Building Efficient Portfolios *

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Abstract

This article provides a brief and accessible overview of three fundamental concepts in modern portfolio theory: the Capital Asset Pricing Model (CAPM), Markowitz Mean-Variance Optimization (MVO), and Arbitrage Pricing Theory (APT). We begin by exploring the CAPM, which describes the relationship between systematic risk and expected return for assets, particularly stocks. Next, we delve into Markowitz MVO, a framework for assembling a portfolio of assets such that the expected return is maximized for a given level of risk, using this to build the efficient frontier. Finally, we examine APT, which extends the ideas of CAPM by considering multiple factors that might affect asset returns. We conclude by discussing the advantages and limitations of these models.

*Code and data supporting this analysis is available at: https://github.com/Aman-Rana-02/Efficient_Market_Portfolios

Contents

1 Introduction

TODO the INTRO!!!!!

The remainder of the article is structured as follows:

- Section ?? provides an overview of the dataset used for analysis.
- Section ?? explores the Capital Asset Pricing Model (CAPM) and its implications.
- Section ?? discusses the importance of diversification and the construction of efficient portfolios.
- Section ?? delves into the Arbitrage Pricing Theory (APT) and its applications.
- Section ?? concludes by discussing limitations of the methods discussed.

2 Data

We use Python (?), Pandas (?), NumPy (?), Statsmodels (?) to analyze S&P 500 price data from Finaeon's Global Financial Dataset (?) and the Fama-French 3-factor data library (?). We use Matplotlib for plotting (?). We get the S&P500's current constituents from the Finaeon website, and download a time-series of daily prices for each stock using Finaeon's API. Kenneth french's website (?) provides the risk-free rate, market excess return, and daily returns of the Size and Value portfolios. The risk-free rate they provide is the 1-month T-bill rate, and the market risk premium is the difference between the total US stock market's return and the risk-free rate. The size and value portfolios are constructed according to ?. By only using the return histories of the current S&P 500 constituents, we introduce a survivorship bias in our analysis. Any risk premia we include will be biased upwards, as we only consider firms that have survived to the present day. The purpose of this article is to introduce concepts of modern portfolio theory, and not to provide a comprehensive analysis of risk factors and premia, so we note this deficiency and move forward with our analysis.

Throughout this article, we'll use a few sample assets to illustrate concepts. We'll refer to them by ticker symbol, and their full names are shown in table ??. These are randomly chosen from the S&P 500, and are not meant to be representative of the index as a whole.

Company Name	Ticker
Apple Inc.	AAPL
General Electric Co.	GE
International Business Machines Corp.	IBM
The Coca-Cola Company	KO
Microsoft Corp.	MSFT

Table 1: Sample assets and their full names

3 Capital Asset Pricing Model (CAPM)

3.1 Intuition of the CAPM β

$$E[R_i] = R_f + \beta_i(E[R_m] - R_f) \tag{1}$$

The Capital Asset Pricing Model is a model that describes the expected returns of an asset as a function of its exposure to systematic risk. The model is given by Equation **??**, where:

- $E[R_i]$ is the expected return of asset i
- R_f is the risk-free rate
- β_i is the asset's beta
- $E[R_m]$ is the expected return of the market

Notice that according to the model, a firm's expected return is only a function of its expsure to the market's risk. This comes from a fundamental belief that in the long-run, any firm-specific/idiosyncratic risk can be diversified away, therefore investors look to be compensated for the risk that cannot be diversified away, which is the market risk.

To estimate the CAPM beta for firms, we regress a firm's historical returns against the market's returns, and take the slope of the line of best fit. This is given by Equation **??**:

$$R_i - R_f = \alpha + \beta_i(R_m - R_f) + \epsilon \tag{2}$$

Where:

- R_i is the firm's return
- R_f is the risk-free rate
- R_m is the market return

Asset	**Beta**
AAPL	1.10
GE	0.92
IBM	0.75
KO	0.49
MSFT	1.14

Table 2: Sample assets and their CAPM betas

- α is the intercept of the regression line
- β_i is the slope of the regression line
- ϵ is the error term

α is known as Jensen's alpha, it is a reflection of how much a firm under or outperforms the market, given its beta. In a world where CAPM perfectly models a firm's returns, α should be zero.

Table **??** shows the CAPM betas for a few sample assets. Higher beta assets are 'riskier' since they are more exposed to the market's risk, and therefore should have higher expected returns.

We can see this more clearly in figure **??**, where we plot the historical average annualized return against a firm's beta. We can see that there is a positive relationship between beta and expected return.

3.2 Cost of Capital - DDM vs CAPM

Recall the definition of cost of capital, and that it is synonymous with expected return. We previously explored using the Dividend Discount Model (DDM) to estimate the cost of capital. The intuition of the DDM is that a stock price represents the present value of all future cashflows, where we proxy all future cashflows using a dividend and expected growth rate. A DDM feels more realistic the better we can forecast a firm's future dividends, as well as their dividend growth rate, given that they pay dividends. If we start to consider that there are firms that don't pay dividends at all, or that the dividend growth rate is hard to forecast, we start to see the limitations of the DDM. Additionally, if we are investors that don't care about dividend payouts, we may not find the DDM useful at all.

The CAPM, on the other hand, is a model that is based on the idea that investors are compensated for the risk they take on. If a risk can be diversified away, then investors shouldn't be compensated for it (as they can get rid of it). If markets are efficient, and investors are rational, then the current stock price should reflect all available information about a firm. There is no need to forecast dividends, or growth rates, or anything else about the firm. We only need to know the firm's exposure to systematic risk.

4 Diversification and Portfolios

By now we have an understanding of how to estimate the expected return of an asset using the Capital Asset Pricing Model (CAPM), and how risk and return should have a proportional relationship. In this section we introduce the concept of diversification, and how it can be used to construct efficient portfolios.

4.1 The Simple Math of Diversification

$$E[R_p] = \sum_{i=1}^{n} w_i E[R_i] \tag{3}$$

Where:

- $E[R_p]$ is the expected return of the portfolio
- w_i is the weight of asset i in the portfolio
- $E[R_i]$ is the expected return of asset i
- n is the number of assets in the portfolio
- w_i is the weight of asset i in the portfolio
- $E[R_i]$ is the expected return of asset i

The expected return of a portfolio is simply the weighted average of the expected returns of the assets in the portfolio.

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij} \tag{4}$$

Where:

- σ_p^2 is the variance of the portfolio
- w_i is the weight of asset i in the portfolio

- σ_i^2 is the variance of asset i
- σ_{ij} is the covariance between assets i and j
- n is the number of assets in the portfolio
- w_i is the weight of asset i in the portfolio

The variance of a portfolio is the weighted average of the variances of the assets in the portfolio, plus the covariance between the assets. Since we square the weights, and they are between 0 and 1, the variance of the portfolio is always less than or equal to the weighted average of the variances of the assets in the portfolio. This means that as we add more assets to the portfolio, the variance of the portfolio will decrease, and the expected return will increase. This is the essence of diversification, and it is the reason why we can construct portfolios that have a higher expected return for a given level of risk.

4.2 Efficient Portfolios

The Markowitz Mean-Variance Optimization (MVO) portfolio is the optimal portfolio for a given level of risk. It is the portfolio that has the highest expected return for a given level of risk, or the lowest risk for a given level of expected return. This is done by solving the following optimization problem:

$$\begin{aligned} \text{maximize} \quad & E[R_p] \\ \text{subject to} \quad & \sigma_p^2 = \sigma^2 \\ & w_i \geq 0, \forall i \end{aligned} \tag{5}$$

Where:

- $E[R_p]$ is the expected return of the portfolio
- σ_p^2 is the variance of the portfolio
- σ^2 is the target variance
- w_i is the weight of asset i in the portfolio
- n is the number of assets in the portfolio
- w_i is the weight of asset i in the portfolio

Lets say that we can't short-sell, or take leverage, therefore we have the constraint that $1 \geq w_i \geq 0, \forall i$.

This has a closed form solution:

$$w_i = \frac{E[R_i] - R_f}{\sigma_i^2} \sum_{j=1}^{n} \frac{E[R_j] - R_f}{\sigma_j^2} \tag{6}$$

Where:

- $E[R_i]$ is the expected return of asset i
- R_f is the risk-free rate
- σ_i^2 is the variance of asset i
- w_i is the weight of asset i in the portfolio
- n is the number of assets in the portfolio

The weights of the assets in the portfolio are given by the difference between the expected return of the asset and the risk-free rate, divided by the variance of the asset. This means that the higher the expected return of the asset, the higher the weight in the portfolio, and the lower the variance of the asset, the higher the weight in the portfolio.

4.3 The Efficient Frontier

The efficient fron tier is just the set of all efficient portfolios. We can see this visually in figure **??**, where we plot the expected return of every efficient portfolio at every level of risk.

4.4 The Tangent Portfolio and The Capital Market Line

The capital market line (CML) is the line that connects the risk-free rate to the tangent portfolio. The tangent portfolio is the optimal risky portfolio, and it is the portfolio that has the highest Sharpe ratio. The Sharpe ratio is given by:

$$S = \frac{E[R_p] - R_f}{\sigma_p} \tag{7}$$

Where:

- S is the Sharpe ratio

figures/efficient_frontier.png

Figure 1: Plot showing the efficient frontier

- $E[R_p]$ is the expected return of the portfolio
- R_f is the risk-free rate
- σ_p is the standard deviation of the portfolio

The Sharpe ratio is a measure of the risk-adjusted return of a portfolio, and it is used to compare the performance of different portfolios. The higher the Sharpe ratio, the better the portfolio's return per unit of risk.

Going back to Figure **??**, we can see that the CML is the line that connects the risk-free rate to the tangent portfolio. It represents the set of all efficient portfolios that can be constructed by combining the risk-free asset with the tangent portfolio. The line to the left of the tangent portfolio represents having a positive exposure to the risk-free asset, and the line to the right of the tangent portfolio represents having a negative exposure to the risk-free asset. A negative exposure means taking out a loan to invest in the tangent portfolio.

The formula for the CML is given by some weight on the risk free rate, and some weight on the tangent portfolio:

$$E[R_p] = w_f R_f + w_t E[R_t] \tag{8}$$

Where:

- $E[R_p]$ is the expected return of the portfolio
- w_f is the weight of the risk-free asset in the portfolio
- R_f is the risk-free rate
- w_t is the weight of the tangent portfolio in the portfolio
- $E[R_t]$ is the expected return of the tangent portfolio

5 Arbitrage Pricing Theory

In this section we'll briefly discuss Arbitrage Pricing Theory (APT), and how it generalizes the Capital Asset Pricing Model (CAPM) as well as how Fama-Macbeth regressions can be used to estimate risk premia. The purpose of this section is not to be comprehensive, but to briefly introduce concepts, as well as the code used when implementing portfolios in a systematic risk framework.

5.1 Arbitrage Pricing Theory

We've discussed **?** and the Size and Value risk factors it proposes. Throughout the article so far we've focused on one source of systematic risk, market risk. From now on we will include the Size and Value factors in our equation for expected returns.

This multi-factor model has the form as per Equation **??**. This is the model given by Arbitrage Pricing Theory (APT).

$$E[R_i] = R_f + \beta_{i,m}\gamma_m + \beta_{i,s}\gamma_s + \beta_{i,v}\gamma_v \tag{9}$$

Where:

- $E[R_i]$ is the expected return of asset i
- R_f is the risk-free rate
- $\beta_{i,m}$ is the asset's exposure to the market risk factor
- $\beta_{i,s}$ is the asset's exposure to the size risk factor
- $\beta_{i,v}$ is the asset's exposure to the value risk factor
- γ_m is the market risk premium
- γ_s is the size risk premium
- γ_v is the value risk premium

For an asset i, the expected return is a function of its exposure to the market, size, and value risk factors, as represented by the Betas. Risk premia are the expected returns of the systematic risk factors, and they are the same for all assets. Recall in the CAPM model, we were concerned only with the market risk premium, now we have three risk premia.

We used to get the market risk premia by taking the average market return over our data period, but we will now introduce a way to get the risk premia for the size and value factors.

5.2 Fama-Macbeth Regressions

Fama-Macbeth regressions are a two stage process that allows us to get the risk premia and factor sensitivities for a set of risk factors.

The first stage is a cross-sectional regression of the asset returns against the risk factors. This gives us the factor sensitivities (betas) for each asset. The second stage is a time-series regression of the factor sensitivities against the risk factors. This gives us the risk premia for each factor at every time-step T.

Stage 1 is given by Equation **??**:

$$R_i = \alpha + \beta_{i,m} R_m + \beta_{i,s} R_s + \beta_{i,v} R_v + \epsilon \tag{10}$$

Where:

- R_i is the return of asset i
- α is the intercept of the regression line
- $\beta_{i,m}$ is the asset's exposure to the market risk factor
- $\beta_{i,s}$ is the asset's exposure to the size risk factor
- $\beta_{i,v}$ is the asset's exposure to the value risk factor
- R_m is the market return
- R_s is the size return
- R_v is the value return
- ϵ is the error term

The second stage is given by Equation **??**:

$$R_m = \alpha + \gamma_m R_m + \gamma_s R_s + \gamma_v R_v + \epsilon \tag{11}$$

Where:

- R_m is the market return
- α is the intercept of the regression line
- γ_m is the market risk premium
- γ_s is the size risk premium

figures/factor_returns.png

Figure 2: Plot showing the cumulative sum of the risk premia for the market, size and value factors

- γ_v is the value risk premium
- R_s is the size return
- R_v is the value return
- ϵ is the error term

We then take an average of the timeseries regression coefficients to get the risk premia for each factor. These risk premia are also referred to as factor returns, since they are the expected returns of the risk factors.

If we take the cumulative sum of these risk premia coefficients, we can visually see the performance of the risk factors over time. We can see this in figure **??**, where we plot the cumulative sum of the risk premia for the size and value factors.

We can take the averages of these coefficients to get the risk premia for each factor.

Asset	Market Beta	Size Beta	Value Beta
AAPL	1.10	0.20	0.30
GE	0.92	0.15	0.25
IBM	0.75	0.10	0.20
KO	0.49	0.05	0.10
MSFT	1.14	0.25	0.35

Table 3: Sample assets and their Fama-Macbeth regression coefficients

We need two parts to contruct portfolios, expected returns and risk. We can get the expected returns from the Fama-Macbeth regressions, and we now, since we believe that returns are only a function of risk factors, we can usse the covariance matrix of the risk factors to get the risk of the portfolio. This greatly reduces the dimensionality of the problem, since we only need to estimate the covariance matrix of the risk factors, and not the covariance matrix of the assets.

Table **??** shows the Fama-Macbeth regression coefficients for a few sample assets.

6 Conclusion

6.1 Summary

6.2 Limitations

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Appendix

A Appendix

In this appendix I provide evidence from Form 10-Ks for the numbers used in the DDM and DFCFM.

Advanced Micro Devices, Inc.

Consolidated Statements of Cash Flows

	Year Ended		
	December 28, 2024	December 30, 2023	December 31, 2022
	(In millions)		
Supplemental cash flow information:			
Cash paid during the year for:			
Interest	$ 72	$ 84	$ 85
Income taxes, net of refund	$ 1,386	$ 523	$ 685
Non-cash investing and financing activities:			
Purchases of property and equipment, accrued but not paid	$ 144	$ 106	$ 157
Issuance of common stock and treasury stock for the acquisition of Xilinx	$ —	$ —	$ 48,514
Fair value of replacement share-based awards related to acquisition of Xilinx	$ —	$ —	$ 275
Non-cash activities for leases:			
Operating lease right-of-use assets acquired by assuming related liabilities	$ 102	$ 273	$ 115
Reconciliation of cash, cash equivalents, and restricted cash			
Cash and cash equivalents	$ 3,787	$ 3,933	$ 4,835
Restricted cash included in Prepaid expenses and other current assets	24	—	—
Total cash, cash equivalents, and restricted cash	$ 3,811	$ 3,933	$ 4,835

See accompanying notes to the Consolidated Financial Statements.

Figure 3: Screenshot from ? with Cash values

Indicate the number of shares outstanding of each of the registrant's classes of common stock, as of the latest practicable date: 1,620,477,962 shares of common stock, $0.01 par value per share, as of January 30, 2025.

Figure 4: Screenshot from ? with common stock values

Debt

The Company's total debt as of December 28, 2024 and December 30, 2023 consisted of:

	December 28, 2024	December 30, 2023
	(In millions)	
2.950% Senior Notes Due 2024 (2.950% Notes)	$ —	$ 750
2.375% Senior Notes Due 2030 (2.375% Notes)	750	750
3.924% Senior Notes Due 2032 (3.924% Notes)	500	500
4.393% Senior Notes Due 2052 (4.393% Notes)	500	500
Total debt (principal amount)	1,750	2,500
Unamortized debt discount and issuance costs	(29)	(32)
Total debt (net)	1,721	2,468
Less: current portion of long-term debt and related unamortized debt premium and issuance costs	—	(751)
Total long-term debt	$ 1,721	$ 1,717

Assumed Xilinx Notes due 2024 and 2030

Figure 5: Screenshot from ? with AMD's debt

Earnings per share	
Basic	$ 1.01
Diluted	$ 1.00
Shares used in per share calculation	
Basic	1,620
Diluted	1,637

Figure 6: Screenshot from ? with AMD's EPS

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The following table provides a summary of net revenue and operating income (loss) by segment for 2024 and 2023:

	Year Ended	
	December 28, 2024	December 30, 2023
	(In millions)	
Net revenue:		
Data Center	$ 12,579	$ 6,496
Client	7,054	4,651
Gaming	2,595	6,212
Embedded	3,557	5,321
Total net revenue	$ 25,785	$ 22,680
Operating income (loss):		
Data Center	$ 3,482	$ 1,267
Client	897	(46)
Gaming	290	971
Embedded	1,421	2,628
All Other	(4,190)	(4,419)
Total operating income	$ 1,900	$ 401

Figure 7: Screenshot from ? with AMD's Operating Income (EBIT)

Long-Term Debt

($ In Millions)	Dec 28, 2024 Effective Interest Rate	Dec 28, 2024 Amount	Dec 30, 2023 Amount
Fixed-rate senior notes:			
2.88%, due May 2024	— %	$ —	$ 1,250
2.70%, due June 2024	— %	—	600
3.40%, due March 2025	3.44%	1,500	1,500
3.70%, due July 2025	7.49%	2,250	2,250
4.88%, due February 2026	4.93%	1,500	1,500
2.60%, due May 2026	5.97%	1,000	1,000
3.75%, due March 2027	3.78%	1,000	1,000
3.15%, due May 2027	6.54%	1,000	1,000
3.75%, due August 2027	3.81%	1,250	1,250
4.88%, due February 2028	4.92%	1,750	1,750
1.60%, due August 2028	1.67%	1,000	1,000
4.00%, due August 2029	4.05%	850	850
2.45%, due November 2029	2.38%	2,000	2,000
5.13%, due February 2030	5.14%	1,250	1,250
3.90%, due March 2030	3.91%	1,500	1,500
5.00%, due February 2031	4.99%	500	—
2.00%, due August 2031	2.02%	1,250	1,250
4.15%, due August 2032	4.17%	1,250	1,250
4.00%, due December 2032	6.59%	750	750
5.20%, due February 2033	5.23%	2,250	2,250
5.15%, due February 2034	5.20%	900	—
4.60%, due March 2040	4.59%	750	750
2.80%, due August 2041	2.81%	750	750
4.80%, due October 2041	7.33%	802	802
4.25%, due December 2042	6.70%	567	567
5.63%, due February 2043	5.61%	1,000	1,000
4.90%, due July 2045	7.46%	772	772
4.10%, due May 2046	6.74%	1,250	1,250
4.10%, due May 2047	6.70%	1,000	1,000
4.10%, due August 2047	6.27%	640	640
3.73%, due December 2047	7.11%	1,967	1,967
3.25%, due November 2049	3.19%	2,000	2,000
4.75%, due March 2050	4.73%	2,250	2,250
3.05%, due August 2051	3.05%	1,250	1,250
4.90%, due August 2052	4.89%	1,750	1,750
5.70%, due February 2053	5.68%	2,000	2,000
5.60%, due February 2054	5.61%	1,150	—
3.10%, due February 2060	3.10%	1,000	1,000
4.95%, due March 2060	4.98%	1,000	1,000
3.20%, due August 2061	3.20%	750	750
5.05%, due August 2062	5.03%	900	900
5.90%, due February 2063	5.88%	1,250	1,250

Figure 8: Screenshot from ? with INTC's debt rates

Consolidated Results of Operations

Years Ended (In Millions, Except Per Share Amounts)	December 28, 2024 Amount	December 28, 2024 % of Net Revenue	December 30, 2023 Amount	December 30, 2023 % of Net Revenue	December 31, 2022 Amount	December 31, 2022 % of Net Revenue
Net revenue	$ 53,101	100.0 %	$ 54,228	100.0 %	$ 63,054	100.0 %
Cost of sales	35,756	67.3 %	32,517	60.0 %	36,188	57.4 %
Gross margin	17,345	32.7 %	21,711	40.0 %	26,866	42.6 %
Research and development	16,546	31.2 %	16,046	29.6 %	17,528	27.8 %
Marketing, general, and administrative	5,507	10.4 %	5,634	10.4 %	7,002	11.1 %
Restructuring and other charges	6,970	13.1 %	(62)	(0.1)%	2	— %
Operating income (loss)	(11,678)	(22.0)%	93	0.2 %	2,334	3.7 %
Gains (losses) on equity investments, net	242	0.5 %	40	0.1 %	4,268	6.8 %
Interest and other, net	226	0.4 %	629	1.2 %	1,166	1.8 %
Income (loss) before taxes	(11,210)	(21.1)%	762	1.4 %	7,768	12.3 %
Provision for (benefit from) taxes	8,023	15.1 %	(913)	(1.7)%	(249)	(0.4)%
Net income (loss)	(19,233)	(36.2)%	1,675	3.1 %	8,017	12.7 %
Less: net income (loss) attributable to non-controlling interests	(477)	(0.9)%	(14)	— %	3	— %
Net income (loss) attributable to Intel	$ (18,756)	(35.3)%	$ 1,689	3.1 %	$ 8,014	12.7 %
Earnings (loss) per share attributable to Intel—diluted	$ (4.38)		$ 0.40		$ 1.94	

Figure 9: Screenshot from ? with INTC's Operating Income (EBIT) and EPS

(In Millions)	Dec 28, 2024
Cash and cash equivalents	$ 8,249
Short-term investments	13,813
Total cash and short-term investments	$ 22,062
Total debt	$ 50,011

Figure 10: Screenshot from ? with INTC's Cash and Debt

Consolidated Statements of Operations

Years Ended (In Millions, Except Per Share Amounts)	Dec 28, 2024
Net revenue	$ 53,101
Cost of sales	35,756
Gross margin	17,345
Research and development	16,546
Marketing, general, and administrative	5,507
Restructuring and other charges	6,970
Operating expenses	29,023
Operating income (loss)	(11,678)
Gains (losses) on equity investments, net	242
Interest and other, net	226
Income (loss) before taxes	(11,210)
Provision for (benefit from) taxes	8,023
Net income (loss)	(19,233)
Less: net income (loss) attributable to non-controlling interests	(477)
Net income (loss) attributable to Intel	$ (18,756)
Earnings (loss) per share attributable to Intel—basic	$ (4.38)
Earnings (loss) per share attributable to Intel—diluted	$ (4.38)
Weighted average shares of common stock outstanding:	
Basic	4,280
Diluted	4,280

See accompanying notes.

Figure 11: Screenshot from ? with INTC's Shares Outstanding

INTC / Dividend History

Intel Corporation Common Stock (INTC) Dividend History

Ex-Dividend Date	Dividend Yield	Annual Dividend	P/E Ratio
08/07/2024	1.92%	$0.50	N/A

Ex/EFF Date	Type	Cash Amount	Declaration Date	Record Date	Payment Date
08/07/2024	Cash	$0.125	07/17/2024	08/07/2024	09/01/2024
05/06/2024	Cash	$0.125	04/22/2024	05/07/2024	06/01/2024
02/06/2024	Cash	$0.125	01/24/2024	02/07/2024	03/01/2024
11/06/2023	Cash	$0.125	N/A	11/07/2023	12/01/2023
08/04/2023	Cash	$0.125	07/18/2023	08/07/2023	09/01/2023
05/04/2023	Cash	$0.125	02/17/2023	05/07/2023	06/01/2023
02/06/2023	Cash	$0.365	01/26/2023	02/07/2023	03/01/2023

Figure 12: Screenshot from ? with INTC's Dividend Payments

TSM / Dividend History

Taiwan Semiconductor Manufacturing Company Ltd. (TSM) Dividend History

Ex-Dividend Date	Dividend Yield	Annual Dividend	P/E Ratio
12/12/2024	1.23%	$2.462372	38.63

Ex/EFF Date	Type	Cash Amount	Declaration Date	Record Date	Payment Date
03/18/2025	Cash	$0.694165	11/12/2024	03/18/2025	04/10/2025
12/12/2024	Cash	$0.615593	08/13/2024	12/12/2024	01/09/2025
09/12/2024	Cash	$0.625999	05/10/2024	09/12/2024	10/09/2024
06/13/2024	Cash	$0.54429	02/06/2024	06/13/2024	07/11/2024

Figure 13: Screenshot from ? with TSMC's Dividend Payments

TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY LIMITED AND SUBSIDIARIES

Consolidated Condensed Statements of Comprehensive Income (Audited)

(Expressed in Millions of New Taiwan Dollars ("NTD") and U.S. Dollars ("USD") (1)

Except for Per Share Amounts and Shares Outstanding)

	For the Years Ended December 31						
	2024			2023		YoY	
	USD	NTD	%	NTD	%	NTD	%
Net Revenue	$ 90,083	$ 2,894,308	100.0	$ 2,161,736	100.0	$ 732,572	33.9
Cost of Revenue	(39,526)	(1,269,954)	(43.9)	(986,625)	(45.6)	(283,329)	28.7
Gross Profit	50,557	1,624,354	56.1	1,175,111	54.4	449,243	38.2
Operating Expenses							
Research and Development Expenses	(6,355)	(204,182)	(7.1)	(182,370)	(8.5)	(21,812)	12.0
Sales, General and Administrative Expenses	(3,016)	(96,889)	(3.3)	(71,464)	(3.3)	(25,425)	35.6
Total Operating Expenses	(9,371)	(301,071)	(10.4)	(253,834)	(11.8)	(47,237)	18.6
Other Operating Income and Expenses	(38)	(1,230)	-	189	-	(1,419)	(750.8)
Income from Operations	41,148	1,322,053	45.7	921,466	42.6	400,587	43.5
Non-operating Income and Expenses							
Share of Profits of Associates	152	4,880	0.2	4,655	0.2	225	4.8
Net Interest Income (Expenses)	2,388	76,718	2.6	48,294	2.3	28,424	58.9
Other Gains and Losses	68	2,188	0.1	4,756	0.2	(2,568)	(54.0)
Total Non-operating Income and Expenses	2,608	83,786	2.9	57,705	2.7	26,081	45.2
Income before Income Tax	43,756	1,405,839	48.6	979,171	45.3	426,668	43.6
Income Tax Expenses	(7,265)	(233,407)	(8.1)	(141,403)	(6.5)	(92,004)	65.1
Net Income	36,491	1,172,432	40.5	837,768	38.8	334,664	39.9
Other Comprehensive Income (Losses)	2,228	71,585	2.5	(8,814)	(0.5)	80,399	NM
Comprehensive Income	$ 38,719	$ 1,244,017	43.0	$ 828,954	38.3	$ 415,063	50.1
Net Income (Losses) Attributable to:							
Shareholders of the Parent	$ 36,517	$ 1,173,268	40.5	$ 838,498	38.8	$ 334,770	39.9
Noncontrolling interests	(26)	(836)	-	(730)	-	(106)	(14.5)
	$ 36,491	$ 1,172,432	40.5	$ 837,768	38.8	$ 334,664	39.9
Earnings per Share - Diluted	$ 1.41	$ 45.25		$ 32.34		$ 12.91	39.9
Earnings per ADR - Diluted (2)	$ 7.04	$ 226.24		$ 161.69		$ 64.55	39.9
Weighted Average Outstanding Shares - Diluted ('M)		25,930		25,929			

Note:

(1) Amounts in New Taiwan dollars have been translated into U.S. dollars at the weighted average rate of NT$32.129 for the year ended December 31, 2024.

(2) 1 ADR equals 5 ordinary shares.

Figure 14: Screenshot from ? with TSMC's EBIT, and EPS

TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY LIMITED AND SUBSIDIARIES

Consolidated Condensed Cash Flow Statements

For the Year Ended December 31, 2024 and for the Three Months Ended December 31, 2024, September 30, 2024 and December 31, 2023

(Expressed in Millions of New Taiwan Dollars ("NTD") and U.S. Dollars ("USD")) (1)

	2024 (Audited)		4Q 2024 (Unaudited)	3Q 2024 (Unaudited)	4Q 2023 (Unaudited)
	USD	NTD	NTD	NTD	NTD
Cash Flows from Operating Activities:					
Income Before Income Tax	$ 43,756	$ 1,405,839	$ 448,798	$ 384,187	$ 278,281
Depreciation & Amortization	20,629	662,796	170,378	168,229	150,648
Share of Profits of Associates	(152)	(4,880)	(1,289)	(1,561)	(1,315)
Income Taxes Paid	(5,715)	(183,639)	(1,190)	(93,295)	(37,567)
Changes in Working Capital & Others	(1,679)	(53,939)	3,508	(65,567)	4,782
Net Cash Generated by Operating Activities	56,839	1,826,177	620,205	391,993	394,829
Cash Flows from Investing Activities:					
Interest Received	2,379	76,434	18,473	21,356	14,872
Cash Dividend Received	109	3,507	207	2,405	58
Acquisitions of:					
Property, Plant and Equipment	(29,755)	(956,007)	(361,949)	(207,079)	(170,160)
Marketable Financial Instruments	(7,489)	(240,623)	(77,351)	(54,209)	(55,485)
Proceeds from Disposal or Redemption of:					
Property, Plant and Equipment	28	895	256	146	312
Marketable Financial Instruments	5,790	186,035	56,885	34,426	52,334
Others	2,020	64,916	51,560	7,446	25,750
Net Cash Used In Investing Activities	(26,918)	(864,843)	(311,919)	(195,509)	(132,319)
Cash Flows from Financing Activities:					
Decrease in Hedging Financial Liabilities - Bank Loans	(825)	(26,496)	-	-	-
Proceeds from Issuance of Bonds	1,068	34,300	-	-	9,800
Repayment of Bonds	(218)	(7,000)	(1,750)	(5,250)	-
Proceeds from Long-term Bank Loans	962	30,897	7,455	17,064	-
Repayment of Long-term Bank Loans	(72)	(2,296)	(636)	(604)	(513)
Interest Paid	(584)	(18,751)	(5,946)	(4,385)	(5,995)
Cash Dividends Paid for Common Stock	(11,300)	(363,055)	(103,734)	(90,763)	(77,796)
Repurchase of Treasury Stock	(96)	(3,089)	-	-	-
Others	286	9,189	3,879	299	(863)
Net Cash Used in Financing Activities	(10,779)	(346,301)	(100,732)	(83,639)	(75,367)
Effect of Exchange Rate Changes on Cash and Cash Equivalents	1,468	47,166	33,292	(25,191)	(33,522)
Net Increase in Cash and Cash Equivalents	20,610	662,199	240,846	87,654	153,621
Cash and Cash Equivalents at Beginning of Period	45,611	1,465,428	1,886,781	1,799,127	1,311,807
Cash and Cash Equivalents at End of Period	$ 66,221	$ 2,127,627	$ 2,127,627	$ 1,886,781	$ 1,465,428

Note:

(1) Amounts in New Taiwan dollars have been translated into U.S. dollars at the weighted average rate of NT$32.129 for the year ended December 31, 2024.

Figure 15: Screenshot from ? with TSMC's Cash Statements