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Analyzing the Influential Factors of Valuation: A Case Study on Taiwan Semiconductor Manufacturing Company

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Abstract: During the Artificial Intelligence (AI) revolution, the semiconductor industry saw unprecedented demand, driven mostly by the need for more powerful computational technology. This study examines the value impact of AI breakthroughs on Taiwan Semiconductor Manufacturing Company (TSMC) using a rigorous Discounted Cash Flow (DCF) analysis. With AI technologies largely driving demand in the semiconductor business, this study adapts classic financial modeling approaches to capture the subtle implications of technical advancements on firm valuation. Using substantial financial data from TSMC, the research modifies growth rates to reflect AI-driven market potential, while also incorporating cautious forecasts to allow for industry volatility. The findings indicate that the market may undervalue TSMC, implying an upbeat forecast for the firm in the middle of the AI boom. The research contributes to financial academic knowledge by illustrating the use of DCF to evaluate technology influences on business values, providing important insights for investors and corporate strategists. Future refinements to the DCF model are proposed, with an emphasis on incorporating dynamic market data and policy effect research to improve investment assessments in technology.

Keywords: DCF, TSMC, Weighted Average Cost of Capital.

1. Introduction

The year 2022 marked a pivotal moment in AI with the rise of generative AI technologies based on Large Language Models (LLMs). This emergence has driven a significant shift in public and industrial attention towards generative AI, a subset of technologies known for their ability to produce human-like text responses. This requirement has underscored and accelerated the demand for high-performance semiconductor products, leading to significant developments within the semiconductor industry. As these LLMs continue to evolve, they increasingly integrate into various sectors of corporate strategies and operational frameworks, transitioning from basic chatbot applications to becoming central to business innovation and competitive dynamics. The semiconductor industry, which is critical to supplying the necessary hardware for AI advancements, has experienced unprecedented growth and transformation, driven by the need to support increasingly complex AI applications.

The spike in demand for precise semiconductor chips designed expressly for AI capabilities demonstrates a significant shift in chip makers' requirements. This transition has been particularly

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noticeable since 2022, with a greater emphasis on CPUs capable of handling complicated AI algorithms and large-scale data processing. TSMC, a major industry participant, demonstrates this tendency [1].

Against the backdrop of these technological advancements, TSMC has adjusted its strategies to harness the burgeoning potential of AI. The company's response to the AI wave has been swift and strategic, positioning it as a pivotal entity in the global semiconductor market. In 2023, TSMC's revenue from advanced technology chips, including CPUs and GPUs that are crucial for AI computations, saw a year-over-year increase of approximately 5% [2]. Simultaneously, TSMC's investment in R&D to further its capabilities in AI-related technologies grew by about 11.7% from 2022 to 2023 [2]. These specific adjustments and their impacts not only highlight TSMC's adaptability and foresight in a dynamically changing sector but also underscore the growing importance of financial models to evaluate such technological investments.

This emphasis on financial modelling leads to the application of the DCF model, commonly used within the semiconductor industry to navigate its complexities. Lu et al. specifically applied the DCF method within the Taiwanese semiconductor industry, basing their calculations on the assumption that the Weighted Average Cost of Capital (WACC) equals the Weighted Average Return on Assets (WARA) [3]. Their research focused on how factors such as patents, computer software, customer relationships, and trademarks affect the discount rates for various intangible assets [3]. Separately, Medeiros explored the valuation and investment potential of Samsung Electronics Co., Ltd. using both the DCF and relative valuation methods, providing detailed investment insights [4]. Additionally, Piedade used a mix of DCF, multiples, and the dividend discount model to assess Intel Corporation's business operations, industry context, financial performance, and valuation [5].

While the preceding studies demonstrate the DCF model's adaptability and significance, they mostly focus on its generic applications within the semiconductor industry rather than its employment in the context of AI-driven demand. This mistake presents an important research question: how does the DCF model represent value changes at TSMC throughout the AI boom. This subject is critical because it seeks to reconcile financial theory with known market impacts, specifically the spike in demand for high-performance computer processors caused by AI technologies such as ChatGPT. Despite TSMC's crucial role in the global semiconductor business, DCF has not conducted a full financial analysis of these technical advancements.

Exploring this gap is crucial for two reasons. First, it advances academic knowledge by expanding DCF applications to incorporate the impact of technical breakthroughs on firm values. Second, it gives useful information for semiconductor investors and corporate strategists, allowing them to make more informed decisions by employing a valuation methodology that takes into account both technological advancements and market trends.

This study presents a quantitative analysis of TSMC that uses the DCF model to examine the value effect of AI breakthroughs in the semiconductor sector. The study focuses on how AI-driven demands have affected TSMC's valuation, using a conservative growth rate adjustment to present a fair and realistic outlook on the company's financial future. By incorporating significant financial data and adjusting the growth rate to reflect both the opportunities and risks associated with AI technology, this study aims to provide a robust valuation methodology for similar semiconductor industry businesses.

2. Literature Review

2.1. Discounted Cash Flow

Finance uses the DCF model as a powerful tool to value investment opportunities, including projects, assets, and companies. It estimates the value of an investment based on the present value of expected

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future cash flows generated by the asset. The time value of money is the fundamental principle underlying the DCF model, which posits that money today is worth more than money in the future due to its potential earning capacity [6].

The formula for the DCF model is expressed as following Formular 1:

$$PV = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n} \quad (1)$$

Where:

- CFt is the cash flow in year t,
- r is the discount rate, and
- n is the number of periods.

Each component of the formula represents a future cash flow adjusted to its present value. The cash flows (CF) may include net income, operating expenses, capital expenditures, and changes in working capital. The accuracy of a DCF analysis heavily relies on the precision of these estimated future cash flows, which are subject to uncertainties such as market demand, economic conditions, and company performance [6].

To calculate the present value of these cash flows, the DCF model employs a discount rate, typically the WACC, which reflects the riskiness of the cash flows. The formula for WACC is given Formular 2 [6,7].

$$\text{WACC} = \frac{E}{E+D} \times r_E + \frac{D}{E+D} \times r_d \times (1 - T_c) \quad (2)$$

Where:

- E is the market value of the firm’s equity,
- D is the market value of the firm’s debt,
- rE is the cost of equity,
- rD is the cost of debt,
- Tc is the corporate tax rate.

This rate incorporates the cost of equity and the cost of debt, providing a comprehensive measure of how much interest the company must pay, on average, to finance its assets [6].

A critical aspect of applying the DCF model is choosing an appropriate discount rate, which can significantly impact the valuation. This rate is intended to reflect the risk-free rate plus a risk premium, adjusted for the unique risks of the investment or project being evaluated [8].

The DCF model is a cornerstone in corporate finance and investment analysis, widely applied to assess the value of companies across diverse financial scenarios. By projecting future cash flows and discounting them to their present value using an appropriate discount rate, the DCF model helps analysts and investors gauge company values comprehensively. It is particularly influential in evaluating mergers, acquisitions, and new projects, providing a framework to determine a company’s fair value, and facilitating informed investment decisions [9].

In the semiconductor industry, for example, the DCF model has proven effective in assessing the financial health and investment potential of leading technology firms such as Nvidia, Intel, and Texas Instruments. By analyzing forecasted future cash flows, the DCF method offers a quantitative measure of each company’s stock intrinsic value, which is crucial for investors and financial analysts aiming to determine the fair market value of stocks and assess investment worth [10].

2.2. AI Technology Development and Its Impact on the Semiconductor Industry

The evolution of AI technologies promises to have a significant impact on semiconductor companies' financial performance. AI’s role in enhancing resource optimization and profitability is becoming increasingly critical in an industry where efficiency and rapid innovation are paramount.

AI technologies are pivotal in navigating the complexities of modern production environments, as noted by Haefner et al., who discuss AI's contributions to better management of production variables and improved yield rates through enhanced quality control mechanisms [11]. This capability not only streamlines manufacturing operations but also reduces waste and energy consumption, thereby supporting sustainable manufacturing practices [11]. Additionally, McKinsey highlights that AI and Machine Learning (ML) use cases are pivotal in reducing manufacturing costs, improving yields, and increasing throughput [12]. AI-driven changes to tool parameters and visual inspection systems enable these improvements [12]. This enhances the accuracy and efficiency of the processes used to produce semiconductors [12]. Research from the 2022 SEMI Advanced Semiconductor Manufacturing Conference illustrates the use of AI to create optimized scheduling algorithms for cluster tools in semiconductor manufacturing. These AI-enabled tools adjust to changing conditions without human input, helping to avoid bottlenecks and improve overall production schedules, which in turn enhances resource utilization and operational efficiency [13]. These studies collectively illustrate how AI contributes to optimizing resource management in semiconductor manufacturing, not only by enhancing specific production processes but also by improving overall manufacturing efficiency and reducing costs.

Moreover, AI plays a crucial role in improving the financial performance of semiconductor firms. For example, Park et al. highlight how AI brings financial benefits, particularly to fabless semiconductor firms, by streamlining product development, reducing time-to-market, and enhancing cost-effectiveness and market responsiveness [14]. The strategic application of AI in these areas not only boosts operational efficiency but also opens up new avenues for revenue generation and growth [14]. Additionally, AI drives innovation in products and services within the semiconductor industry, leading to the creation of new revenue streams. According to another report by McKinsey, AI empowers companies to expand their revenue sources by enhancing supply chain management and facilitating predictive maintenance, which altogether boosts operational efficiency [15]. Tekic et al. and Kim et al., who elaborate on how AI reshapes innovation management and supports digital transformation strategies, further support this by enabling companies to develop competitive strategies and digital capabilities, thereby securing a competitive edge in the global market [16, 17].

2.3. Summary

AI promotes a transformation in production and technology, resulting in improved efficiency, profitability, and innovation throughout the sector. However, the extent of this beneficial impact is not consistent and depends on the individual operational and strategic approaches adopted in different areas of the business. AI is essential for maintaining a competitive edge in high-tech industries such as semiconductor manufacturing because it improves decision-making, increases manufacturing plant productivity, and speeds up product development.

Overall, the development of AI exerts a profound and predominantly positive impact on the semiconductor industry, enhancing resource optimization, profitability, and innovation. This strategic integration of AI not only leads to technological upgrades but also significantly expands the industry's growth and innovation horizons.

Considering a specific case such as TSMC, AI's role becomes even more pivotal. TSMC, as the leader in semiconductor manufacturing, can leverage AI to further optimize its production processes, improve product quality, and drive chip design innovation. Moreover, AI can aid TSMC in navigating the increasingly challenging technical demands of ultra-small-scale precision manufacturing, thus maintaining its leadership in the sector.

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3. Methodology

3.1. Research Design

This study adopts a quantitative analysis approach, focusing on the TSMC as a case study to explore the valuation impact of AI advancements on the semiconductor industry. The primary analytical tool employed is the DCF model, which is instrumental in determining the intrinsic value of TSMC by projecting future cash flows and discounting them to the present value using an appropriate discount rate.

The quantitative analysis involves collecting extensive financial data from TSMC, including revenue forecasts, capital expenditures, and R&D investments specifically linked to AI technologies. This data is critical in constructing a reliable financial model that accurately captures the cash flows attributable to AI-driven growth within the semiconductor sector. In this study, the DCF model is used to figure out how much AI technologies affect TSMC's value. This gives us a solid way to look at the economic benefits of new technologies in semiconductor manufacturing.

Academic research and industry practice widely apply the DCF model, valuing its robustness in financial forecasting and investment evaluation. For technology-driven companies like TSMC, where dynamic market conditions and technological innovations heavily influence future cash flows, it provides a structured method to assess long-term financial viability. Studies frequently use the model to assess the financial health and strategic value of firms within technology-intensive sectors, highlighting its relevance.

In conclusion, the integration of the DCF model into this research aligns with established financial practices and offers a rigorous analytical tool for assessing the economic impacts of AI on the semiconductor industry. By doing so, the study not only enhances the understanding of TSMC's financial dynamics but also contributes valuable insights into the broader economic implications of technological advancements in high-tech industries.

3.2. Case Description

TSMC is a key player in the worldwide semiconductor industry, known for producing a wide range of semiconductor chips that power a variety of electronic products. TSMC, the world's biggest dedicated independent semiconductor foundry, has earned a reputation for its revolutionary chip fabrication technology, which is important for high-performance computer applications, especially those driven by recent advances in AI.

TSMC has made a substantial contribution to the AI market by developing the sophisticated semiconductor solutions required for AI technology. The global rise in AI applications has spurred more demand for TSMC semiconductors. TSMC's financial performance mirrors the jump in demand, with the business reporting a significant increase in sales. For example, in early 2024, TSMC's sales climbed by 17% in a quarter due to growing demand in industries like AI, which has an impact on the larger technology and cryptocurrency markets [18].

The company's involvement in AI extends beyond mere production; it encompasses strategic initiatives aimed at enhancing its technological capabilities to better serve the AI-driven market demands. TSMC is continuously adapting its operations and investment strategies to align with the evolving needs of the AI industry. This strategic focus aims to maintain and enhance TSMC's leadership and competitive edge in the semiconductor industry.

3.3. Data Collection & Data Analysis

TSMC's official financial annual reports from 2013 to 2023 provide a solid and reputable foundation for the quantitative analysis of the data used in this study. The dataset contains a wealth of financial

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information, such as revenue, net cash from operational operations, capital expenditures (CapEX), and operating income. These financial parameters are critical for developing the DCF model, which seeks to estimate the company's intrinsic value using future cash flow estimates. The analysis begins with the computation of free cash flow (FCF), which is obtained by deducting CapEX from net cash from operating operations. This metric is important because it indicates the actual cash available to shareholders after a necessary reinvestment in the firm.

Following that, this paper calculates the compound annual growth rate (CAGR) using historical sales data to forecast future growth. This rate is used to forecast future revenues with the premise that previous growth trends will continue. For a more targeted study, this paper uses an AI market CAGR of 33% based on industry predictions from 2022 to 2032, representing the predicted rise from AI developments [19]. The research proceeds by forecasting future operating margins. This paper starts with the most current margin and forecast future margins, taking into account both historical patterns and the potential influence of AI on operational efficiency. This technique anticipates an initial improvement in margins, followed by their stabilization upon reaching a present threshold, thereby guaranteeing a profit margin within a realistic numerical range.

After establishing the basic parameters, this paper constructs the DCF model by projecting future revenues and associated financial metrics, such as operating income, CapEX, and changes in working capital. These projections are then used to calculate annual free cash flows. The final step involves discounting these free cash flows back to their present value using the WACC, which serves as the discount rate. This rate reflects the average returns required by investors, weighted by the company's debt and equity structure. Additionally, a terminal value is calculated to account for the company's value beyond the forecast period, using a long-term growth rate derived from projected GDP growth rates from the International Monetary Fund [20].

The final part of this analysis is an estimation of TSMC's total enterprise value, which includes both the present value of forecasted free cash flows and the discounted terminal value, providing a comprehensive valuation based on the DCF model. This systematic approach ensures a rigorous and transparent valuation, aligning with academic standards and industry practices for financial analysis.

4. Results and Discussion

4.1. Valuation Results

The WACC is calculated using the Formula 2:

$$\text{WACC} = \frac{E}{E+D} \times r_E + \frac{D}{E+D} \times r_d \times (1 - T_c) \quad (2)$$

Where D and E are the market values of debt and equity, Rd is the cost of debt, Re is the cost of equity and Tc is the corporate tax rate. This rate plays a critical role in discounting future cash flows to their present value, reflecting the risks associated with the investment.

Following the computation of WACC, the final DCF valuation was determined through the sum of discounted future cash flows, using Formula 3:

$$DCF\ Valuation = \sum \left(\frac{CF_t}{(1+WACC)^t} \right) = \$\,772{,}171{,}244{,}800.81 \quad (3)$$

Where CFt are the forecasted free cash flows over the period considered. This approach results in an enterprise value of approximately $772.17 billion for TSMC.

Comparatively, TSMC's current market capitalisation stands at about $734.23 billion [21]. This slight discrepancy between the DCF valuation and the market value might suggest that the market slightly undervalues TSMC's future potential. Alternatively, it may reflect a cautious stance in the

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model's assumptions, balancing optimism for AI-driven growth with the real volatility observed in the semiconductor market.

The valuation using the DCF model, factoring in a conservative adjustment of the annual growth rate to 24.75% from a more optimistic initial 33% due to AI-driven market expansion, shows a comprehensive effort to temper expectations with market realism. This careful approach helps navigate the uncertainties of forecasting in a high-growth industry influenced by rapid advancements in AI technology.

4.2. Interpretation of Valuation and AI Influence

The valuation underscores the significant impact of AI on TSMC's operational and financial outlook. The AI revolution has not only spurred demand for more sophisticated semiconductor technologies, but it has also pushed companies like TSMC to innovate aggressively in order to meet this new demand. The adjusted growth rate reflects a balanced view, recognizing the substantial impact of AI while also accounting for economic and sector-specific risks.

In the context of the current AI wave, TSMC's strategic positioning and operational adaptations aimed at embracing AI technologies are pivotal. The company's ability to upscale its operations to produce high-performance AI chips is a crucial driver of its valuation. The analysis suggests that TSMC is well-positioned to capitalize on the ongoing technological shift towards more AI-integrated functionalities across various industries.

4.3. Analysis and Recommendations Based on DCF Valuation

The DCF model results indicate that the market may undervalue TSMC by approximately $772.17 billion, compared to its current market capitalization of about $734.23 billion. This discrepancy highlights the underestimation of TSMC's potential growth driven by AI advancements. The valuation that was done with conservative growth assumptions shows a strategic balance, taking into account both the huge potential of AI in semiconductor applications and the risks that come with integrating technologies quickly. The principal cause of valuation fluctuation for TSMC in the AI wave lies in the dynamic interplay between rapid technological advances and market adaptation rates. As AI technologies evolve, they demand increasingly sophisticated semiconductor designs, pushing companies like TSMC to innovate at a breakneck pace. This scenario suggests that TSMC's strategic focus on AI and high-performance computing technologies could significantly enhance its market position and financial performance in the future.

By integrating AI-driven market dynamics, which traditional financial models within the semiconductor industry have somewhat overlooked, this research extends the application of the DCF model in comparison to previous studies. Prior analyses, such as those by Lu et al. and de Medeiros, focused broadly on the effects of intangible assets and sector-wide financial health without a specific emphasis on the impact of AI. This study diverges by directly linking AI technological impacts to corporate valuation, providing a tailored approach to understanding how emerging technologies influence market valuation.

This analysis underscores the importance of revising traditional valuation models to incorporate the rapid technological changes characteristic of industries like semiconductor manufacturing. It provides a more accurate financial representation of companies at the forefront of technological innovation, offering critical insights for stakeholders and informing strategic corporate decision-making.

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5. Conclusion

This study provides a detailed analysis of the valuation impact of AI on TSMC amidst the rapid evolution of the semiconductor industry. This paper, set against the backdrop of increasing AI integration, employs the DCF model to assess how AI-driven demands influence TSMC's market valuation. The study shows how technological advances have changed TSMC's finances in a complex way by using the DCF model to look at both past financial data and expected growth that will be affected by AI progress. The findings reveal that, while the current market slightly undervalues TSMC's potential, there is significant room for growth spurred by ongoing technological developments and AI integration.

This paper extends the application of the DCF model to a technology-driven market, providing a methodological framework that similar industries facing technological disruptions can replicate. The findings have critical implications for investors and corporate strategists, emphasizing the importance of incorporating advanced forecasting techniques to better predict financial outcomes in dynamic sectors. Moreover, the study introduces a balanced perspective on valuation, advocating for a cautious yet optimistic forecasting approach to account for the inherent volatility of tech-driven markets.

However, the study is not without its limitations. Despite rigorous calculations, the reliance on projected growth rates introduces uncertainty due to the speculative nature of AI's market penetration and technological adoption. Future research should aim to address these uncertainties by incorporating real-time market data and broader macroeconomic factors, such as policy changes and global economic conditions, which could significantly impact the semiconductor industry. Further refinement of the DCF model could include scenario analysis to evaluate the potential impacts of various global economic conditions and technological advancements on TSMC’s valuation.

In conclusion, this paper not only sheds light on the valuation intricacies of TSMC during an AI-driven market surge, but it also lays the groundwork for future studies to explore the broader implications of technological advancements on industry valuation. The adaptive approach recommended for future DCF modelling promises to enhance the robustness and reliability of financial forecasts, providing a more comprehensive tool for stakeholders navigating the complexities of the global semiconductor industry.

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