinds of stocks are suitable for wealthy and self-willed investors due to their strong financial strength, ability to purchase high-priced stocks, and risk-taking ability. Therefore, choosing stocks with higher stock prices and profitability is recommended.

The second type of stock has the largest number of stocks which includes 40 of the 60 stocks of the semiconductor companies in this study, accounting for about 67% of the total. This phenomenon is consistent with the fact that in the actual stock market, high-quality stocks, growth stocks, and stable stocks are hard to come by, but most people encounter stocks with normal qualifications. As shown in Table 3-2, it can be found that this type of stock does not have any prominent factor.

The third type of stock has the second largest number of stocks which includes 17 of the 60 stocks of the semiconductor companies in this study, accounting for about 28% of the total. The outstanding advantage of this type of stock lies in the solvency factor. In terms of short-term solvency, the average current ratio of this type of stock is 3.47, and the average quick ratio is 2.77, which is higher than the current ratio of the remaining 60 stocks of the semiconductor companies which is 3.17 and 2.44 respectively, and the risk of short-term debt is extremely low. In terms of long-term solvency, the average debt asset ratio of this type of stock is 27.1%, which is lower than the other 60 stocks which are 33.1%. Therefore, it is clear to see that this type of companies that is conservative in its operations. They mainly rely on their funds to operate and may have problems such as idle internal monetary funds, poor financial management or low financing capabilities, and difficulty in exerting financial leverage. On the other hand, cluster 3 scored lower on the profit factor, representing its insufficient profitability. This type of stock is attracted to prudent investors because they are more cautious in investment, it is recommended to invest with strong solvency and strong growth.

Only 1 stock in cluster 4. This type of stock is very active in the market, highly liquid, and has the highest trading factor of the four types of stocks. The value of turnover rate and amplitude are 83.16 and 66.05, which is much larger than the average of the other 60 stocks (9.76 and 10.75 respectively). Other factors are relatively smaller, showing a lower tendency to borrow and operate, the contribution of liabilities to the growth of assets is weak, the growth of total assets is relatively slow, and the growth rate is not obvious.

The classification results are verified through the data of the above 60 stocks. To sum up, the results are in line with expectations. China's semiconductor industry is developing well, with a promising future, and is suitable for investment. In this paper, factor analysis and cluster analysis are applied to analysis the semiconductor company stock, which offers suggestions to the investors so that they could select more suitable for their preferences.

References

[1] Ross, L. and Sara, Z., " Stock Market Development and Long-Run Growth, " The World Bank Economic Review, Volume 10, Issue 2, Pages 323–339, May (1996).

[2] Masoud, N. M., "The Impact of Stock Market Performance upon Economic Growth," an Internationale Journal of Economics and Financial Issues 3: 788-798(2013).

[3] Surya, B., "Stock Market and Economic Development: A Causality Test," The Journal of Nepalese Business Studies, Vol. 3, No. 1, December (2006).

[4] Fan, X. M., Wu, Y. R. and Nicolaas, G., "The Chinese Stock Market: Development and Prospects, " Economics Discussion / Working Papers, 03-04, The University of Western Australia, Department of Economics, (2003).

[5] Seddighi, H. R. and Nian, W.,"The Chinese stock exchange market: operations and efficiency, " Applied Financial Economics, 14:11, 785-797 (2004).

[6] Peter, R. M. and Brian, B., "A History of the World Semiconductor Industry, " Institution of Engineering and Technology, IET, (1990).

[7] Ondrej, B., Marcde, J., Ankit, M. and Nakul, V., "Value creation: How can the semiconductor industry keep outperforming? " October 15, (2021).

[8] Int. Com. J.& Econ. 1 “Chinese Semiconductor Industrial Policy: Past and Present," (2019).

[9] Li, Y., "The Semiconductor Industry: A Strategic Look at China’s Supply Chain, " In Spigarelli, F., McIntyre, J.R. (eds) The New Chinese Dream. Palgrave Studies of Internationalization in Emerging Markets. Palgrave Macmillan, Cham. (2021).

[10] "Semiconductor integrated circuit industry analysis report," https://www.colliers.com/zh-cn/research/e22-20220321semiconductor，March 21, (2022).

[11] Basto, M., and Pereira, J. M. "An SPSS R-Menu for Ordinal Factor Analysis," Journal of Statistical Software, 46(4), 1–29. https://doi.org/10.18637/jss.v046.i04 (2012).

[12] Yim, O. and Kylee, T. R., "Hierarchical cluster analysis: comparison of three linkage measures and application to psychological data," The quantitative methods for psychology 11, no. 1: 8-21, (2015).

[13] Williams, B., Andrys, O., and Ted, B., "Exploratory factor analysis: A five-step guide for novices," Australasian Journal of paramedicine 8, no. 3 (2010).

[14] Adema, J., Marjolein, H.P., Elisabeth, A., Van, H. and Janke, C.S., "Necessary steps in factor analysis: enhancing validation studies of educational instruments. The PHEEM applied to clerks as an example," Medical teacher 31, no. 6: e226-e232. (2009).

[15] Wu, J., "Cluster Analysis and K-means Clustering: An Introduction. In: Advances in K-means Clustering," Springer Theses. Springer, Berlin, Heidelberg. (2012).

[16] Edwards, A. W. and Luigi, L. C., "A method for cluster analysis," Biometrics: 362-375. (1965).