Valuation Analysis of Semiconductor Industry of US Based on Portfolio Principle

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Abstract: Many of the world's semiconductor R&D, production and manufacturing technology companies are going public in the US, hoping to leverage the power of US stock market capitalization to promote their own companies and industries. Valuation of the semiconductor industry is therefore essential. This study evaluates US-listed semiconductor companies based on portfolio principles with an enterprise value greater than $50billion. In the benchmark portfolio, individual stock's weights are assigned in accordance with the enterprise value weighting and a number of indicators are calculated based on fundamental data for comparison with the forecast portfolio. The paper uses absolute and relative valuation methods to value the forecast portfolio, and compares with benchmark portfolio on the derived results. Finally, conclusions and future investment outlook are drawn from the results of the comparative analysis. According to the analysis, investing in the semiconductor industry is a good choice. In fact, not only can investors share in the huge profits from the rapid development of the industry, the semiconductor industry itself can also benefit from the strong capital market, which is something that complements each other. These results shed light on guiding further exploration of valuation analysis of semiconductor industry.

Keywords: semiconductor, valuation, portfolio

1. Introduction

Semiconductor is a material with controlled electrical conductivity that ranges from insulator to conductor [1]. Since the world's first transistor was manufactured in 1947, the semiconductor industry has been inseparable from global economic development and technological progress. Over the years, semiconductor products have been used in a wide range of industrial and technological fields such as computers, telecommunications, automotive, medical and aerospace. Plenty of the world's technology companies that develop, produce and manufacture semiconductors have gone public in the US in the hope of leveraging the power of US stock market capitalization to promote the growth of their companies and industries. This has proven to be true, as the total revenue of the semiconductor industry has grown rapidly from around $160,000m in 2000 to nearly $600,000m by 2021 [2], an annualized growth rate of 5.19%, compared to an annualized growth rate of 2.02% in the US GDP over the same 20-year period [3], demonstrating the rapid growth of the semiconductor industry.

The semiconductor industry is characterized by high operational risks, high initial investment in R&D, rapid technological updates and unpredictable profitability, so risk-averse banks are not willing

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to lend to semiconductor companies. As a result, equity investment has become an important financing channel for the semiconductor industry. If semiconductor companies want to raise capital through the capital market, how to scientifically and reasonably conduct valuation is an inevitable issue. Valuation of the semiconductor industry can help the fair pricing of semiconductor companies' shares, promote more efficient and rational allocation of funds, and make the semiconductor industry grow more benignly and orderly [4].

Fisher pioneered the concept of the time value of money, which was the theoretical basis for discounting future cash flows to estimate the present value of securities, and Williams proposed the DDM model from the perspective of dividend discounting, which allowed the value of stocks to begin to be quantified and provided a strong theoretical basis for fundamental analysis of equity investments [5]. In the 1980s, Alfred Rappaport introduced the concept of free cash flow, followed by Professor Tom Copeland, one of the senior leaders of McKinsey & Company, Inc. who gave a specific algorithm and model interpretation of the FCFF model, where the value of a company is the free cash flow expected to be generated by the company at the company's cost of capital The net present value of free cash flows is therefore the source of value creation for the firm.

The use of valuation methods in the industry has also changed since the technology stock bubble in 1999, with the choice of different valuation methods depending on the stage of development of the company becoming the dominant thinking adopted by investment banks. Convenient and effective market analogies have also begun to be added to investors' toolboxes in conjunction with absolute valuation tools (e.g., DCF [6]). The indicator of P/E ratio P/E is widely circulated and accepted among investors. Scholars such as McWilliams, Miller and Widmann have empirically concluded that stocks with high returns usually have low P/E ratios [7] and Alford established the use of P/E ratios to find similar firms for enterprise value Fama and French confirmed that the P/B ratio is inversely proportional to the future earnings of a firm [8]. Shaughnessy concluded empirically that the P/S ratio P/S metric is significant in predicting the future earnings of firms with low P/S ratios [9]. The firm value multiplier EV/EBITDA is also a commonly used relative estimator, and Kim showed that the firm value calculated by market value/EBITDA was more accurate in an empirical study of newly listed firms [10]. Evans and Bishop showed that the average value of the value multiplier of all firms in the industry can be taken to allow for differences in financing structure and profitability between firms in the same industry. The impact of differences in financing structure and profitability between firms in the same industry can be offset.

Most of current studies focus on quantitative analysis of individual stocks in the semiconductor industry, or on linking the semiconductor industry as a whole to economic variables and using economic index to determine the next trend in the semiconductor industry. Focusing on the stock market, there is still a gap in research on the use of listed semiconductor companies to construct portfolios and analyze the overall valuation of the portfolio, so research in this area is of great significance.

2. Data & Methodology

Based on the financial data and valuation data of US-listed semi-directed companies as at 30 April 2023, this study selected companies listed on the NASDAQ＆NYSE market with an enterprise value greater than $50billion and assigned individual equity weights in accordance with the enterprise value weighting to construct a benchmark portfolio and a valuation forecast portfolio. In this paper, absolute and relative valuation methods are used to analyze the valuation forecasts of the portfolio. In the absolute valuation method, the FCFF model is used for the valuation analysis. The risk-free rate of return is determined using the US 10-year Treasury bond, and then the covariance between the return of the individual stocks and the return of the Nasdaq Composite Index is divided by the variance of the market return to derive the beta of the individual stocks, which allows the cost of equity capital

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to be calculated using the CAMP formula. The WACC formula is then used to obtain the discount rate in the FCFF model. Finally, the growth rate is determined for the individual stocks using their fundamental data and the model calculates the enterprise value of the valuation forecast portfolio, which is compared to the enterprise value of the benchmark portfolio. Relative valuation methods include P/E and P/N ratios as well as enterprise value multiple models. Using the data from the valuation forecast portfolio, the corresponding relative valuation indicators are calculated and compared to the benchmark portfolio and the corresponding indicators.

3. Construction of Portfolio Benchmark

There are a large number of companies belonging to the semiconductor industry listed on the US stock exchange, which together support the splendid edifice of modern semiconductor industry development. We have selected a representative sample of these companies to represent the industry as a whole, based on companies with an enterprise value greater than $50billion as at 30 April 2023. Enterprise value is the theoretical acquisition price of a company and is calculated using the following formula

$$Enterprise\ Value\ =\ Total\ Market\ Value\ +\ Preference\ Shares\ +\ Minority\ Interest\ +\ Market\ Value\ of\ Debt\ -\ Cash\ and\ Cash\ Equivalents\ -\ Marketable\ Securities \tag{1}$$

There were 17 companies that met the criteria, of which we excluded two stocks traded on OTC Pink, Infineon Technologies AG (IFNNY) and Tokyo Electron Ltd (TOELY). The remaining 15 companies are listed on the NASDAQ exchange, with the exception of TSMC (TSM), which is listed on the New York Stock Exchange.

Table 1: Fundamental information.

Name	Exchange	Code	Price	Enterprise value (billion)	Weight
NVIDIA	NASDAQ	NVDA	$277.49	$684.83	24.31%
Taiwan Semiconductor Manufacturing Company	NYSE	TSM	$84.30	$432.13	15.34%
Broadcom	NASDAQ	AVGO	$626.50	$294.11	10.44%
ASML Holding N. V	NASDAQ	ASML	$636.86	$265.61	9.43%
Texas Instruments	NASDAQ	TXN	$167.20	$168.78	5.99%
Advanced Micro Devices	NASDAQ	AMD	$89.37	$154.94	5.50%
Qualcomm	NASDAQ	QCOM	$116.80	$150.90	5.36%
Intel	NASDAQ	INTC	$31.06	$148.76	5.28%
Applied Materials	NASDAQ	AMAT	$113.03	$105.89	3.76%
Analog Devices	NASDAQ	ADI	$179.88	$104.65	3.71%
Lam Research	NASDAQ	LRCX	$524.08	$71.95	2.55%
Micron Technology Inc.	NASDAQ	MU	$64.36	$68.10	2.42%
Kla Corporation	NASDAQ	KLAC	$386.54	$58.65	2.08%
NXP Semiconductors	NASDAQ	NXPI	$163.74	$55.72	1.98%
Microchip Technology	NASDAQ	MCHP	$72.99	$52.23	1.85%
Portfolio benchmark	/	/	$267.17	$337.71	100.00%

We have constructed a benchmark portfolio using these 15 companies, which serves to compare with the valuation portfolio calculated later, as shown in Table 1. In the benchmark portfolio, we list the current day closing prices of the companies' stocks, their enterprise values and their respective weights in the benchmark portfolio. The weighting is calculated based on the enterprise value weighting and is calculated as:

$$Wi=\frac{EVi}{EVtotal} \tag{2}$$

This gives us the benchmark portfolio and we know that the price per unit of the benchmark portfolio is \$278.54 and the value of the benchmark portfolio is \$337.71billion. This provides a benchmark against which the price and value per unit of the forecast portfolio can later be compared.

4. Construction of Portfolio Forecast

We valued the forecast portfolio using the FCFF model, calculated as:

$$EV=\sum_{i=1}^{n}\frac{FCFF_i}{(1+WACC)^i} \tag{3}$$

The model assumes that the value of a business should be equal to the discounted value of all the free cash flows it can generate in the future. Next, we estimate the two parameters WACC as well as FCFF, respectively. The Weighted Average Cost of Capital WACC is a method of calculating a company's cost of capital by weighting the weight of each type of capital to the total source of capital. The formula is calculated as follows:

$$WACC=\frac{S}{S+B}R_S+\frac{B}{S+B}R_B(1-Tc) \tag{4}$$

Where S represents the market value of equity, B represents the market value of liabilities, and S+B is the total value of the business; R_B is the cost of debt capital and the expected rate of return on R_S equity; and (Tc) is the corporate income tax rate. Generally, a company's assets are financed through debt and equity. Here we need to calculate the weight of equity and the weight of debt. The market value of equity (S) is also known as the total market value; the market value of debt is often difficult to measure, so we use the book value of debt (D) to simplify this process. R_S is determined through the CAPM, which is calculated using the following formula:

$$R_S=R_f+\beta（R_m-R_f） \tag{5}$$

Here, R_f represents the risk-free rate, which we have replaced with the geometric mean yield on the YTM of the 10-year US Treasury bond from 30 April 2013 to 30 April 2023; R_m is the market's yield, and as 14 of the 15 semiconductor companies are traded on the NASDAQ market, we have chosen the geometric mean of monthly return of the Nasdaq Composite Index from 30 April 2013 to 30 April 2023 to indicate it; (R_m-R_f) represents the market risk premium; β coefficient, a risk index, is used to measure the price volatility of individual stocks or equity funds relative to the overall stock market, so we measured beta using the covariance between the monthly individual stock returns and monthly market return over the period from 30 April 2013 to 30 April 2023 divided by the variance of the monthly market returns. For the cost of debt capital R_B, we then use the most recent year's interest expense divided by the most recent two years of average debt to arrive at a simplified cost of debt. The average tax rate for the most recent two years is reported in financial statement. Finally, the WACC for each company is obtained as shown in Table 2 by using the Eq. (4).

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Table 2: Applied CAPM to calculate requity and WACC.

Code	β	Rf	Market premium	Requity	WACC
NVDA	1.7056			23.028%	7.30%
TSM	0.9704			14.050%	8.99%
AVGO	1.1338			16.045%	8.39%
ASML	1.2153			17.041%	6.71%
TXN	0.8958			13.139%	6.82%
AMD	2.2222			29.336%	9.24%
QCOM	1.1340			16.048%	8.31%
INTC	0.7452	2.201%	12.211%	11.301%	4.67%
AMAT	1.3523			18.714%	9.68%
ADI	0.9812			14.182%	8.34%
LRCX	1.2714			17.726%	8.33%
MU	1.2535			17.508%	8.02%
KLAC	1.1356			16.068%	8.43%
NXPI	1.2009			16.865%	7.90%
MCHP	1.1228			15.911%	10.15%

FCFF refers to free cash flow, which is the cash flow generated by a business that remains after reinvestment needs have been met, and which is the maximum amount of cash available for distribution to the business's capital suppliers without affecting the company's ongoing growth. The formula for calculating this is as follows:

$$\text{FCFF}=\text{EBIT}-\text{Tax expense}+\text{D\&A}-\text{CAPEX}-\Delta\text{NWC} \tag{6}$$

where EBITDA refers to the earnings before interest, tax, depreciation and amortization of the business, D&A refers to depreciation and amortization charges, CAPEX refers to capital expenditure and ΔNWC refers to the change in net working capital.

Here, TSMC (TSM) is taken as an example for future FCFF projections. Tts financial statements for the past four years is shown in Table 3. It is important to note that in TSMC's published statements are denominated in New Taiwan Dollars (NTD), so we have to exchange them at the NTD/USD rate on the base date. In addition, ASML is denominated in Euros and therefore also needs to be remitted against the Euro/US Dollar exchange rate at the base date. The next is to forecast free cash flow for the next four years. The forecast is based on the percentage of sales revenue method, future operating income depends on the growth rate of the last few years, while operating costs and operating expenses are measured as a percentage of operating income. As data closer to the present is more representative, different weightings are given to different years of data. For example, to forecast the growth rate of operating income in 2023, we use the following formula:

$$Growth\ rate\ in\ 2023 = Growth\ rate\ in\ 2022 \times 0.4 + Growth\ rate\ in\ 2021 \times 0.3 + Growth\ rate\ in\ 2020 \times 0.2 + Growth\ rate\ in\ 2019 \times 0.1 \tag{7}$$

The same methodology is applied to the operating cost ratio, operating expense ratio, depreciation and amortization ratio, capital expenditure ratio and the ΔNWC ratio; income tax expense is substituted by calculating the average tax rate*EBIT and the tax rate is substituted by the average tax rate for the last two years. TSM's past financial data and FCFF for future projections are shown in Table 3. Other constituent companies are forecasted using the same methodology and are not described in detail due to space constraints.

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Table 3: Financial data and expectation.

$/hundreds of million	2019	2020	2021	2022	2023E	2024E	2025E	2026E
Operating income	350.81	469.59	571.83	731.99	914.85	1153.95	1450.84	1827.02
Year-on-year growth%	4.76%	33.86%	21.77%	28.01%	24.98%	26.14%	25.73%	25.93%
COGS	189.27	220.24	276.61	296.02	415.93	515.61	644.72	809.67
%Operating revenue	53.95%	46.90%	48.37%	40.44%	45.46%	44.68%	44.44%	44.32%
Gross profit	161.54	249.35	295.22	435.97	498.93	638.34	806.12	1017.35
Gross margin	46.05%	53.10%	51.63%	59.56%	54.54%	55.32%	55.56%	55.68%
Operating expense	39.34	50.61	61.08	73.42	96.98	121.25	152.09	191.44
%Operating expense	24.36%	20.30%	20.69%	16.84%	19.44%	19.00%	18.87%	18.82%
EBIT	122.20	198.74	234.14	362.54	401.94	517.08	654.03	825.92
Average tax rate	/	/	/	/	15.28%	15.28%	15.28%	15.28%
(-) Tax expense	11.75	25.86	25.27	48.75	61.42	79.01	99.94	126.20
(+) D&A	91.81	106.14	135.17	139.94	126.94	130.40	131.75	131.20
(-) Capex	153.08	180.62	305.12	349.71	282.85	297.14	304.17	302.35
(-) ΔNWC	-119.60	87.87	144.34	52.74	70.01	81.48	78.58	75.15
FCFF	/	/	/	/	114.60	189.86	303.10	453.41

After a high growth phase, it will shift to a perpetual growth phase. Generally, the perpetual growth rate does not exceed the country's GDP growth rate, so the 10-year average GDP growth rate of the US of 2.02% has been chosen instead of the perpetual growth rate. We demonstrate the Present Value of Forecast, the Present Value of Perpetual Value and the Total Enterprise Value for all companies in the portfolio as shown in Table 4. The total market value can be derived from Eq. (1) in reverse and the price is obtained from total market value divided by shares outstanding. One particular note is that Intel (INTC) is not valued using the FCFF method due to its severe decline in 2022 and the first quarter of 2023, with EBIT in the last four quarters being a large loss and EBIT in 2022 being even close to a tenth of that in 2021, so it is estimated using the enterprise value multiple method. The formula to calculate the enterprise value of INTC is following:

$$EV(\,INTC) = \text{Enterprise Value Multiple}\ (INTC) * EBITDA\ (INTC) \tag{8}$$

Table 4 shows that the forecast portfolio has an enterprise value of $363.996billion and the benchmark portfolio has an enterprise value of $337.712billion, a premium of $26.284billion or 7.78%, and the forecast portfolio has a unit price of $348.83 compared to the benchmark portfolio's unit price of $267.17, a premium of $81.66 or 30.56%.

Furthermore, it can be seen that, with the exception of NVDA and INTC, the remaining 13 companies are all somewhat undervalued as an enterprise value, with QCOM being the most notable. Its high growth rates and high gross margins which was about 60% over the past few years have led to an extremely upward revision of its valuation.

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Table 4: Expectations of EV and total market value.

	PV of rapidly growth period (billion)	PV of perpetual growth period (billion)	EV (billion)	Total market value (billion)	Shares (billion)	Price
NVDA	$38.275	$310.156	$348.431	$350.774	2.473	$141.84
TSM	$83.342	$660.086	$743.428	$787.082	25.932	$30.35
AVGO	$58.176	$350.025	$408.201	$381.561	0.413	$923.88
ASML	$33.075	$255.022	$288.097	$291.415	0.395	$737.76
TXN	$29.264	$230.157	$259.421	$254.272	0.908	$280.04
AMD	$26.809	$202.307	$229.116	$230.474	1.627	$141.66
QCOM	$76.186	$547.131	$623.317	$614.004	1.114	$551.17
INTC	/	/	$107.311	$62.922	4.171	$15.09
AMAT	$30.515	$167.615	$198.130	$197.045	0.84	$234.58
ADI	$19.966	$177.132	$197.098	$191.5464	0.501	$382.33
LRCX	$24.827	$165.166	$189.993	$190.302	0.134	$1420.16
MU	$14.741	$109.76	$124.501	$122.022	1.094	$111.54
KLAC	$15.393	$109.455	$124.848	$121.849	0.137	$889.41
NXPI	$10.953	$75.095	$86.048	$78.511	0.26	$301.97
MCHP	$12.171	$61.325	$73.496	$68.688	0.545	$126.03
Portfolio forecast	/	/	$363.996	/	/	$348.83

We have calculated a number of relative valuation indicators for our benchmark portfolio, where PE (TTM) refers to the current price per share divided by the EPS for the last four quarters, calculated as:

$$PE=\frac{\text{Price}}{\text{Earnings per share}} \tag{9}$$

PB(LF) refers to the current price per share divided by the latest book value per share and is calculated as:

$$PB=\frac{\text{Price}}{\text{Book value per share}} \tag{10}$$

EV/EBITDA is the enterprise value divided by EBITDA for the last four quarters and is calculated as:

$$EV/EBITDA=\frac{\text{Enterprise value}}{\text{EBITDA}} \tag{11}$$

The relative valuation indicators for the Benchmark Portfolio are calculated using the share prices at the benchmark date; while the relative valuation indicators for the Forecast Portfolio are calculated using the share prices projected in Table 4. The specific data is shown in Table 5. It can be seen that the benchmark portfolio has a weighted average P/E ratio of 49.23, a weighted average P/B ratio of 13.13 and a weighted average enterprise value multiple of 37.72, while the forecast portfolio has a weighted average P/E ratio of 67.59, a weighted average P/N ratio of 13.50 and a weighted average enterprise value multiple of 39.44.

Table 5: Estimation of multiplier model.

	Benchmark			Forecast		
Code	PE(TTM)	PB(LF)	EV/EBITDA	PE(TTM)	PB(LF)	EV/EBITDA
NVDA	143.04	28.01	106.36	73.11	14.31	54.11
TSM	13.71	4.44	8.19	4.94	1.59	14.09
AVGO	18.89	11.32	14.32	27.85	16.69	19.87
ASML	31.22	21.97	29.69	36.16	25.44	32.20
TXN	18.37	9.96	15.73	30.77	16.67	24.18
AMD	77.11	2.63	31.61	566.62	4.17	46.75
QCOM	12.35	6.61	10.53	58.26	31.17	43.48
INTC	-45.68	1.32	15.55	-22.18	0.64	11.22
AMAT	14.62	6.72	12.70	30.35	13.93	23.75
ADI	24.88	2.50	15.85	52.88	5.32	29.86
LRCX	14.32	8.37	11.74	38.80	22.69	30.99
MU	43.78	1.49	6.89	75.88	2.58	12.59
KLAC	15.12	19.77	12.63	34.78	45.49	26.90
NXPI	15.49	5.35	11.15	28.57	9.86	17.23
MCHP	17.80	6.11	12.73	30.74	10.56	17.91
Portfolio	49.23	13.13	37.72	67.59	13.50	31.70

5. Implications and Investment Recommendation

Summarizing the data obtained in the previous section, then compare the portfolio benchmark with the portfolio forecast. It is obviously that the later has higher price per unit, enterprise value, P/E ratio and P/B ratio although its enterprise value multiple are slightly lower, as shown in Table 6. The decline in EV/EBITDA was primarily driven by a decline in this indicator for NVDA, the largest contributor to the portfolio, with pulling down the portfolio indicator by around 12.7 points with its own cutback, nearly a third of the benchmark portfolio sum. In terms of unit price and P/E indicators, the forecast portfolio increased rapidly, compared to the benchmark portfolio. This implies that the semiconductor sector is very likely to be undervalued and has significant scope for future appreciation. We believe that the 15 companies selected are representative of the current and future trends in the semiconductor industry and therefore investing in the semiconductor industry may be a good investment option, as the industry will continue to grow rapidly in the future, bringing huge profit returns to investors.

Table 6: Comparation of two portfolio.

	Price	EV(billion)	PE	PB	EV/EBITDA
Portfolio benchmark	$267.17	$337.712	49.23	13.13	37.72
Portfolio forecast	$348.83	$363.996	67.59	13.50	31.70
%change	30.56%	7.78%	37.29%	2.82%	-15.96%

6. Conclusion

In summary, the article starts with some basics and applications of semiconductors, followed by a description of the rapid growth of the semiconductor industry and an explanation of why it is important to value the semiconductor industry. This paper represents the sector by constructing a portfolio of top public companies and then analyses the portfolio as a whole, discussing future valuation analysis and investment recommendations for the semiconductor sector. Overall, the

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semiconductor sector has huge potential for future appreciation and investors may consider adding stocks in the semiconductor sector to their portfolios.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Zhang, L., Ran, J., Qiao, S. Z., et al. (2019) Characterization of semiconductor photocatalysts. Chemical Society Reviews, 48(20), 5184-5206.

[2] Jelinek, L. (2018) Global semiconductor market trends. IHS Markit, May.

[3] Tahir, M., ur Rehman, Z., Javed, F. (2022). Asymmetric effects of inflation instability and GDP growth volatility on environmental quality in the USA. Human Nature Journal of Social Sciences, 3(1), 31-43.

[4] Qiu, X. (2021) Research on domestic semiconductor enterprise valuation based on EVA model. Dissertation of Shanghai University of Finance and Economics.

[5] McWilliams, J. (1966) Prices, Earnings and P-E Ratios: Financial Analysts Journal, 22.

[6] Huang, Y. (2020) Research on valuation methods of semiconductor industry in China. Dissertation of Shanghai University of Finance and Economics.

[7] Miller, P., Widmann, E. (1966) Stock & Bond Issue, Commercial & Financial.

[8] Fama, E., French, K. (1995) Size and Book-to-Market Factors in Earnings and Returns: Journal of Finance, 50, 131-55.

[9] Shaughnessy, J. O. (2005) What Works on Wall Street.: New York: McGraw-H.

[10] Liu, Y. (2019) Semiconductor industry investment value research report. Dissertation of Southwestern University of Finance and Economics.