

# BT Finance Project

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Group 17

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## 1.1 Characteristics of Selected ETFs

**Developed Market (DM)** exchange-traded funds (ETFs) focus on holdings within the world's most advanced economies. In contrast, **Emerging Market(EM)** ETFs focus on holdings in economies that are currently developing from a closed economy to a market economy. The table below shows the markets and Asset Classes that make up each individual ETF in our portfolio.

	Bonds	Equities	Alternatives (Real Estate)	Alternatives (Commodities)
DM	AGG, SCHP, VCSH, BNDX	1306, VOO, VO, VSS, VGK	1343, VNQ, VNQI	IAU, BCI
EM	VWOB	VWO	VNQI	IAU, BCI

The selection of ETFs serve to capture a range of asset classes across both EMs & DMs.

## 1.2 Justification for ETF characteristics

The following statistics were computed and compared among ETFs to select for our portfolio.

Characteristic	Justification
Asset Class	Breakdown of asset classes is the diversification of portfolios.
Benchmark	Benchmarks allow investors to assess the relative success of their portfolios.
Currency	Converting all the rates to the same rate when comparing returns is to ensure consistency by providing the same benchmark for all ETFs.
Trading Fees	Being well informed about trading fees is important as excessive fees may eat into your profits.
Bid-Ask Spread	Bid-Ask Spread indicates the liquidity of ETFs in the portfolio.
20-Y Mean Excess Returns (MER)	Investors can use excess returns to assess their investment performance in contrast to other investment options.
Tracking Difference	Tracking difference informs investors about the relative performance of an ETF in comparison to its benchmark index.
Expense Ratio	The expense ratio informs an investor of both their costs when investing in a specific fund, and the amount that their returns will be reduced by. The expense ratio of an ETF can have a big impact on investment performance over time.

## 1.3 Characteristics of Selected ETFs

The table below summarises the characteristics of the selected ETFs as listed earlier.

	Asset Class	Benchmark	CCY	Fees	Bid-Ask Spread	20-Y MER	Tracking Difference (%)	Expense Ratio (%)
AGG	USIGFI	Core US Agg	USD	0.040	0.02	0.0001545	-0.01	0.03
SCHP	TIPFI	US TIPS	USD	0.050	0.01	0.0001996	-0.07	0.04
VCSH	USSTCorpFI	US 1/5 yr Corp	USD	0.040	0.01	0.0001457	0	0.07
BNDX	GFI	BGA ex-USD H	USD	0.070	0.01	0.0001531	-0.03	0.07
VWOB	EMFI2	USD EM Govies	USD	0.200	0.08	0.0003033	0.40	0.20
1306	JEQ	TOPIX	JPY	0.088	1.00	0.0002619	NA	0.05
VOO	USEQ	S&P500	USD	0.030	0.02	0.0004529	-0.04	0.04
VO	USMEQ	US Mid Cap	USD	0.040	0.13	0.0005221	-0.02	0.05
VSS	WexUSsEQ	FTSE AC ex-US Small	USD	0.070	0.29	0.0004052	0.02	0.07
VGK	EUREQ	FTSE EU	USD	0.080	0.03	0.0003572	0.11	0.08
VVO	EMEQ	FTSE EM	USD	0.080	0.01	0.0005353	-0.17	0.14
1343	JREIT	TSE REIT	JPY	0.155	4.00	0.0003700	NA	0.12
VNQ	USREIT	MSCI REIT	USD	0.120	0.02	0.0005736	-0.12	0.12
VNQI	GREIT	S&P REIT	USD	0.120	0.20	0.0003748	0.36	0.12
IAU	GOLD	Gold Bullion	USD	0.250	0.01	0.0003987	-0.25	0.25
BCI	COMMO	S&P GSCI	USD	0.250	0.06	0.0001581	NA	0.25

## 2 Assumptions & Data Manipulation

### 1. Conversion of Currency to JPY

Returns of ETFs priced in USD were adjusted to account for currency fluctuations between USD/JPY. Hence, the following formula was used to calculate the excess returns:  $(1 + \text{DailyReturn}) * (1 + \text{fxRate}) - 1$

### 2. Risk Free Rate

The risk free rate used in our portfolio weight optimisation was taken to be the arithmetic mean returns of the JY0003M Index which tracks the 3-Month Yen LIBOR.

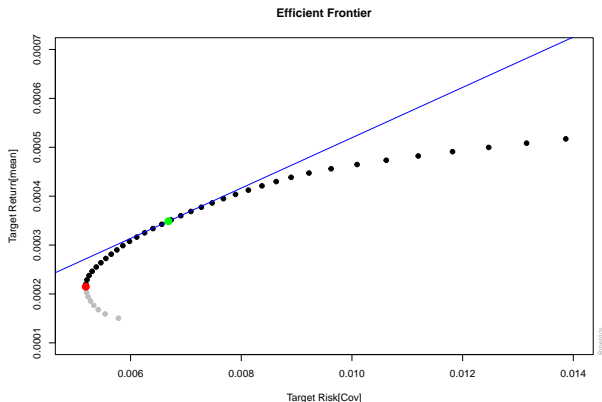
### 3. Segmentation of portfolio inputs

To conduct forward predictions for out-of-sample data of 3 years, we optimised our portfolio weights using the daily returns of each ETF from *1 OCT 2001 to 31 DEC 2018*. Following which, we will evaluate the predicted performance of our ETFs from *1 JAN 2019 to 18 MAR 2022* against the actual returns.

### 3 Efficient Frontier

Using the fPortfolio package, the efficient frontier was plotted.

- The red dot represents the GMVP.
- The green dot represents the maximum sharpe ratio portfolio.



## 4 Portfolio Construction

### Asset class allocation

In the process of optimizing the portfolios, constraints were placed on the weightage of different asset classes to avoid uneven allocation. The constraints were curated for each portfolio with respect to the risk levels of different asset classes.

#### Max allocation in Alternatives:

- All portfolios: 15%

#### Max allocation in Bonds:

- Low risk: 60%
- Medium risk: 50%
- High risk: 40%

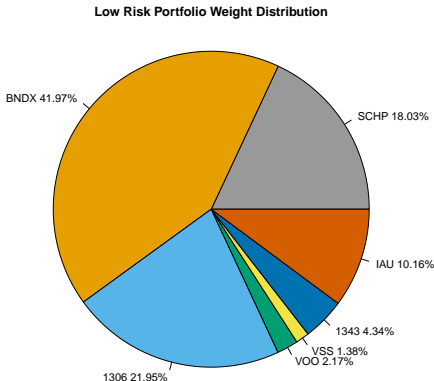
#### Max allocation in Equities:

- Low risk: 40%
- Medium risk: 50%
- High risk: 60%



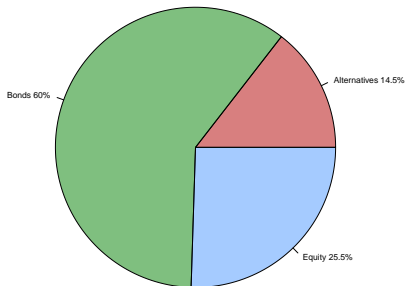
## 4.1.1 Low Risk Portfolio (GMVP) - Weights Distribution

The Global Minimum Variance Portfolio (GMVP) provides a portfolio with minimum risk. This portfolio is catered to investors who are more risk averse and are willing to take lesser risk.



## 4.1.2 Low Risk Portfolio - Breakdown

*Asset Class Allocation*

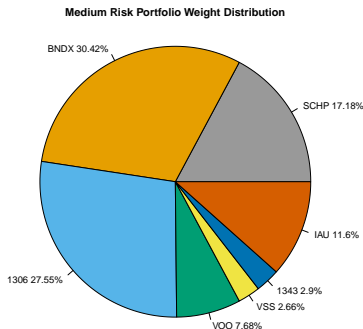


*Geographic Distribution*

Country	Distribution (%)
Japan	33.66
Others	30.88
US	19.96
France	5.00
Germany	4.42
UK	3.07
Canada	3.01

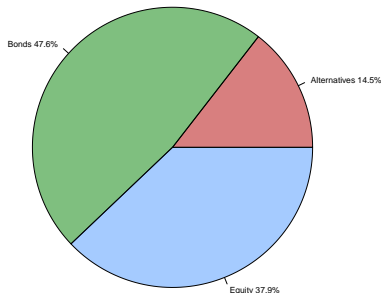
## 4.2.1 Medium Risk Portfolio (Tangency Portfolio) - Weights Distribution

The Medium Risk Portfolio provides a portfolio with medium risk and returns. The maximum Sharpe-Ratio portfolio was chosen because it gives us the highest risk-adjusted returns. This portfolio is catered to investors who are willing to tolerate a moderate amount of risk and are able to withstand moderate changes in their investments.



## 4.2.2 Medium Risk Portfolio - Breakdown

*Asset Class Allocation*

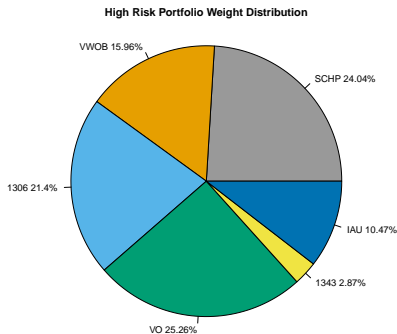


*Geographic Distribution*

Country	Distribution (%)
Others	30.88
Canada	3.01
Japan	33.66
Germany	4.42
UK	3.07
France	5.00
US	19.96

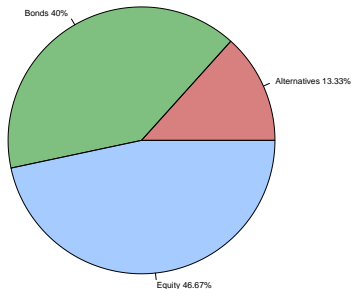
## 4.3.1 High Risk Portfolio - Weights Distribution

The High Risk Portfolio provides a portfolio with high returns. This portfolio is catered to investors who are more risk tolerant and are willing to tolerate a higher amount of risk and in exchange for possible higher returns.



## 4.3.2 High Risk Portfolio - Breakdown

*Asset Class Allocation*



*Geographic Distribution*

Country	Distribution (%)
Japan	33.66
Others	30.88
Germany	4.42
US	19.96
France	5.00

# 5 Back Testing

## 1. Back Testing against benchmark

Firstly, we assessed the performance of our portfolios against the market portfolio by backtesting using historical data from 1 Oct 2001 to 31 Dec 2018.

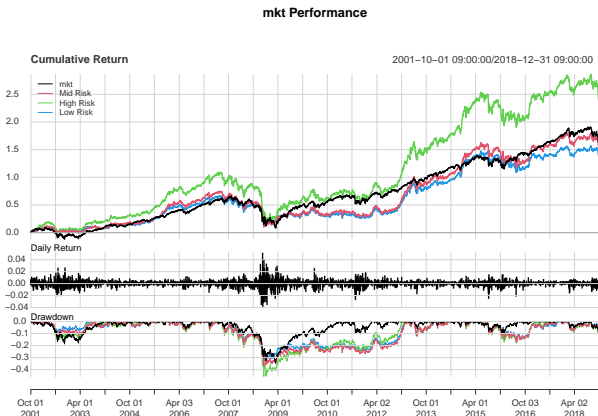
The benchmark is meant to be a market portfolio which captures all assets, even non-tradable ones. To represent the market portfolio, we decided to use *mkt* as a proxy, which uses weights of 60% ACWI and 40% BGA. Hence, we will evaluate the performance of our portfolios against that of *mkt*.

## 2. Forward Predictions

Following that, we generated a forecast for each portfolio, based on the daily mean returns for 3 years from 1 Jan 2019 until 18 March 2022. This allows us to compare the performance of our portfolios out of sample, against the market portfolio and the actual returns of each portfolio.

## 5.1 Back Testing of Portfolio against benchmark

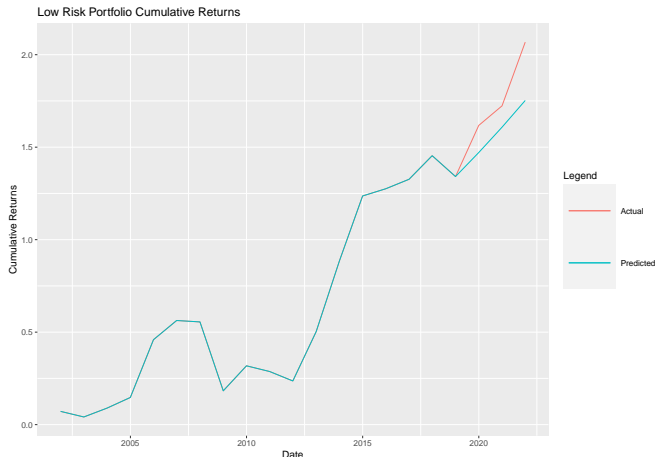
Back testing was executed to examine the performance of our chosen portfolios against the market portfolio using historical data from *1 OCT 2001 to 31 DEC 2018*.





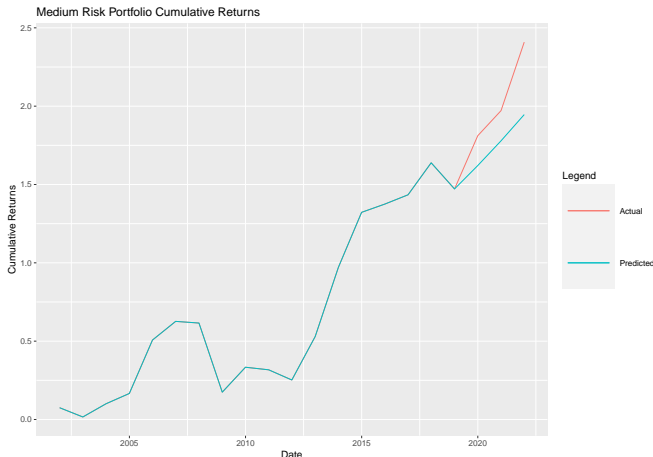
## 5.2.1 Forward Predictions - Low Risk Portfolio

Forward predictions were made to examine the predicted performance of our Low Risk Portfolio against its actual returns using historical data from *1 JAN 2019 to 18 MAR 2022*.



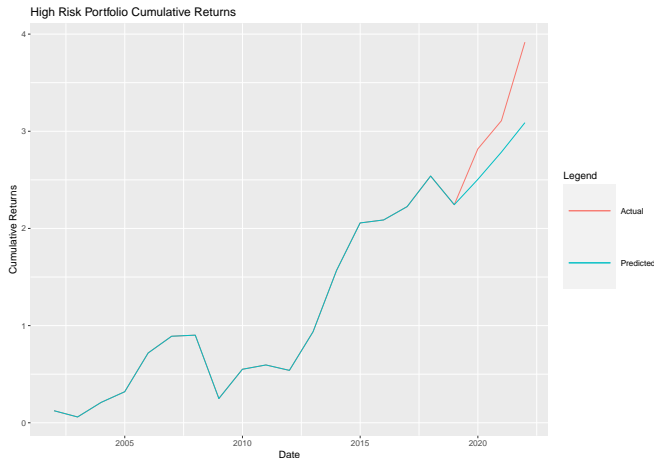
## 5.2.2 Forward Predictions - Medium Risk Portfolio

Forward predictions were made to examine the predicted performance of our Medium Risk Portfolio against its actual returns using historical data from *1 JAN 2019 to 18 MAR 2022*.



## 5.2.3 Forward Predictions - High Risk Portfolio

Forward predictions were made to examine the predicted performance of our High Risk Portfolio against its actual returns using historical data from *1 JAN 2019 to 18 MAR 2022*.



## 6 Summary - Performance of Portfolios

Portfolios	Cumulative Returns - 1Y (%)	Cumulative Returns - 5Y (%)	Cumulative Returns - 10Y (%)
Market	4.9	42.16	83.25
Low Risk	10.71	30.86	86.63
Mid Risk	12.11	36.67	96.03
High Risk	14.12	45.09	111.89

After comparing the performance of our 3 portfolios and the market portfolio with in-sample data from 1 Oct 2001 - 31 Dec 2018 and out-of-sample data from 1 Jan 2019 - 18 March 2022, we believe that the **High Risk Portfolio** would be the **best** choice for risk-tolerant investors who are looking for a long term investment strategy as it yielded the highest cumulative returns over the 10 year investment horizon, beating the market portfolio.

Furthermore, **all portfolios have performed well** out-of-sample as seen in the previous section. The performance of all portfolios have been underestimated by our predicted daily returns as compared to their actual returns. Hence, our portfolios provide a robust estimate of returns, even in out-of-sample timeframes and have outperformed the market portfolio in the long run investment horizon.

## Appendix 1 - CAPM/Excess Returns

	Intercept	Beta	Excess Return
AGG	0.0000720	0.3286105	0.0002403
SCHP	0.0001332	0.2676382	0.0002694
VCSH	0.0000622	0.3319874	0.0002323
BNDX	0.0000788	0.2971475	0.0002306
VWOB	0.0001082	0.7524019	0.0004996
1306	0.0000258	0.9068658	0.0004985
VOO	-0.0001490	2.2846494	0.0010488
VO	-0.0001132	2.4105063	0.0011508
VSS	-0.0000881	1.8756390	0.0008944
VGK	-0.0003002	2.4937665	0.0010076
VWO	-0.0001517	2.6052000	0.0012148
1343	0.0002239	0.5678881	0.0005182
VNQ	-0.0000436	2.3423410	0.0011846
VNQI	-0.0000664	1.6794341	0.0010117
IAU	0.0002885	0.4325583	0.0005115
BCI	-0.0000929	0.9632796	0.0004094

## Appendix 2 - Covariance Matrix I

	AGG	SCHP	VCSH	BNDX	VWOB	1306	VOO	VO
AGG	0.0000345	0.0000307	0.0000309	0.0000304	0.0000370	0.0000148	0.0000498	0.0000507
SCHP	0.0000307	0.0000351	0.0000297	0.0000289	0.0000348	0.0000137	0.0000437	0.0000448
VCSH	0.0000309	0.0000297	0.0000334	0.0000315	0.0000371	0.0000142	0.0000543	0.0000554
BNDX	0.0000304	0.0000289	0.0000315	0.0000332	0.0000361	0.0000105	0.0000538	0.0000545
VWOB	0.0000370	0.0000348	0.0000371	0.0000361	0.0000600	0.0000262	0.0000813	0.0000850
1306	0.0000148	0.0000137	0.0000142	0.0000105	0.0000262	0.0001680	0.0000349	0.0000397
VOO	0.0000498	0.0000437	0.0000543	0.0000538	0.0000813	0.0000349	0.0002257	0.0002321
VO	0.0000507	0.0000448	0.0000554	0.0000545	0.0000850	0.0000397	0.0002321	0.0002521
VSS	0.0000381	0.0000335	0.0000410	0.0000373	0.0000693	0.0000723	0.0001503	0.0001631
VGK	0.0000468	0.0000396	0.0000509	0.0000481	0.0000830	0.0000441	0.0002186	0.0002301
VWO	0.0000546	0.0000476	0.0000582	0.0000563	0.0000958	0.0000551	0.0002360	0.0002506
1343	0.0000088	0.0000076	0.0000098	0.0000051	0.0000182	0.0000757	0.0000196	0.0000244
VNQ	0.0000512	0.0000466	0.0000566	0.0000565	0.0000856	0.0000229	0.0002380	0.0002581
VNQI	0.0000384	0.0000342	0.0000409	0.0000367	0.0000674	0.0000796	0.0001297	0.0001404
IAU	0.0000201	0.0000211	0.0000196	0.0000196	0.0000293	0.0000164	0.0000444	0.0000491
BCI	0.0000339	0.0000341	0.0000363	0.0000350	0.0000530	0.0000320	0.0000958	0.0001050

## Appendix 2 - Covariance Matrix II

	VSS	VGK	VWO	1343	VNQ	VNQI	IAU	BCI
AGG	0.0000381	0.0000468	0.0000546	0.0000088	0.0000512	0.0000384	0.0000201	0.0000339
SCHP	0.0000335	0.0000396	0.0000476	0.0000076	0.0000466	0.0000342	0.0000211	0.0000341
VCSH	0.0000410	0.0000509	0.0000582	0.0000098	0.0000566	0.0000409	0.0000196	0.0000363
BNDX	0.0000373	0.0000481	0.0000563	0.0000051	0.0000565	0.0000367	0.0000196	0.0000350
VWOB	0.0000693	0.0000830	0.0000958	0.0000182	0.0000856	0.0000674	0.0000293	0.0000530
1306	0.0000723	0.0000441	0.0000551	0.0000757	0.0000229	0.0000796	0.0000164	0.0000320
VOO	0.0001503	0.0002186	0.0002360	0.0000196	0.0002380	0.0001297	0.0000444	0.0000958
VO	0.0001631	0.0002301	0.0002506	0.0000244	0.0002581	0.0001404	0.0000491	0.0001050
VSS	0.0001740	0.0001851	0.0001952	0.0000445	0.0001534	0.0001498	0.0000522	0.0000963
VGK	0.0001851	0.0002795	0.0002695	0.0000270	0.0002401	0.0001558	0.0000571	0.0001114
VWO	0.0001952	0.0002695	0.0003519	0.0000309	0.0002665	0.0001722	0.0000727	0.0001286
1343	0.0000445	0.0000270	0.0000309	0.0001682	0.0000183	0.0000672	0.0000165	0.0000201
VNQ	0.0001534	0.0002401	0.0002665	0.0000183	0.0003935	0.0001317	0.0000495	0.0000954
VNQI	0.0001498	0.0001558	0.0001722	0.0000672	0.0001317	0.0001679	0.0000429	0.0000844
IAU	0.0000522	0.0000571	0.0000727	0.0000165	0.0000495	0.0000429	0.0001193	0.0000651
BCI	0.0000963	0.0001114	0.0001286	0.0000201	0.0000954	0.0000844	0.0000651	0.0001471