Finance Project Report

BT2201 Business Concepts and Metrics for Analytics
Semester 1, Academic Year 2022/2023

Group #11
Fan Kai Jie, A0233048L
Fiona Xiao Jingyi, A0240290R
Ong Yong Chein, A0235421R
Ryan Koh Fang Rong, A0233182M
Shayer Ahmed, A0150756A

Acknowledgements

1 Introduction

We propose 3 portfolios of ETFs as wealth management solutions for the typical Japanese retail investor while considering their varying levels of risk tolerance. Our 3 portfolios are differentiated according to risk levels and corresponding expected returns:

  i. Low Risk (Low expected return)
 ii. Medium Risk (Medium expected return)
iii. High Risk (High expected return)

2 Our Selected List of ETFs

16 ETFs which are traded in Japan and the United States have been chosen for the construction of our portfolios. These 16 ETFs are selected to give Japanese retail investors exposure to a large range of assets, both domestically and overseas.

Furthermore, the ETFs were selected to have low fees, high liquidity (low bid-ask spread, high market capitalisation and/or high average daily volume), as well as low tracking error values.
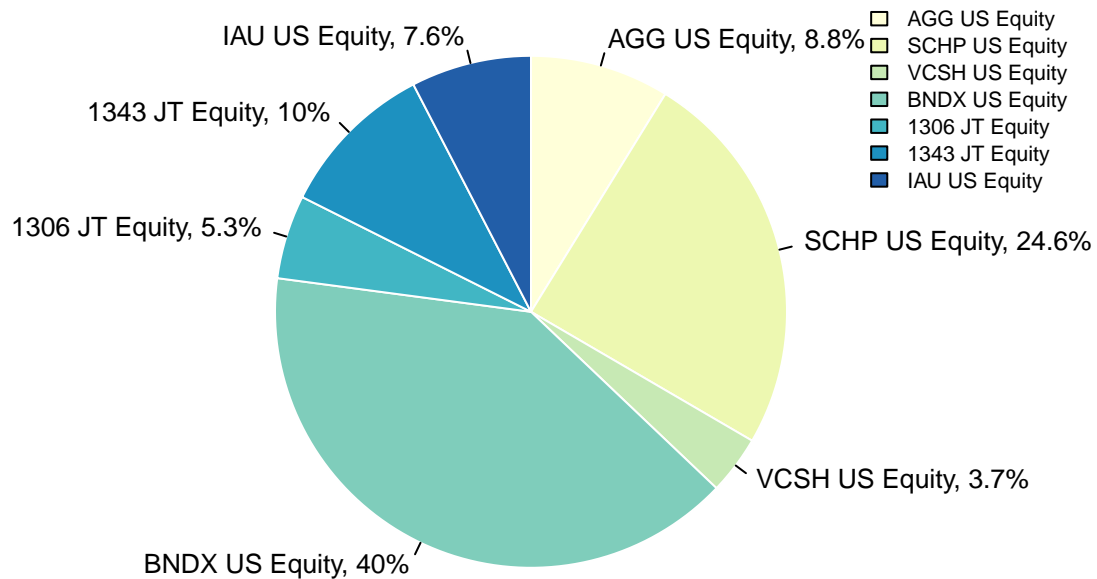
Table 1: Information on selected ETFs

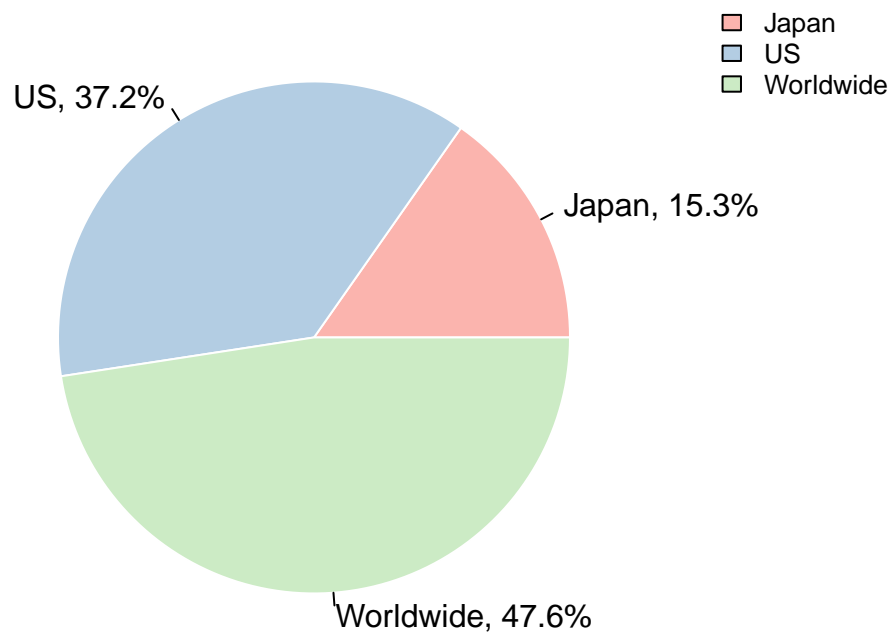| ETF	Asset Class	Benchmark	Currency	Fees	Bid/Ask Spread	Tracking Error
AGG	USIGFI	Core US Agg	USD	0.040	0.02	0.12
SCHP	TIPFI	US TIPS	USD	0.050	0.01	5.39
VCSH	USSTCorpFI	US 1/5 yr Corp	USD	0.040	0.01	3.44
BNDX	GFI	BGA ex-USD H	USD	0.070	0.01	3.55
VWOB	EMFI2	USD EM Govies	USD	0.200	0.08	8.30
1306	JEQ	TOPIX	JPY	0.088	1.00	NA
VOO	USEQ	S&P500	USD	0.030	0.02	0.02
VO	USMEQ	US Mid Cap	USD	0.040	0.13	4.52
VSS	WexUSsEQ	FTSE AC ex-US Small	USD	0.070	0.29	4.12
VGK	EUREQ	FTSE EU	USD	0.080	0.03	8.19
VWO	EMEQ	FTSE EM	USD	0.080	0.01	11.63
1343	JREIT	TSE REIT	JPY	0.155	4.00	NA
VNQ	USREIT	MSCI REIT	USD	0.120	0.02	11.66
VNQI	GREIT	S&P REIT	USD	0.120	0.20	9.17
IAU	GOLD	Gold Bullion	USD	0.250	0.01	22.78
BCI	COMMO	S&P GSCI	USD	0.250	0.06	0.29

3 Global Minimum Variance Portfolio (Low Risk)

The first portfolio is the Global Minimum Variance Portfolio (GVMP), which is the portfolio with the lowest risk. It caters to investors who prefer safe investments with minimal risk.
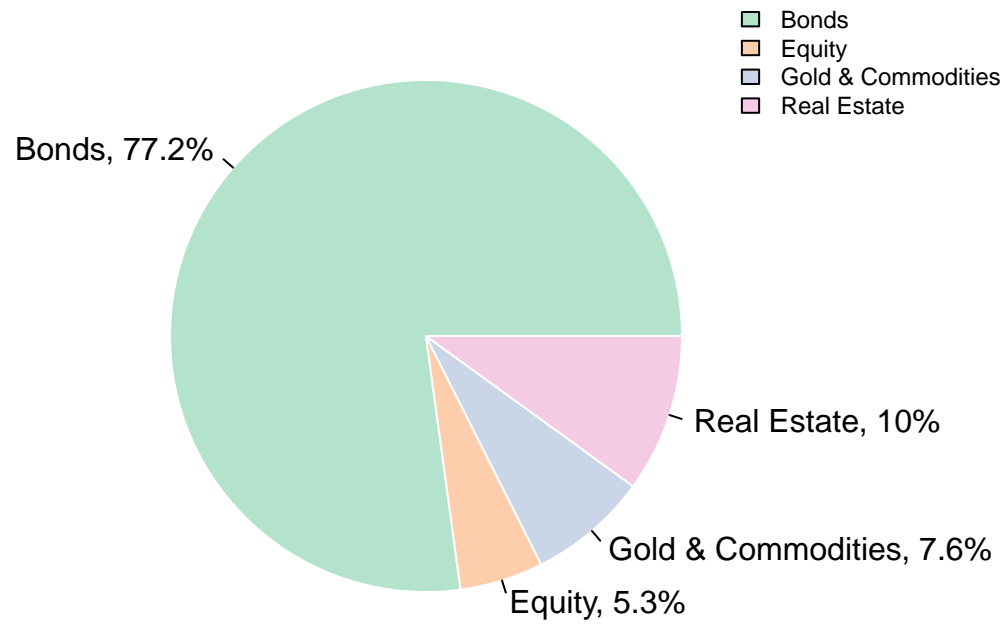
Global Minimum Variance Portfolio Weights

IAU US Equity, 7.6%

AGG US Equity, 8.8%

1343 JT Equity, 10%

1306 JT Equity, 5.3%

SCHP US Equity, 24.6%

VCSH US Equity, 3.7%

BNDX US Equity, 40%

Legend:
- AGG US Equity
- SCHP US Equity
- VCSH US Equity
- BNDX US Equity
- 1306 JT Equity
- 1343 JT Equity
- IAU US Equity

Countries Invested in the Global Minimum Variance Portfolio

US, 37.2%

Japan, 15.3%

Worldwide, 47.6%

Legend:
- Japan
- US
- Worldwide

Types of Assets Invested in the Global Minimum Variance Portfolio

Legend:
- Bonds
- Equity
- Gold & Commodities
- Real Estate

Bonds, 77.2%
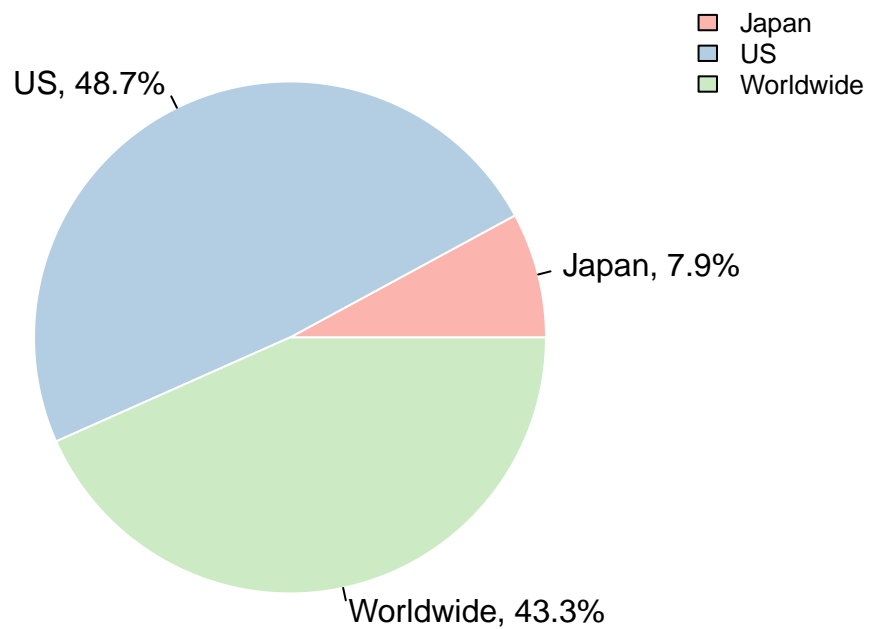
Real Estate, 10%

Gold & Commodities, 7.6%

Equity, 5.3%

4 Tangency Portfolio (Medium Risk)

The second portfolio is the Tangency Portfolio. This portfolio maximises the Sharpe ratio and is the most balanced in terms of risk and return. Relative to the other portfolios, this portfolio carries medium risk.
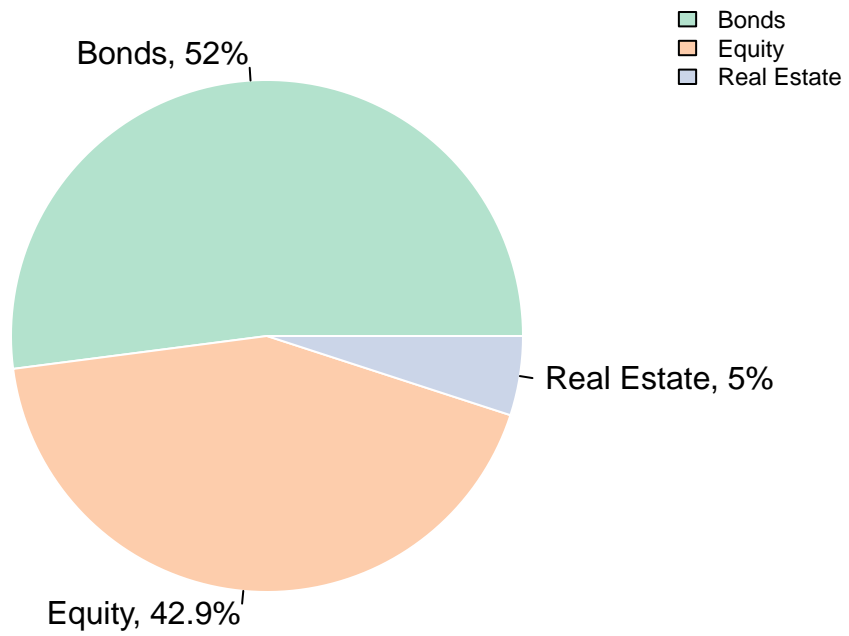
Tangency Portfolio Weights

VNQI US Equity, 5%
VGK US Equity, 6.1%
AGG US Equity, 7.7%
VCSH US Equity, 12.1%
VOO US Equity, 28.9%
BNDX US Equity, 26.5%
1306 JT Equity, 7.9%
VWOB US Equity, 5.7%

Legend:
- AGG US Equity
- VCSH US Equity
- BNDX US Equity
- VWOB US Equity
- 1306 JT Equity
- VOO US Equity
- VGK US Equity
- VNQI US Equity

Countries Invested in the Tangency Portfolio

US, 48.7%
Japan, 7.9%
Worldwide, 43.3%

Legend:
- Japan
- US
- Worldwide

Types of Assets Invested in the Tangency Portfolio

Bonds, 52%

Real Estate, 5%
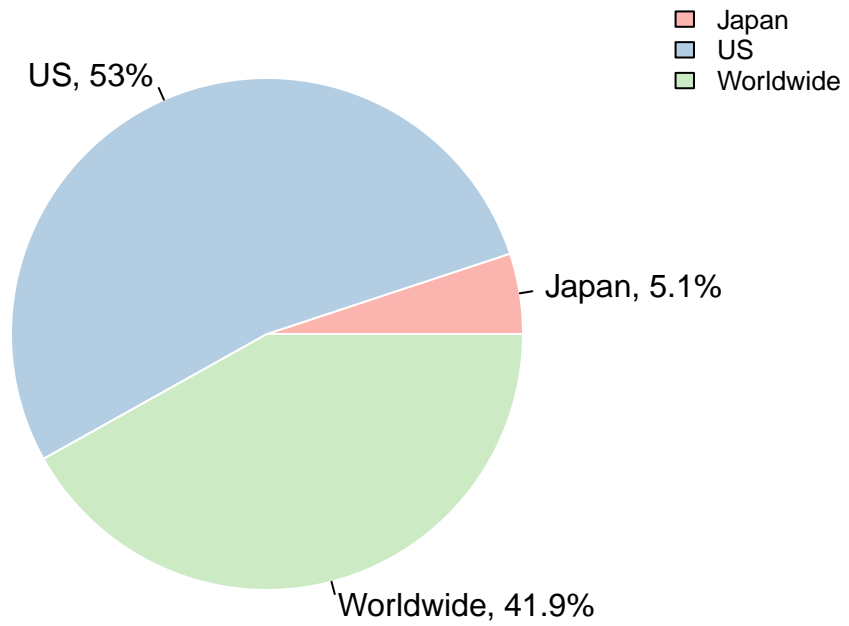
Equity, 42.9%

Legend:
- Bonds
- Equity
- Real Estate

5 Maximum Returns Portfolio (High Risk)

The last portfolio is the Maximum Returns Portfolio. It is weighted to have the highest returns as well as the highest risk. It caters to investors with higher risk tolerance who are willing to take on larger amounts of risk with their holdings.
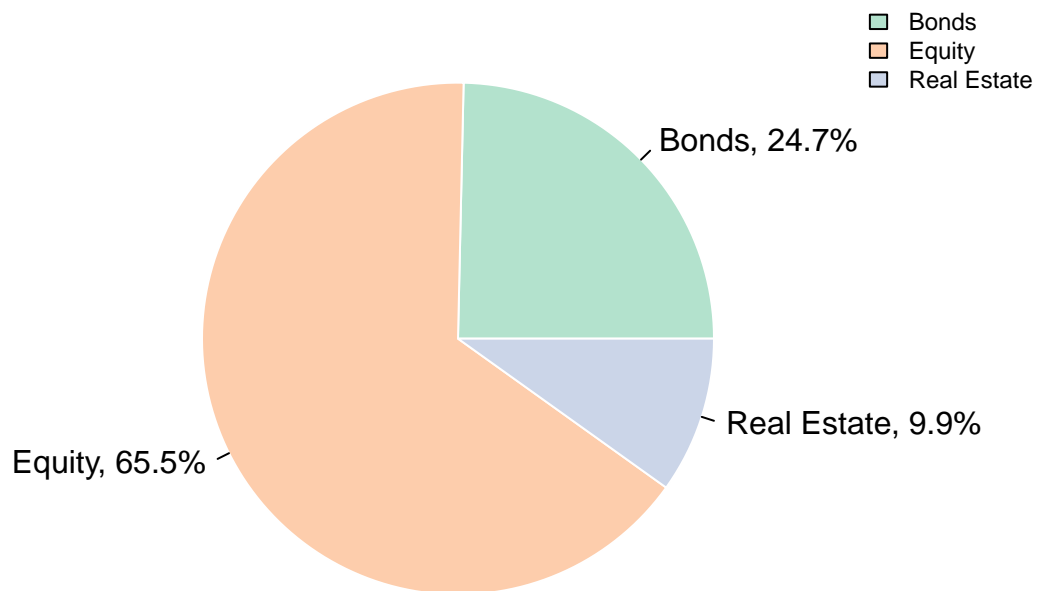
Maximum Returns Portfolio Weights

VWO US Equity, 3.1%
BNDX US Equity, 8.4%
VWOB US Equity, 16.2%
VGK US Equity, 4.3%
1306 JT Equity, 5.1%
VNQI US Equity, 9.9%
VO US Equity, 4.7%
VOO US Equity, 48.3%

- VWOB US Equity
- 1306 JT Equity
- VOO US Equity
- VO US Equity
- VNQI US Equity
- VGK US Equity
- BNDX US Equity
- VWO US Equity

Countries Invested in the Maximum Returns Portfolio

US, 53%

Japan, 5.1%

Worldwide, 41.9%

Legend: Japan, US, Worldwide

Types of Assets Invested in the Maximum Returns Portfolio

Bonds, 24.7%

Real Estate, 9.9%

Equity, 65.5%

Legend: Bonds, Equity, Real Estate
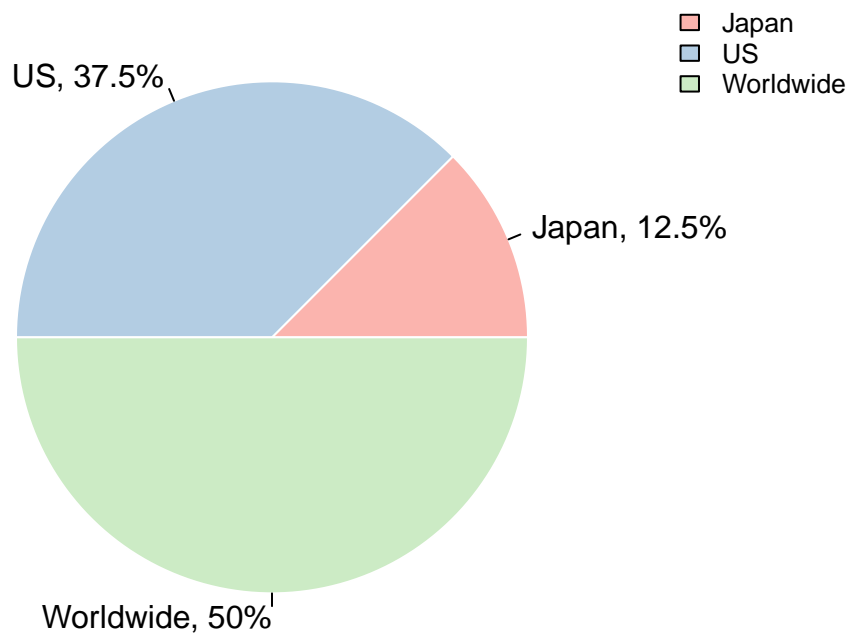
6 Equal Weights Portfolio

We have also included the Equal Weights Portfolio. This portfolio allows investors to examine the performance of a portfolio that allocates equal weights to our selected ETFs.
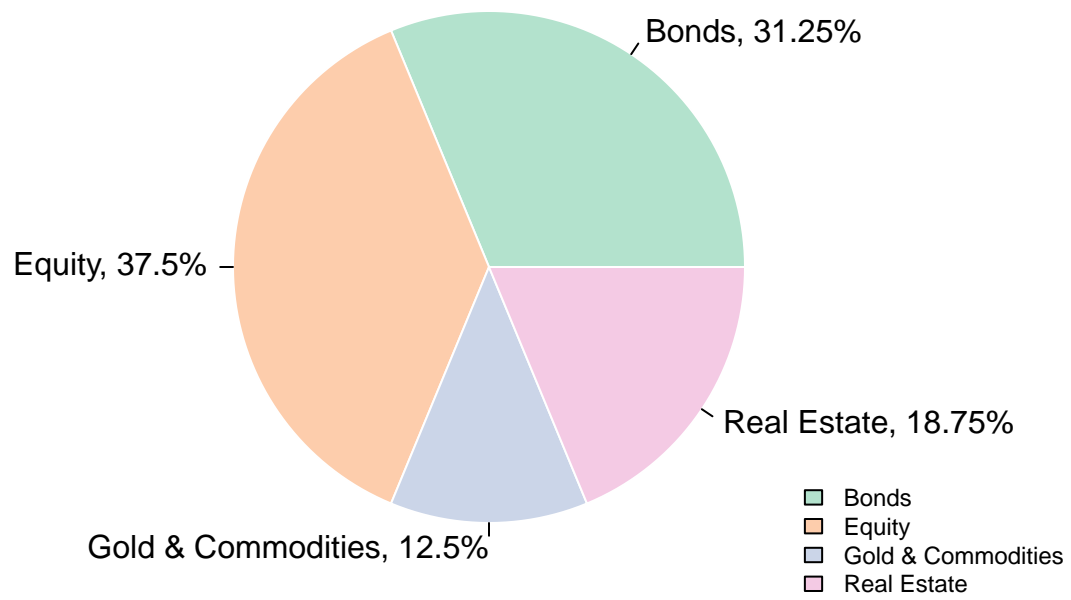
Equal Weights Portfolio weights
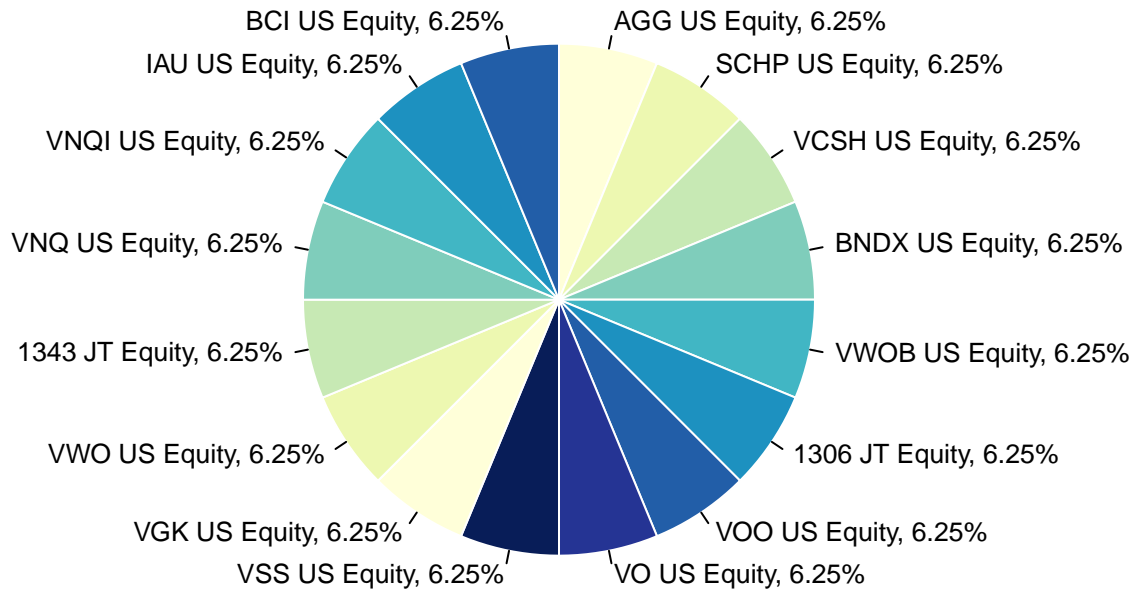
Countries Invested in the Equal Weights Portfolio

Types of Assets Invested in the Equal Weights Portfolio

Bonds, 31.25%

Equity, 37.5%

Real Estate, 18.75%

Gold & Commodities, 12.5%

Legend:
- Bonds
- Equity
- Gold & Commodities
- Real Estate

7 Portfolio Statistics

The following table displays the performance summary of each of our portfolios as well as the Equal Weights Portfolio. It shows the percentages of portfolio returns, portfolio risk, and the Sharpe ratios of each portfolio.

Table 2: Portfolio Statistics

	Portfolio Returns (%)	Portfolio Risk (%)	Sharpe Ratio
Global Minimum Variance (Low Risk)	2.81	8.24	0.321
Tangency (Medium Risk)	5.46	13.18	0.402
Maximum Returns (High Risk)	7.35	18.24	0.393
Equal Weights (Reference)	5.58	14.05	0.385

The **Global Minimum Variance Portfolio** provides investors with the lowest risk at 8.24%. This portfolio is suitable for investors with low risk tolerance.

The **Tangency Portfolio** has the highest Sharpe ratio amongst all the portfolios at 0.402. This portfolio provides investors with the highest return to risk. When compared to the other portfolios, the Tangency Portfolio has a medium amount of risk.

The **Maximum Returns Portfolio** provides the highest returns of 7.35%. This portfolio is suitable for investors looking to take on higher levels of risk in order to potentially gain higher returns.

The **Equal Weights Portfolio** is mainly used as a reference point to compare against the 3 portfolios.

8 Backtesting

To evaluate the performance of the portfolios, we performed backtesting using 20 years, 10 years and 5 years of historical data respectively. The Equal Weights Portfolio was included as a point of comparison for the performance of the other portfolios.

Portfolios Backtesting – 20 Years
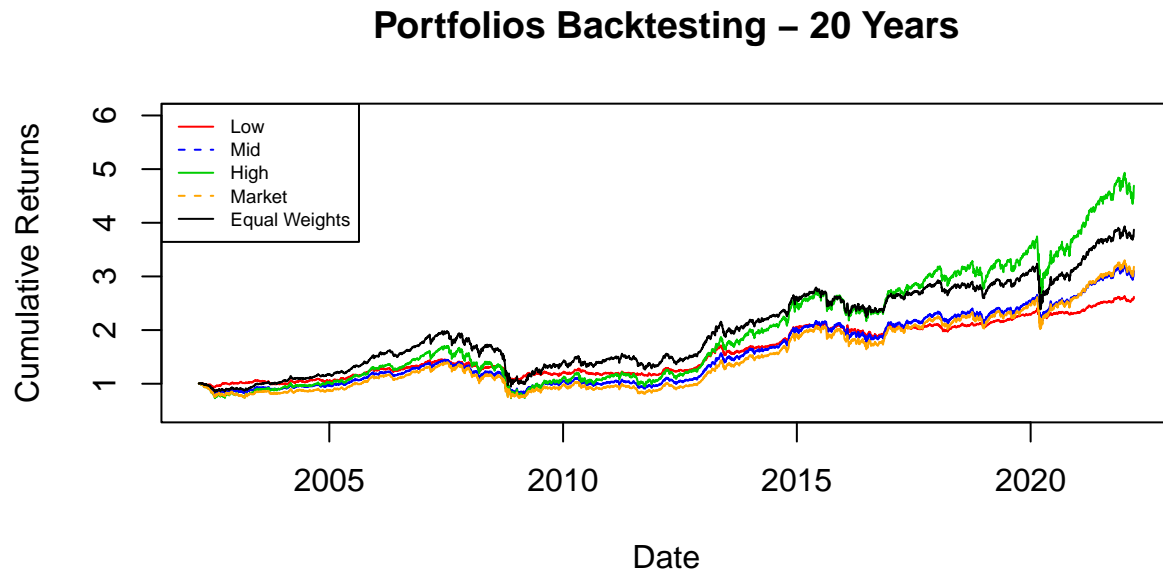
The performance of the portfolios were examined using historical data from 19 Mar 2002 to 18 Mar 2022 (20 Years).

  i. High-risk portfolio **outperforms** the Market and Equal Weights portfolios
 ii. Medium-risk portfolio **underperforms** the Market and Equal Weights portfolios
iii. Low-risk portfolio **underperforms** the Market and Equal Weights portfolios
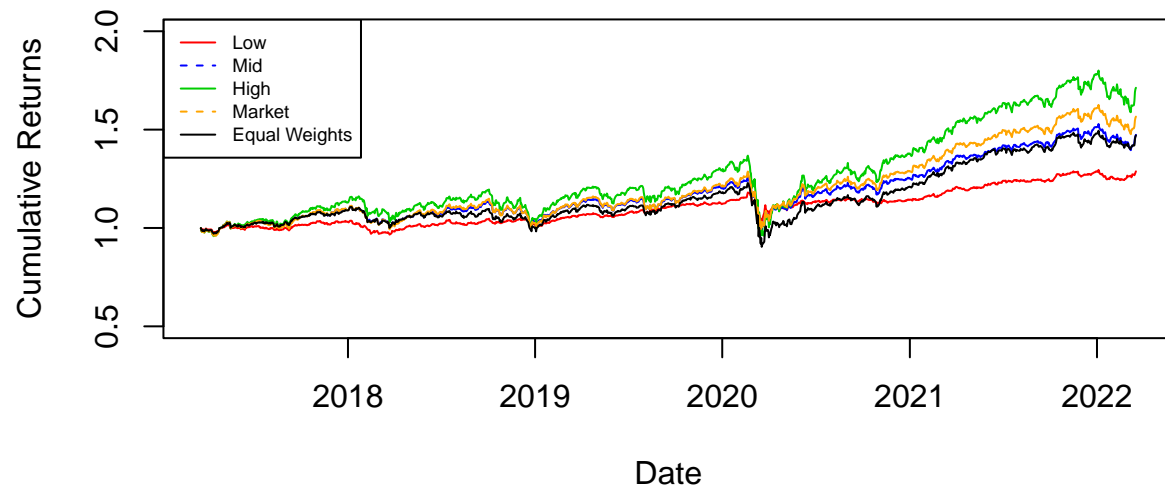
Portfolios Backtesting – 10 Years
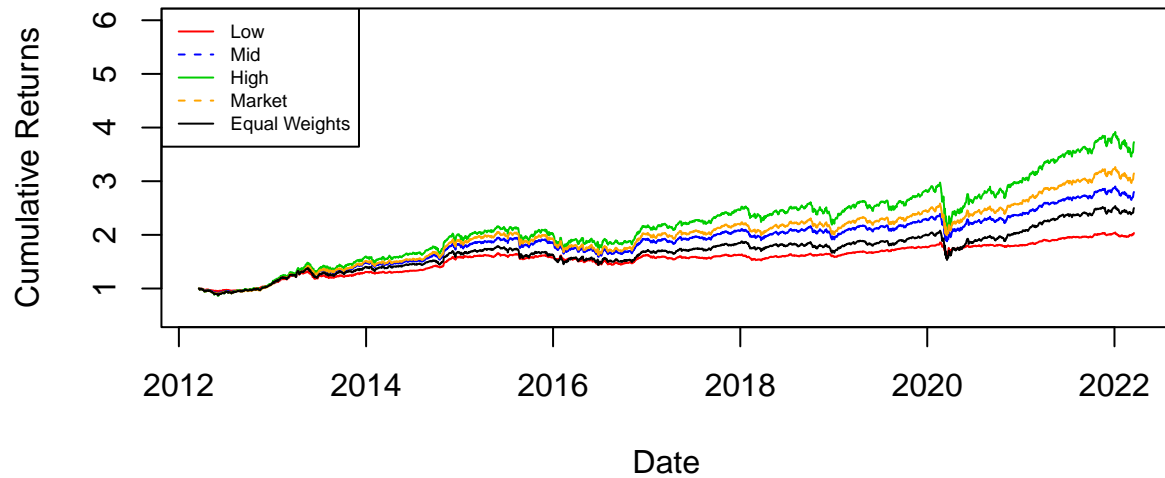
The performance of the portfolios were examined using historical data from 19 Mar 2012 to 18 Mar 2022 (10 Years).

    i. High-risk portfolio **outperforms** the Market and Equal Weights portfolios
    ii. Medium-risk portfolio **underperforms** the Market portfolio but **outperforms** the Equal Weights portfolio
    iii. Low-risk portfolio **underperforms** the Market and Equal Weights portfolios

Portfolios Backtesting – 5 Years

The performance of the portfolios were examined using historical data from 20 Mar 2017 to 18 Mar 2022 (5 Years).

  i. High-risk portfolio **outperforms** the Market and Equal Weights portfolios
 ii. Medium-risk portfolio **underperforms** the Market portfolio but **outperforms** the Equal Weights portfolio
iii. Low-risk portfolio **underperforms** the Market and Equal Weights portfolios

Appendix

We used a 20.5-year period for our calculations, from October 2001 to March 2022.
We used the average number of trading days, 252 days, for the purpose of annualisation.
For ETFs with their currency in USD, we converted the USD returns to JPY returns without hedging for currecy risk.

Historical Statistics

We include a table calculating the historical annualized geometric return (μ), variance (σ^2), and standard deviation (σ) values of the market portfolio, risk-free asset, and individual ETFs over the defined period.

Table 3: Historical Statistics

	Geometric return	Variance	Standard deviation
Market	0.065	0.022	0.147
Risk-Free	0.001	0.000	0.000
AGG	0.036	0.009	0.093
SCHP	0.048	0.009	0.094
VCSH	0.034	0.008	0.092
BNDX	0.036	0.008	0.091
VWOB	0.073	0.015	0.123
1306	0.047	0.042	0.206
VOO	0.091	0.057	0.238
VO	0.106	0.064	0.252
VSS	0.085	0.044	0.209
VGK	0.057	0.070	0.265
VWO	0.096	0.089	0.298
1343	0.076	0.042	0.206
VNQ	0.101	0.099	0.315
VNQI	0.077	0.042	0.206
IAU	0.090	0.030	0.173
BCI	0.023	0.037	0.193

Inputs for Portfolio Optimisation

In order to perform portfolio optimisation, we obtained the expected annualised return, as well as the covariance matrix.

We included constraints for the individual ETFs. Specifically, we limited the weight of each security to between 3%-40%. This was to ensure proper diversification amongst the securities, while maintaining that each security remained sufficiently significant for practical purposes.

We also ensured a mix of country and asset class in the allocation of securities within each portfolio. This was to ensure proper diversification of our portfolio along these lines as well.

Expected Annualised Return

To calculate the expected annualised return, we used capital asset pricing model (CAPM). This is given by

$$\mu_i = R^f + \beta_i * MRP$$

Covariance Matrix

To calculate the covariance matrix, we used the historical values provided.

Table 4: Beta and Expected Annualised Return

	Beta	Expected Annualised Return
AGG	0.472	0.030
SCHP	0.428	0.027
VCSH	0.497	0.032
BNDX	0.488	0.031
VWOB	0.695	0.043
1306	0.476	0.030
VOO	1.498	0.092
VO	1.551	0.095
VSS	1.151	0.071
VGK	1.519	0.093
VWO	1.647	0.101
1343	0.259	0.017
VNQ	1.526	0.093
VNQI	1.064	0.066
IAU	0.378	0.024
BCI	0.791	0.049

Efficient Frontier Plot

Furthermore, we plotted the efficient frontier to visualise where our global minimum variance, equal weights and tangency portfolios lie.

Efficient Frontier
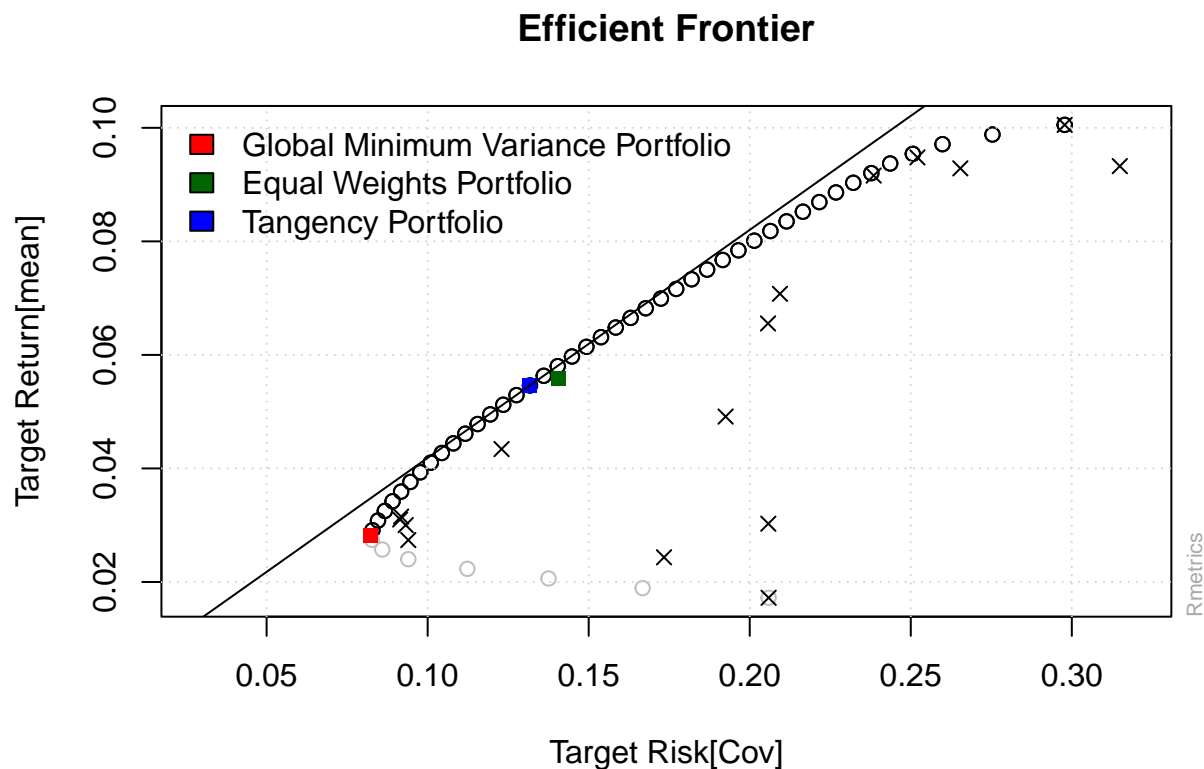
Risk-Free Rate   For our risk-free rate, we used 0.1%. We obtained this figure by calculating the annualised historical geometric mean for our risk-free asset over the period mentioned above. This is a reasonable estimate given the dovish stance of the Bank of Japan.

Beta   Beta is calculated using $\frac{\sigma_{i,m}}{\sigma_m^2}$

Market Risk Premium   For our market risk premium (MRP), we used a rate of 6%.

Correlation Matrix
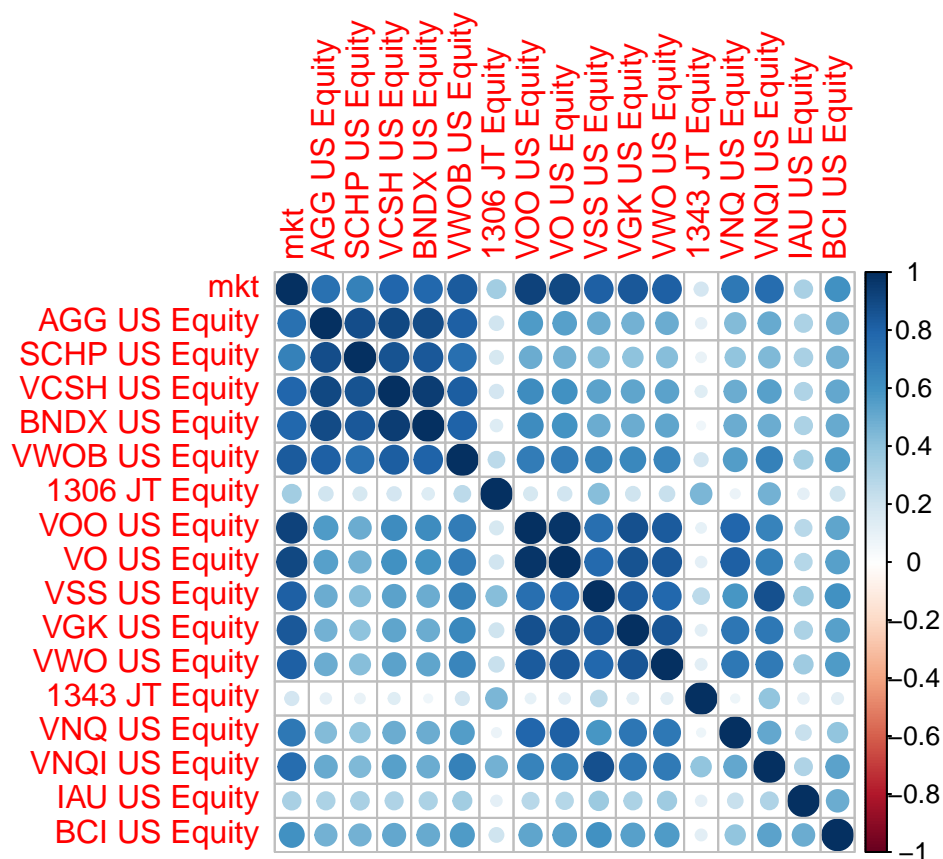
From the correlation matrix, we observed that there are 2 clusters of ETFs which are highly correlated to each other. We were able to group them accordingly using their respective tickers as such:

Group 1: AGG, SCHP, VCSH, BNDX, VWOB

Group 2: VOO, VO, VSS, VGK, VWO

Sharpe Ratio Plot

We also created 400 random portfolios to highlight the performance of our 3 selected portfolios. From the plot, we are able to observe that a higher risk would be associated to higher returns. Additionally, we are able to show how our selected portfolios perform better than if one were to randomly allocate money into different ETFs, as for the same amount of risk, we obtain higher expected returns.

Random Feasible Portfolios