ECO358 (Financial Economics I)

Portfolio Optimization: Japanese Equities

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Contents

Introduction

When planning this assignment, I was interested in challenging myself and setting out to optimise a portfolio for a stock market that is not American. Thus, I chose the Tokyo Stock Exchange (TSE) as my focus, having been recently fascinated by Japan's gradual recovery from decades of monetary stagnation. The three companies listed on the TSE that I chose are the Sony Group Corporation, the Toyota Motor Corporation, and Fujitsu Limited. These are all publicly traded and are amongst the largest Japanese companies by market capitalization. My rationale behind choosing this set of firms is that they are diversified in both their business models and their revenue streams (consider the Appendices for a detailed overview).

- Sony's single biggest revenue source is its gaming and network arm, including brands such as PlayStation – but this only makes up 31.5% of its total revenue (MooMoo, 2024b). It also manufactures technology, imaging, and sensing solutions, boasts music and cinema production studios, and operates other income streams. It sources its revenues from the entire world, and its largest market – the United States – contributes 29% of its revenue.
- Toyota is an iconic automotive manufacturer. It gets a definitive most of its revenue from vehicle sales, but it is a well established household name with a powerful brand image that plausibly endows the firm with relative stability in the face of competition. Toyota sources its revenues from the entire world as well, with the United States making up just around 37% of its revenue (MooMoo, 2024c).
- Fujitsu's business model revolves around trusted technology services, digital solutions like IT components, and manufactured technology products like air conditioning. In contrast to Sony and Toyota, Fujitsu sources 62% of its revenue in Japan (MooMoo, 2024a). The Americas provide only an 8% revenue stream for the company. Fujitsu relies little on manufacturing, making it a good point of comparison to the two former companies.

In obtaining the risk-free rate for Japan, I take its CDS default spread (it being nonzero at 0.43% [Damodaran, 2024]) and subtract it from the yield-to-maturity of the 10-year Japanese treasury bond (0.74% [CNBC, 2024]) to obtain the risk free rate, 0.31%. Furthermore, there are 246 trading days on the TSE (D'Alessio, 2022).

1. CAPM Cost of Capital

Parts a., b., c., and e..

Table 1: Initial Price Analysis and the CAPM Costs of Capital.

	SON-NIKK	TOY-NIKK	FUJ-NIKK	NIKK-NIKK
Covariance	0.02%	0.01%	0.01%	0.02%
Beta	1.01	0.89	0.80	1.00
Annual Exp. Returns	26.4%	27.2%	30.2%	14.7%
Annual Volatility	30.2%	25.5%	30.0%	19.2%
CAPM	14.84%	13.16%	11.79%	

I obtain historical price data (Yahoo Finance, n.d) for the adjusted close prices of the three equities in the five-year range between March 22nd 2019 and March 22nd 2024. I compute simple percentage-change daily returns for each equity across all data points in that range. The covariance row in table 1 returns the covariances between each equity and the market index, the Japanese Nikkei 225. The beta row returns the

sensitivity to fluctuations in the Nikkei 225. Sony seems to have the highest sensitivity to fluctuations in the domestic Japanese index at first glance.

Part f.

The Capital Asset Pricing Model (CAPM) cost of capital specifies the rate of return that investors require in order to invest in a stock based on the sensitivity of the stock to systematic risk in the market. Sony, with its highest systematic risk exposure amongst the portfolio, is the company that is most sensitive to Japanese market fluctuations (a beta of 1.01); and thus exhibits the highest cost of capital (14.84%). Though Sony's revenues are less dependent on the domestic Japanese market than Fujitsu's, it's largest revenue stream comes from gaming; an industry that is sensitive to economic downturns worldwide (Lee, 2023). On the other hand, Fujitsu's lowest beta could illustrate its lack of reliance on manufacturing, a business model that is particularly exposed to systematic risk (via rising costs of production and disrupted supply chains). Alternatively, Fujitsu's product offerings could be understood as experiencing more inelastic demand; corporate IT solutions are necessary all throughout the business cycle.

The Dividend-Discount (DD) model employs an analysis based on the present value of future cash flows returned to the shareholder. The DD framework's reliance on dividend forecasts and a hypothetical growth rate deems it difficult to apply to real-world contexts. It is perhaps more suitable for mature, dividend-paying companies, whereas CAPM is applicable to all companies regardless of their dividend policy. The Discounted Free Cash Flow (DFCF) method is a more comprehensive approach that considers all cash flows available to equity holders. It is flexible and can accommodate companies with varying growth patterns, dividend policies, and financial structures. Here, however, the DCF model's reliance on cash flow projections is challenging as well; especially for companies with uncertain future cash flows or volatile operating conditions.

2. Random Portfolio Allocation and the Efficient Portfolio Line

I assign the following random weights to each Japanese equity for the purpose of this question:

Table 2: Portfolio 1 Random Weights

Stock	Weight
Sony	20%
Toyota	30%
Fujitsu	50%
Sum	100%

Part a.

Table 3: Variance/Covariance Matrix for Portfolio Equities

	R SON	R TOY	R FUJ
R SON	0.000369724	0.000146937	0.000136788
R TOY	0.000146937	0.000264288	0.000105091
R FUJ	0.000136788	0.000105091	0.000365758

I obtain the covariances between each of the three Japanese equities and themselves, i.e. the variance. I populate the entire matrix as opposed to half of it as to avoid mistakes in calculating portfolio betas in upcoming sections.

Parts b. and c.

Table 4: Portfolio 1 CAPM Statistics

Portfolio Annual Exp. Return	28.55%
Portfolio Annual Volatility	22.54%
Portfolio Beta	0.868
Sharpe Ratio	125%

Part e.

By choosing firms in differing industries, I was hoping to capture a portfolio more illustrative of the true efficient market portfolio. To my surprise, all three companies' stocks were tied to the Nikkei 225 index with similar strengths. There could be a number of reasons for this, one being that the sheer size of each of these companies means that not only do their performances impact the performance of the Japanese stock market, but in fact their global significance means that any shocks to the global economy will likely move global equities in the same direction as that of these three Japanese equities.

A drawback of using historical price data in the calculation of above portfolio statistics is that the relationship between each of the firms' future returns and future market movements is impossible to predict, and if changed could drastically weaken the extrapolation of current statistics on the future. Market conditions, economic factors like regulation, and company fundamentals are all variable features of economies and can result in inaccurate portfolio characteristics and thus suboptimal investment decisions. Lastly, we must remember that using the last 5 years of price data represents merely a slice of history, and will likely not capture the relationships between securities and the market index accurately.

Bonus

Table 5: Portfolios Constituting the Efficient Portfolio Line

Bonus Portfolio	Beta	Return	Volatility
1	1.009	26.39%	30.16%
2	0.957	26.75%	24.22%
3	0.929	27.11%	22.80%
4	0.911	27.47%	22.05%
5	0.894	27.83%	21.70%
6	0.869	28.19%	21.94%
7	0.858	28.55%	22.28%
8	0.841	28.91%	23.19%
9	0.827	29.28%	24.48%
10	0.816	29.64%	26.26%
11	0.804	30.00%	28.44%

Using the Excel solver add-in, I obtain the upper and lower bounds for possible returns given the combination of Sony, Toyota, and Fujitsu equities; these are ~26.39% and ~30.00% respectively. I then command Excel to obtain weights that minimize the variance for 11 specified rates of return falling between the obtained return interval. I specify these desired returns in the "return" column. Please consider the

"Bonus" sheet in my calculations document to view statistics and optimal weights for each of the above 11 portfolios.

3. The Tangent Portfolio

Part a.

By using the Excel solver add-in, I maximize the Sharpe Ratio by manipulating portfolio weights, yielding:

Table 6: Tangent Portfolio Optimal Weights

Stock	Weight
Sony	17%
Toyota	46%
Fujitsu	37%
Sum	100%

The weight of Sony and Fujitsu stocks in the portfolio decreased, while the weight of Toyota stock increased relative to my portfolio with arbitrary weights from Table 2.

Part b. and d.

Table 7: Tangent Portfolio CAPM Statistics

Portfolio Annual Exp. Return	28.18%
Portfolio Annual Volatility	21.77%
Portfolio Beta	0.876
Sharpe Ratio	128%

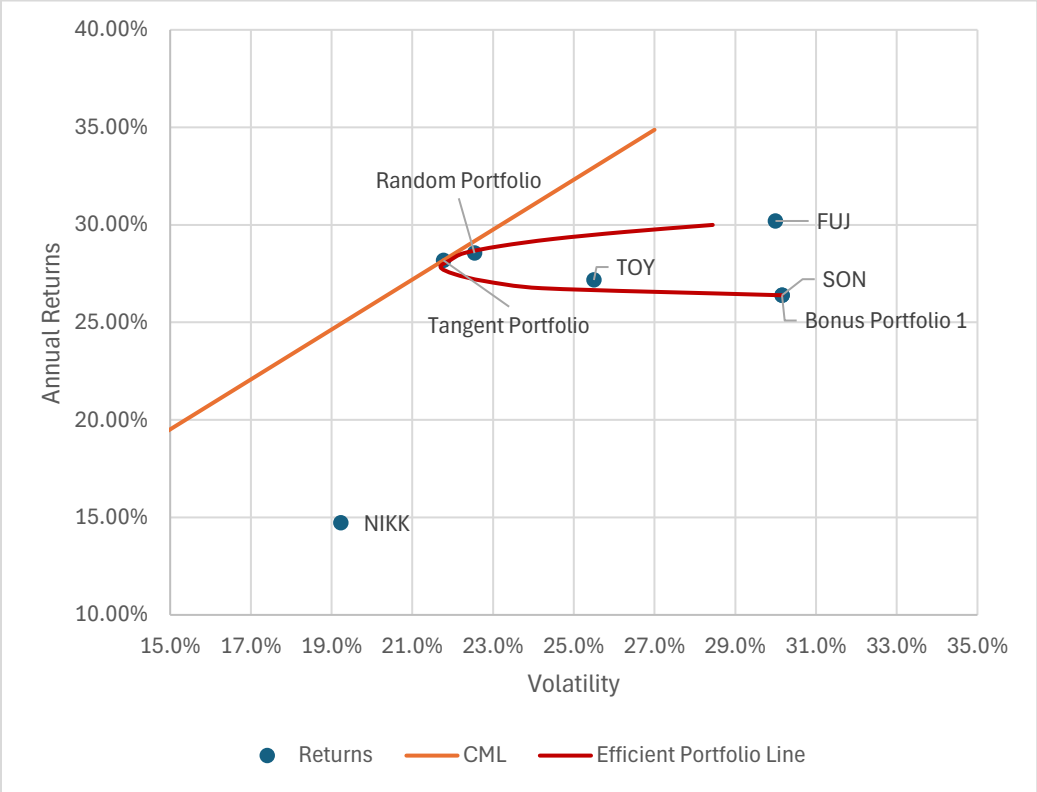
Upon first glance, the Sharpe Ratio of the tangent portfolio increased by 3% relative to the random portfolio from Table 4. Though the annual expected return is marginally smaller than that of the random portfolio, the annual volatility of the tangent portfolio has decreased by more than the returns (0.77% decrease in annual volatility compared to 0.37% decrease in annual return). Investors that are risk-averse will thus prefer this tangent portfolio.

When compared to Nikkei 225 index statistics summarized in Table 1, the tangent portfolio offers much greater annual returns (28.18% > 14.7%), but it is also riskier (21.77% volatility compared to 19.2% for the Nikkei 225). This makes intuitive sense. A greater number of stocks constituting the market index will lower returns by averaging out the particularly high-returning stocks, but it will also average out the volatility of particularly risky equities.

4. Visualisations: Capital and Securities Market Lines

Part a.

Figure 1: Portfolio Optimization and the Capital Market Line

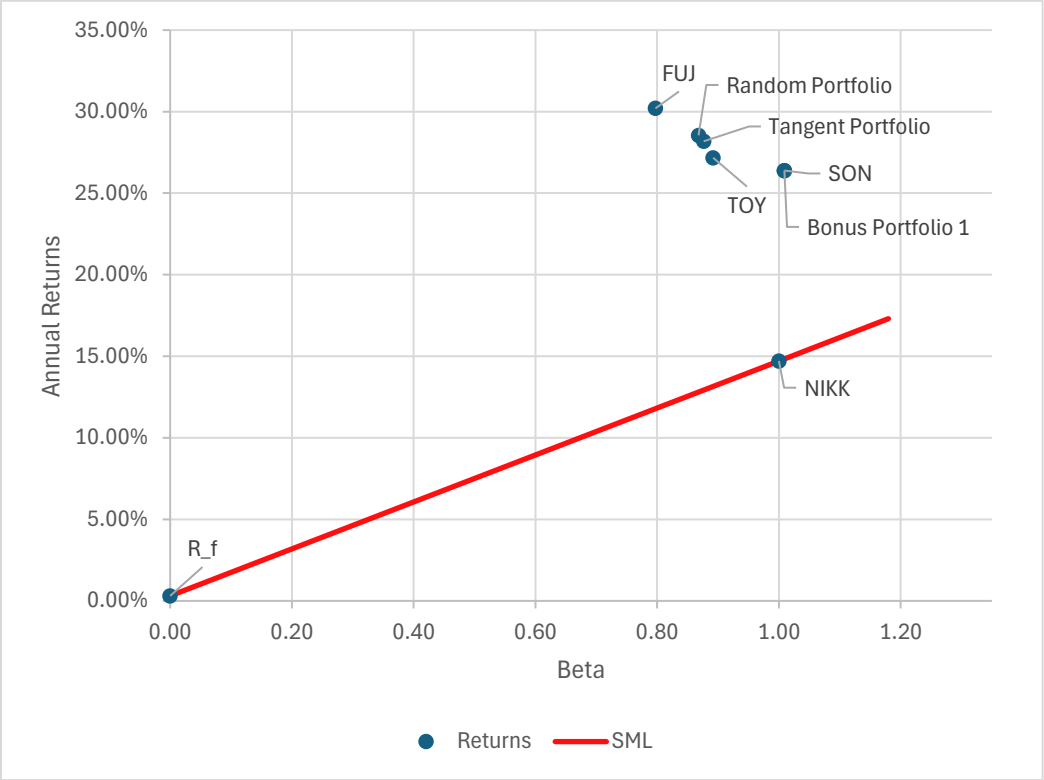


Please note that, as outlined in the introduction, the risk-free rate I use for Japan is 0.31%. However, because all three stocks in my constructed portfolio offer very similar annual returns (consider Table 1), the vertical length of the efficient portfolio line is very small. In order to improve the interpretation and clarity, thus, I modified the horizontal axis so that the intercept (the risk free rate) is not visible.

As expected, the tangent portfolio lies at the intercept of the Capital Market Line and the Efficient Portfolio Line. This means that given the tripartite combination of equities, the tangent portfolio is optimal in terms of risk-adjusted return. At this point, every investor – regardless of their risk preference – should gold a combination of the risk-free asset (the 10-year Japanese treasury) and the tangent portfolio.

Part b.

Figure 2: The Security Market Line (SML)

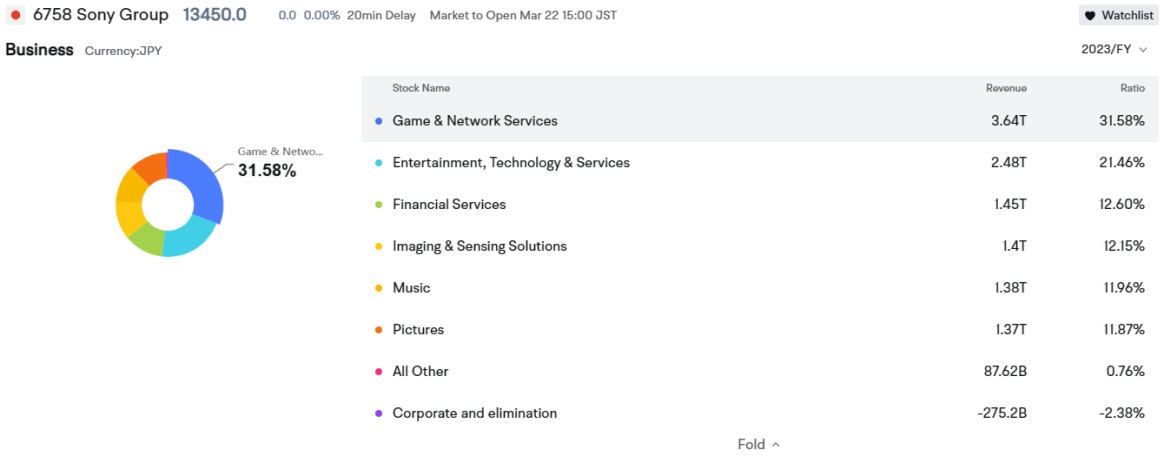


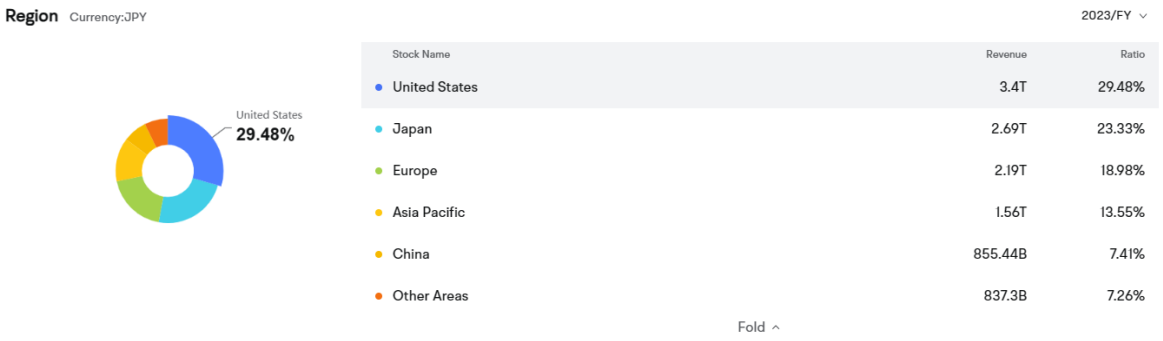
Parts c. and d.

The SML illustrates the tradeoff between risk (captured by beta) and expected return for marketable securities. Figure 2 projects a graph that is consistent with the theoretical underpinning of the CAPM framework. As evident, the Nikkei 225 market index lies directly on the SML which means that the market is efficient in pricing securities, i.e. that the expected return of the market index aligns well with its systematic risk. The remaining equities and portfolios estimated in this paper lie above the SML, indicating that they are undervalued; they offer greater returns against their systematic risk. The fact that these securities lie above the SML is itself an indication that the CAPM is incorrect in assuming constant and universal market efficiency. However, as competition between investors in the Japanese stock market continues, more investment into undervalued securities such as Sony, Toyota, or Fujitsu will cause these securities to gradually approximate the SML. Of course, this relies on the assumption of investors' rational expectations; that they will correctly use and interpret information available about these securities. In reality, and particularly today when capital markets are flooded with novice ("casual") investors (Fitzgerald, 2020), this assumption can be put into question.

Appendices

Appendix I: Sony Revenue Breakdown

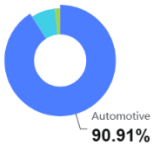




Appendix II: Toyota Revenue Breakdown

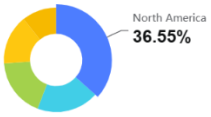
7203 Toyota Motor 3872.0 0.0 0.00% 20min Delay Market to Open Mar 22 15:00 JST Watchlist

Business Currency:JPY 2023/FY



Stock Name	Revenue	Ratio
Automotive	33.78T	90.91%
Financial Services	2.79T	7.50%
All Other	590.75B	1.59%

Region Currency:JPY 2023/FY

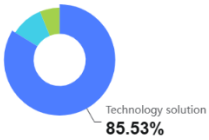


Stock Name	Revenue	Ratio
North America	13.58T	36.55%
Asia	7.15T	19.25%
Japan	6.74T	18.15%
Other	5.71T	15.38%
Europe	3.97T	10.69%

Appendix III: Fujitsu Revenue Breakdown

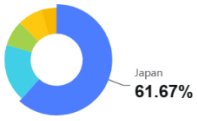
6702 Fujitsu 26040.0 0.0 0.00% 20min Delay Market to Open Mar 22 15:00 JST Watchlist

Business Currency:JPY 2023/FY



Stock Name	Revenue	Ratio
Technology solution	3.18T	85.53%
Device solution	382.68B	10.30%
Ubiquitous solution	233B	6.27%
Elimination/company-wide	-78.46B	-2.11%

Region Currency:JPY 2023/FY



Stock Name	Revenue	Ratio
Japan	2.29T	61.67%
Europe	666.46B	17.95%
America	296.22B	7.98%
Asia-Pacific	282.73B	7.61%
East asia	170.63B	4.59%
Other	7.44B	0.20%

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