AG294: Portfolio Theory Management

Group 13 - "10x Robo Advisor"Assignment

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Executive Summary

The following Investment Policy statement explores different strategies of portfolio construction to reach the best risk adjusted return. Amongst the constructed portfolios there are an equal weighted, a market capitalisation weighted, an optimal portfolio and a portfolio with short-selling. The main finding achieved in this report is that the equal weighted portfolio is outperformed by the market-cap weighted one. In turn, both of them are outperformed by the optimal and short-selling portfolio. This could be due to the choice of a geometric index, which does not fit with a static portfolio. Another explanation could be related to the assumption of no estimation error on optimal portfolios' construction. Lastly, this could also be due to the lack of sufficient number of stocks to diversify the portfolio.

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1 Introduction

The objective of this Investment Policy statement is to explore different investment strategies in order identify which gives the best risk adjusted return. The applied methodologies are equal weighting, market capitalisation weighting, optimisation and optimisation with short-selling. The objective is to test whether the conclusions of the financial academic research in regard to these strategies is consistent with the results obtained for our data of the top 15 US stocks on the Dow Jones Industrial Average Total Return (DJIATR) index. This also allows to explore the effect of estimation error on the different strategies. The tools provided by Matlab's Financial Toolbox package and Bloomberg's Terminal were used to conduct the analysis.

In the following sections of the report, first the assumptions and used methods are presented. Then, the key characteristics of the obtained portfolios are summarised. Finally, the concluding results are discussed.

2 Portfolio setup and assumptions

A. Investment Objective

Two portfolios have been constructed to consider the maximization of returns by allowing for the least amount of risk. This is done by examining 15 US stocks over the time horizon from 01/01/2010 to 01/01/2018. An initial outlay of $1,000,000 was assumed for the purposes of this analysis. The first portfolio uses a naïve diversification approach, by investing equally into each stock. In contrast, the second portfolio focuses on an investment strategy which considers the Market Capitalisation weights of each stock, depending on the set benchmark.

B. Data collection

The time series of prices and dividends were extracted from Bloomberg in USD. The risk-free rate was taken from the US 30 Daily Treasury. However, only the final year within the time series was consider (i.e. 2017) for the risk-free rate. Hence, the rate has been determined by the average rate for the last year (0.082%).

C. Investment Constraints

Both portfolios were constructed by selecting the top 15 stocks (by Market Capitalisation) from the chosen benchmark index and by looking at two different scenarios, with and without short selling.

Furthermore, the following constraints were applied:

*Taxation***:** For the purposes of this analysis tax constraints were not considered.

*Benchmark***:** The Dow Jones Industrial Average Total Return Index (DJIATR) was set as a benchmark for these portfolios. The DJIA index itself is a price-weighted index, where the stock's prices influence its performance. It considers the 30 US companies with the highest quality stocks. It is a well-diversified measure that looks at all the industries represented in the US, excluding transport and utilities (S&P Dow Jones Indices, 2018). However, the DJIA index modified for Total Return (DJIATR) was deemed more suitable to allow for the effects of dividends on the stock prices (Plaehn, 2018).

*Dividend Capitalisation***:** All mid prices of the chosen 15 stocks, for the purpose of this analysis, were adjusted for dividends. This was done using the dividends' payable date.

*Market movements***:** Additional scenarios were considered via the Bloomberg Terminal Reports were exported for the market prices moving down by 10% (See Appendix 9.5 and 9.6)

D. Software and analysis methodology

The output for the analysis were generated using the MATLAB Financial Toolbox "Portfolio Object". This object implements mean-variance portfolio optimisation and allows to obtain the estimation of efficient portfolios and efficient frontier. The Markowitz model is used for the portfolio optimisation computations (see Markowitz, 1952, and Markowitz, 1959).

The main ideas in Markowitz (1952 and 1959) is solving the portfolio choice problem by minimising risk for a given level of return and maximising return for a given level of risk.

Those portfolios which satisfy the above-mentioned criteria are defined efficient portfolio. The curve obtained by plotting the risks and returns of the efficient portfolios is called efficient frontier.

E. MATLAB Financial toolbox

The analysis was conducted by importing the timeseries price data, adjusted for the dividends, and calculating its daily returns. This is done by calculating for the discrete return via the formula (MathWorks, 2018):

PriceSeries(i+1)/PriceSeries(i) - 1

The calculated returns are then set as the primary values for the Portfolio object within the toolbox. The daily assets' mean, and covariance are then estimated and annualised. The annualisation is done by taking 260.75 days.

After this, the efficient frontier is estimated with 100 points for the long and Short-selling portfolios (See Appendix 9.10 and 9.11). The optimal portfolios of each frontier have been calculated and plotted by Maximising the Sharpe Ratios.

The final output of Matlab is then plotted on a Figure 1, discussed later in this report. All relevant code and input data is presented in Appendix 9.7 and 9.8.

3 Method

Bloomberg's Terminal's data was used to complete the final steps of this analysis and to interpret the results in the following sections. The portfolio weightings, used in the Matlab analysis were uploaded onto Bloomberg's PRTU function. Bloomberg's PRTU function is a vital tool of investment process analysis to determine the value of the portfolio on a macro to micro portfolio (from sectors to company specific characteristics). These were then used to create a the equal weighted and Market Capitalised portfolio. A Bloomberg custom report was generated for each portfolio according to the chosen time horizon. Each report contains data on holdings, characteristics, variance, performance, attributions and scenarios.

All the relevant reports are presented Appendix 9.2, 9.3, 9.4, 9.5 and 9.6.

4 Justification of each portfolio's approach

Benchmarks are considered fundamental in portfolio management, as they have a strong impact on investment choices, assets allocation, performance measurement and in evaluating the reward of fund managers. Bolognesi, Torluccio and Zuccheri (2012) stresses the significant role of benchmarks in the asset management industry and points out the consequent centrality of the methodology choice in index construction. According to Bailey (1992) and Bolognesi, Torluccio and Zuccheri (2012) the effectiveness of the benchmark's selection is highly determined by the context of use.

Lot of existing literature deals with the comparison of equally weighted portfolios and Market Capitalisation weighted portfolios concluding that naïve portfolios generally provide higher risk-adjusted returns (see for example Bolognesi, Torluccio and Zuccheri, 2012). Considering that the benchmarks used in the asset management industry are usually based on the cap-weighting methodology, this conclusion is of great importance.

The **Market Capitalisation weighted approach** (or Market Cap) uses a company's market price and the number of outstanding shares to determine the percentage weighting of the company's inclusion in the index. The larger the components, the larger the companies will be weighted in the portfolio. Bolognesi, Torluccio and Zuccheri (2012) suggests that this method is largely used in practice because, consistently with the CAPM, the Market Cap portfolio is automatically maximised for the sharpe ratio. This notion is also presented in Sharpe (1964).

Perold (2007) asserts that Capitalisation weighting is associated with a momentum strategy. This, according to Jegadeesh and Titman (1993), is based on the empirical evidence that in the following period stocks with strong past performance will continue to outperform those which performed poorly. This effect benefits the Market Capitalisation weighting methodology, as it is a buy-and-hold investment strategy.

Bolognesi, Torluccio and Zuccheri (2012) criticises Market Cap indices because when basing the stocks' weights on their Market Capitalisation performance, the largest securities are associated with highest weights in the index while the contribution of smaller securities tends to be minimal. Further criticism to the Market Capitalisation weighted porfolios is found in Hauger and Baker (1991), Arnott et al (2005), Clarke et al (2006), Hsu (2006) Choueifaty and Coignard (2008) Chow et al (2011). These authors reject the mean variance efficiency of Market Capitalisation weighted portfolios and argue that they tend to overweight those stocks whose prices are high in relation to their fundamentals and underweight stocks that have low prices.

Alternatively, the **equal weighted approach** (also called *naïve diversification*) distributes the weight evenly throughout the index fund, regardless of Market Cap or size relative to the economy. Put simply, it gives the same weight to each stock in a portfolio. By investing a greater proportion of the portfolio in mid- or small-cap stocks the equally weighting methodology allows for higher diversification of the portfolio compared to the Market Capitalisation weighting one (Bolognesi, Torluccio and Zuccheri, 2012).

Furthermore, Bolognesi, Torluccio and Zuccheri (2012) discusses that the equal weighting methodology is considered to be a rebalancing strategy which is implicitly based on a contrarian strategy. Indeed, according to the authors this methodology tries to generate profits by going against the trend, mechanically rebalancing away from stocks that increase in price, namely selling the stocks which have shown high returns and buying the underperforming stocks.

Arnott et al (2005) states that portfolios constructed by this methodology fail in being representative of the aggregate equity market, and criticises the fact that they identically treat all caps sizes without regard to their market liquidity. A further negative aspect mentioned by Bolognesi, Torluccio and Zuccheri (2012) is that this method induces more transaction costs due to the higher portfolio turnover. However, they also argue that equally weighted portfolios perform better than the Market Capitalisation weighted ones, suggesting that the contrarian effect derived from stocks reweighting is stronger than the momentum effect.

5 Key constituents and characteristics

5.1 Portfolio characteristics

The following tables illustrate the structure of both the Equal Weighted and Market Capitalisation Weighted portfolios. They outline the weight (%), market value ($), position ($) and closing price ($) of each stock within the portfolios.

User Name: MSC STUDENT 8 | Portfolio: GOD EQUAL WEIGHTED | Benchmark: GOD MARKET CAP

Holdings - Main View

	Port					
	#	% Wgt	Mkt Val	Pos	Px Close	Crncy
GOD EQUAL WEIGHTED	15	100.00	3,781,624			
Consumer Discretionary	1	6.67	252,100			
HOME DEPOT INC		6.67	252,100	1,330.13	189.53	USD
Consumer Staples	2	13.33	504,199			
PROCTER & GAMBLE CO/THE		6.67	252,100	2,743.79	91.88	USD
WALMART INC		6.67	252,100	2,552.91	98.75	USD
Energy	2	13.33	504,199			
CHEVRON CORP		6.67	252,100	2,013.74	125.19	USD
EXXON MOBIL CORP		6.67	252,100	3,014.10	83.64	USD
Financials	1	6.67	252,100			
JPMORGAN CHASE & CO		6.67	252,100	2,357.39	106.94	USD
Health Care	3	20.00	756,299			
JOHNSON & JOHNSON		6.67	252,100	1,804.32	139.72	USD
PFIZER INC		6.67	252,100	6,960.23	36.22	USD
UNITEDHEALTH GROUP INC		6.67	252,100	1,143.52	220.46	USD
Industrials	1	6.67	252,100			
BOEING CO/THE		6.67	252,100	854.84	294.91	USD
Information Technology	5	33.34	1,260,627			
APPLE INC		6.67	252,228	1,490.45	169.23	USD
CISCO SYSTEMS INC		6.67	252,100	6,582.24	38.30	USD
INTEL CORP		6.67	252,100	5,461.43	46.16	USD
MICROSOFT CORP		6.67	252,100	2,947.16	85.54	USD
VISA INC-CLASS A SHARES		6.67	252,100	2,211.01	114.02	USD

Table 1 Equal Weighted portfolio allocation (Appendix 9.2)

Table 1 shows that the equal weighted portfolio is represented by stocks in seven different industries: *Information Technology* (33.34%) followed by *Health Care* (20%), *Consumer Staples* (13.33%), *Energy* (13.33%), *Consumer Discretionary* (6.67%), *Financials* (6.67%), and *Industrials* (6.67%). Over the set time horizon this portfolio creates a market value of about $3.8 million.

User Name: MSC STUDENT 8 | Portfolio: GOD MARKET CAP | As-of Date: 1/1/2018

Holdings - Main View

	Port				
	#	% Wgt	Mkt Val	Pos	Px Close
GOD MARKET CAP	15	100.00	4,026,312		
Consumer Discretionary	1	4.44	178,947		
HOME DEPOT INC		4.44	178,947	944.16	189.53
Consumer Staples	2	9.68	389,734		
PROCTER & GAMBLE CO/THE		4.12	166,050	1,807.25	91.88
WALMART INC		5.56	223,684	2,265.15	98.75
Energy	2	10.92	439,710		
CHEVRON CORP		4.28	172,499	1,377.89	125.19
EXXON MOBIL CORP		6.64	267,212	3,194.78	83.64
Financials	1	8.22	330,891		
JPMORGAN CHASE & CO		8.22	330,891	3,094.18	106.94
Health Care	3	16.02	644,855		
JOHNSON & JOHNSON		7.16	288,169	2,062.48	139.72
PFIZER INC		4.36	175,723	4,851.54	36.22
UNITEDHEALTH GROUP INC		4.49	180,962	820.84	220.46
Industrials	1	4.24	170,887		
BOEING CO/THE		4.24	170,887	579.45	294.91
Information Technology	5	46.48	1,871,288		
APPLE INC		17.99	724,253	4,279.69	169.23
CISCO SYSTEMS INC		4.24	170,887	4,461.79	38.30
INTEL CORP		4.50	181,365	3,929.06	46.16
MICROSOFT CORP		14.62	588,833	6,883.72	85.54
VISA INC-CLASS A SHARES		5.12	205,951	1,806.27	114.02

Table 2 Market Cap portfolio allocation (Appendix 9.3)

From Table 2, the market weighted portfolio is similarly constructed, but it shows slight differences in its loadings: *Information Technology* (46.48%), *Health Care* (16.02%) and *Energy* (10.92%), *Consumer Staples* (9.68%), *Financials* (8.22%), *Consumer Discretionary* (4.44%), and *Industrials* (4.24%). This portfolio creates a higher market value over the ten years ($4 million) compared to the equal weighted portfolio. There are several explanations for the Market Capitalisation weighted portfolio performing better in this case and these are explained in detail in the following section.

5.2 Return analysis

Return Summary

Return Summary	
Portfolio Return	278.16
Benchmark Return	302.63
Active Return	-24.47

Table 3 Total annual return summary.(Appendix 9.4)

The return summary above gives the exact figures of the portfolios' performance and clearly shows that the Market Capitalisation weighted portfolio (used as a benchmark) outperforms the naïve one by 24.47% return annually. Therefore, an investment in the Market Cap portfolio is superior to an investment in the equal weighted portfolio, in accordance to the investment's objective, assumptions and constraints.

Market-Cap Portfolio	
Risk	14.18%
Return	17.85%
Equal Portfolio	
Risk	13.41%
Return	16.67%

Table 4 Annualized Risk and Return figures for Market Cap and Equal Portfolio

Table 4 shows that the annualized standard deviations of the equal weighted portfolio and Market Cap weighted portfolio are 13.41% and 14.18% respectively, which indicate higher volatility and therefore higher risk associated with the Market Cap weighted portfolio. For those given risk values, the respective returns are 16.67% for the equal weighted portfolio and 17.85% for the Market Cap portfolio.

Sharpe ratios	
Market Cap Portfolio	1.77
Equal Portfolio	1.20

Table 5 Sharpe ratios

Table 5 illustrates the Sharpe Ratios of the two portfolios: 1.20% for the equal weighted portfolio and 1.77% for the Market Cap portfolio. This indicates that the Market Cap portfolio has a greater trade-off between risk and return and that it is more efficient than the equal weighted portfolio. The Sharpe Ratio is a key indicator to be considered in deciding whether it is worth to bear more risk to generate higher return.

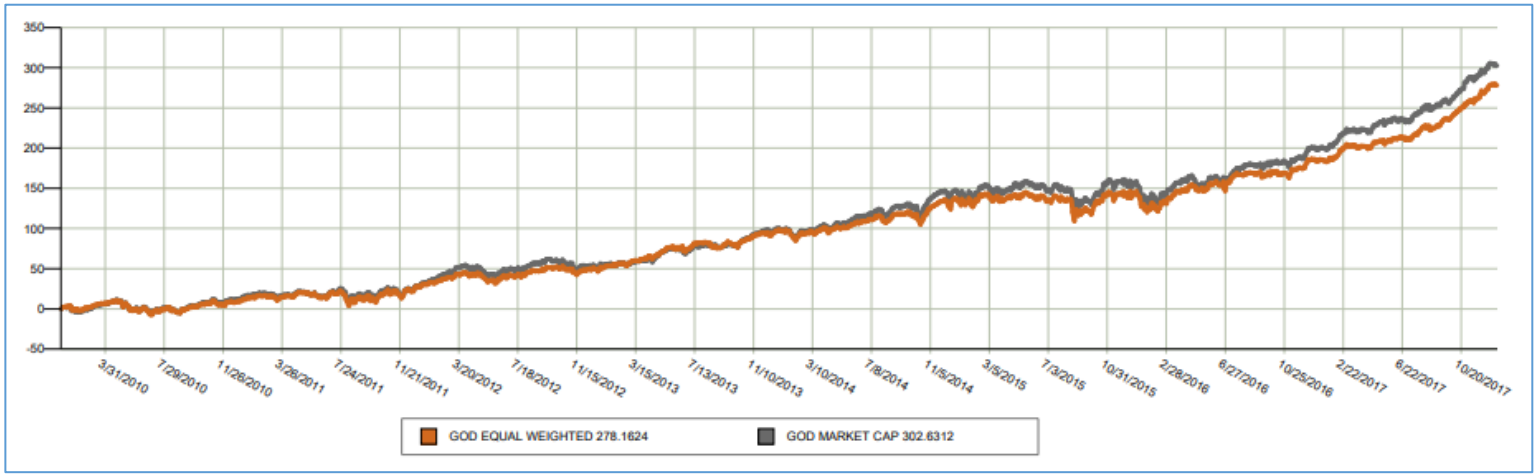


Table 6 Total return (%) of Equal Weighted and Market Capitalisation Portfolio, from 01/01/2010 to 01/01/2018 (Appendix 9.4)

As Table 6 shows, the Market Cap portfolio closely followed the equal weighted portfolio until August 2014, while in the following years it outperforms it to reach a spread of about 25% at the end of the considered period.

5.3 Sectors' analysis

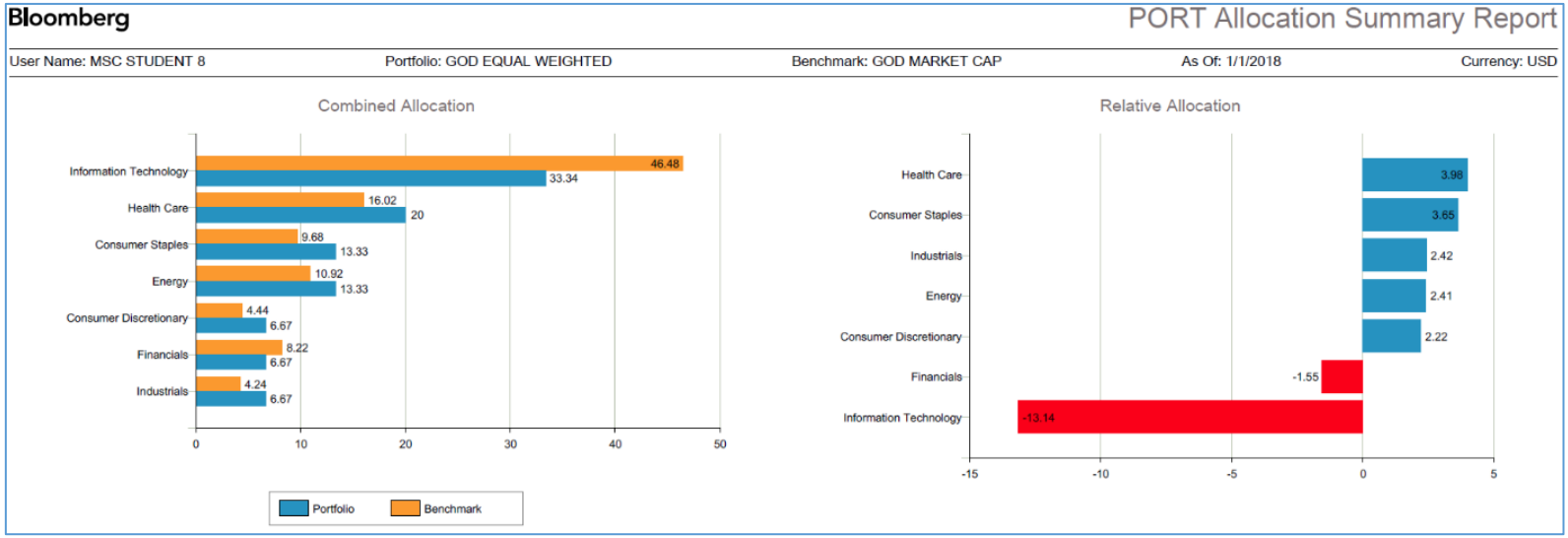


Table 7: Equal Weighted and Market Cap portfolio. Allocation (relative & combined) (Appendix 9.4)

Table 7 presents the data in Table 1 and Table 2 above from a different perspective. It illustrates a comparison of the combined allocation of each sector for both portfolios and their relative allocation.

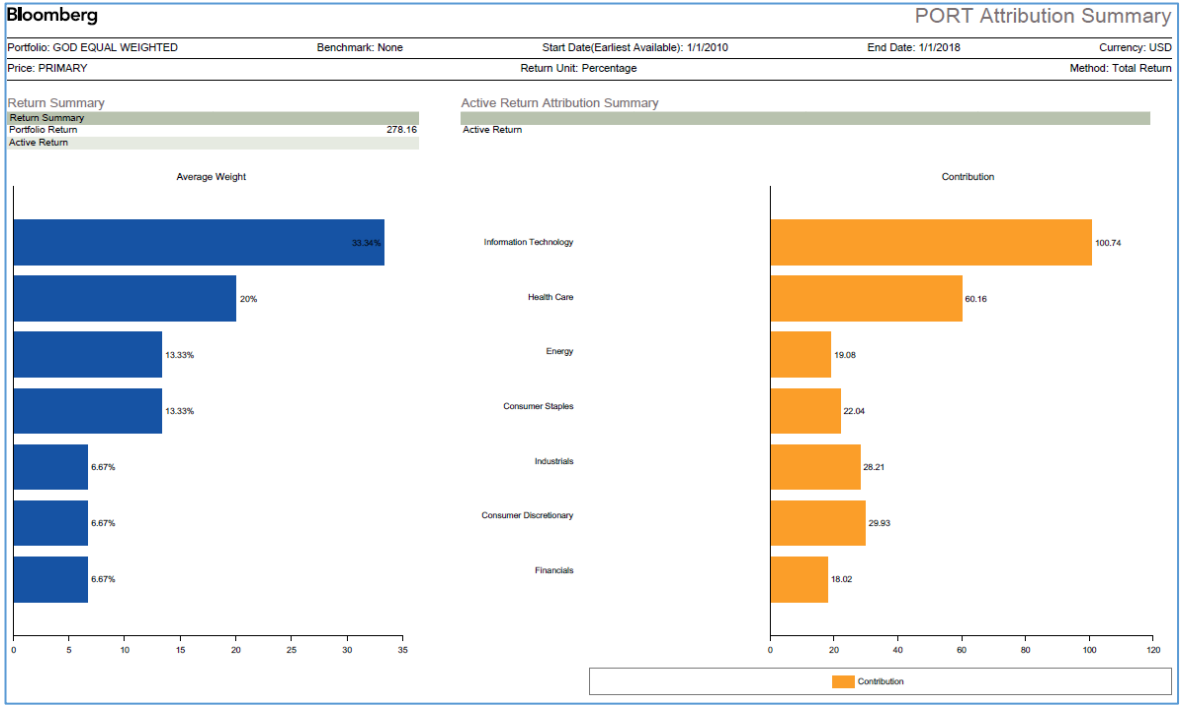


Table 8 Equal weighted portfolio - Attribution summary by sector (Appendix 9.2)

Table 8 shows the average weight per sector and the corresponding stocks' contribution to the total return of the equal weighted portfolio. *Information Technology* (33.34%) and *Health Care* (20%) are the two largest sectors, which contributed the most to the total return (*100.74%* and *60.16%*, respectively). *Energy* (13.33%) and *Consumer Staples* (13.33%) have the same weight, but they offer different contribution to the total return (*19.08%* and *22.04%). Industrials* (6.67%), *Consumer Discretionary* (6.67%) and *Financials* (6.67%), despite being the three smallest sectors in terms of weight, respectively contributed for *28.21%*, *29.93%* and *18.02%* to total return.

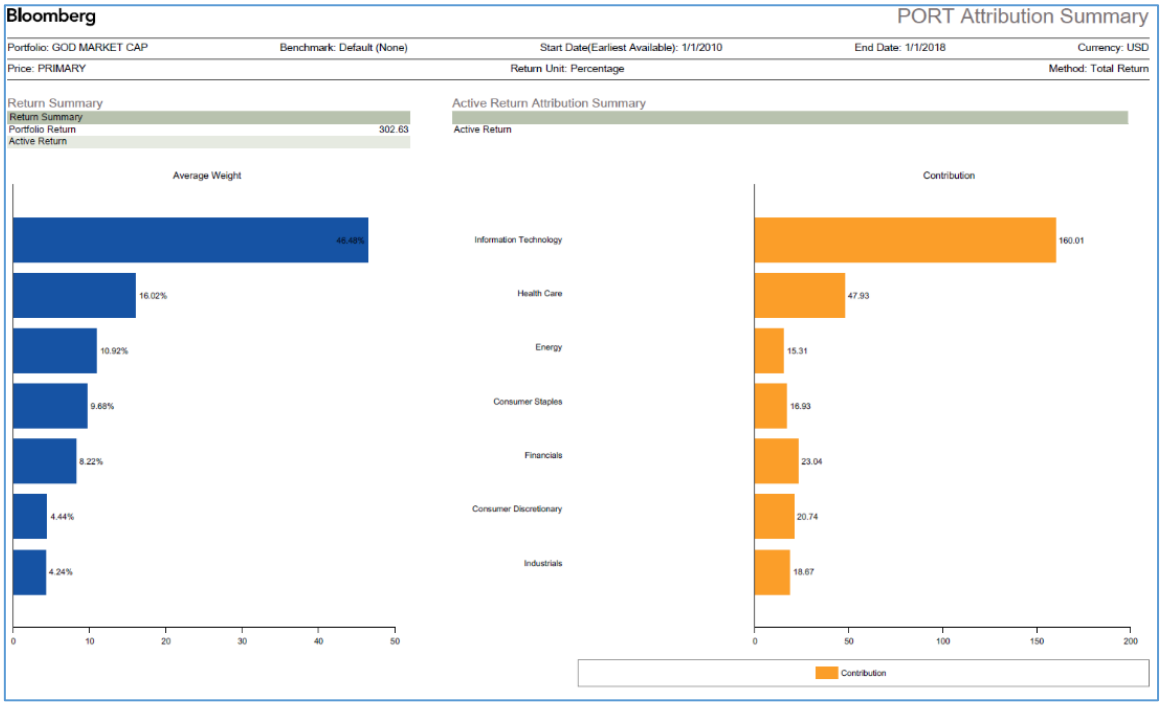


Table 9 Market Cap portfolio - Attribution summary by sector (Appendix 9.3)

Table 9 illustrates the average weight per sector and its contribution to the total return of the Market Cap portfolio. *Information Technology* (46.48%) and *Health Care* (16.02%) are the two largest sectors, which resulted in higher contribution to the total return with *160.01%* and *47.93%* respectively. In terms of weights, *Energy* (10.92%) and *Consumer Staples* (9.68%) stand at third and fourth place respectively, followed by *Financials* (8.22%), *Consumer Discretionary* (4.44%) and *Industrials* (4.24%). In terms of returns *Financials* contribute *23.04%*, *Consumer Discretionary 20.74%, and Industrials 18.67%. Consumer Staples* and *Energy* contribute the least with *16.93%* and *15.31%* respectively.

Bloomberg — PORT Attribution Report

User Name: MSC STUDENT 8 | Portfolio: GOD EQUAL WEIGHTED | Benchmark: GOD MARKET CAP | Start Date(Earliest Available): 1/1/2010 | End Date: 1/1/2018

Currency: USD | Method: Total Return

Attribution - Main View

	% Average Weight			Contribution to Return (%)			Total Return (%)			Total Attribution (Alpha) (%)	Allocation Effect (%)	Selection Effect (%)	Currency Effect (%)
	Port	Bench	+/-	Port	Bench	+/-	Port	Bench	+/-				
GOD EQUAL WEIGHTED	100.00	100.00	0.00	278.16	302.63	-24.47	278.16	302.63	-24.47	-24.47	-11.23	-13.24	0.00
Consumer Discretionary	6.67	4.44	2.22	29.93	20.74	9.19	690.09	690.09	0.00	6.59	6.59	0.00	0.00
HOME DEPOT INC	6.67	4.44	2.22	29.93	20.74	9.19	690.09	690.09	0.00	0.00		0.00	0.00
Consumer Staples	13.33	9.68	3.65	22.04	16.93	5.11	116.40	118.68	-2.28	-8.61	-7.91	-0.71	0.00
PROCTER & GAMBLE CO/THE	6.67	4.12	2.54	9.74	6.27	3.47	95.10	95.10	0.00	-0.41		-0.41	0.00
WALMART INC	6.67	5.56	1.11	12.30	10.66	1.63	126.70	126.70	0.00	-0.30		-0.30	0.00
Energy	13.33	10.92	2.41	19.08	15.31	3.77	87.06	80.21	6.85	-4.99	-7.04	2.05	0.00
CHEVRON CORP	6.67	4.28	2.38	12.16	8.13	4.03	118.44	118.44	0.00	1.25		1.25	0.00
EXXON MOBIL CORP	6.67	6.64	0.03	6.93	7.18	-0.25	55.50	55.50	0.00	0.80		0.80	0.00
Financials	6.67	8.22	-1.55	18.02	23.04	-5.03	209.51	209.51	0.00	0.80	0.80	0.00	0.00
JPMORGAN CHASE & CO	6.67	8.22	-1.55	18.02	23.04	-5.03	209.51	209.51	0.00	0.00		0.00	0.00
Health Care	20.00	16.02	3.98	60.16	47.93	12.23	313.19	290.02	23.17	4.71	0.00	4.72	0.00
JOHNSON & JOHNSON	6.67	7.16	-0.49	14.54	16.23	-1.69	177.55	177.55	0.00	2.86		2.86	0.00
PFIZER INC	6.67	4.36	2.30	14.62	9.97	4.66	168.03	168.03	0.00	-1.56		-1.56	0.00
UNITEDHEALTH GROUP INC	6.67	4.49	2.17	30.99	21.72	9.27	715.30	715.30	0.00	3.43		3.43	0.00
Industrials	6.67	4.24	2.42	28.21	18.67	9.54	567.17	567.17	0.00	5.85	5.85	0.00	0.00
BOEING CO/THE	6.67	4.24	2.42	28.21	18.67	9.54	567.17	567.17	0.00	0.00		0.00	0.00
Information Technology	33.34	46.48	-13.14	100.74	160.01	-59.27	310.21	371.63	-61.42	-28.82	-9.52	-19.30	0.00
APPLE INC	6.67	17.99	-11.32	28.03	77.64	-49.62	526.75	526.75	0.00	-9.85		-9.85	0.00
CISCO SYSTEMS INC	6.67	4.24	2.42	11.42	7.55	3.87	93.60	93.60	0.00	-10.93		-10.93	0.00
INTEL CORP	6.67	4.50	2.16	16.65	11.67	4.98	193.19	193.19	0.00	-5.29		-5.29	0.00
MICROSOFT CORP	6.67	14.62	-7.96	18.84	42.58	-23.74	245.21	245.21	0.00	3.65		3.65	0.00
VISA INC-CLASS A SHARES	6.67	5.12	1.55	25.80	20.57	5.23	453.33	453.33	0.00	3.11		3.11	0.00

Table 10 : Attribution report, comparison between Equal weighted and Market Cap portfolio (Appendix 9.4)

Table 10 shows the average weight of each stock and sector for both Equal weighted and Market Cap portfolios and compares the single contribution to the portfolios' total returns. The *Information Technology* sector is the largest for both portfolios, both in terms of invested amount (*33.34%* in Equal Weighted and *46.48%* in Market Cap) and contribution to the return (*100.74%* for the Equal Weighted and *160.01%* for the Market Cap).

5.4 Securities' analysis

Bloomberg — PORT Allocation Summary Report

User Name: MSC STUDENT 8 | Portfolio: GOD MARKET CAP | Benchmark: | As Of: 1/1/2018 | Currency: USD

Sector	Port
Industrials	4.24
Consumer Discretionary	4.44
Financials	8.22
Consumer Staples	9.68
Energy	10.92
Health Care	16.02
Information Technology	46.48

Top 10 Holdings	Value
APPLE INC	17.99
MICROSOFT CORP	14.62
JPMORGAN CHASE & CO	8.22
JOHNSON & JOHNSON	7.16
EXXON MOBIL CORP	6.64
WALMART INC	5.56
VISA INC-CLASS A SHARES	5.12
INTEL CORP	4.50
UNITEDHEALTH GROUP INC	4.49
HOME DEPOT INC	4.44

Bottom 10 Holdings	Value
PROCTER & GAMBLE CO/THE	4.12
CISCO SYSTEMS INC	4.24
BOEING CO/THE	4.24
CHEVRON CORP	4.28
PFIZER INC	4.36
HOME DEPOT INC	4.44
UNITEDHEALTH GROUP INC	4.49
INTEL CORP	4.50
VISA INC-CLASS A SHARES	5.12
WALMART INC	5.56

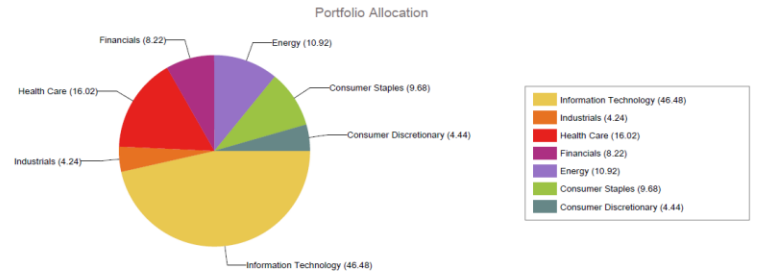
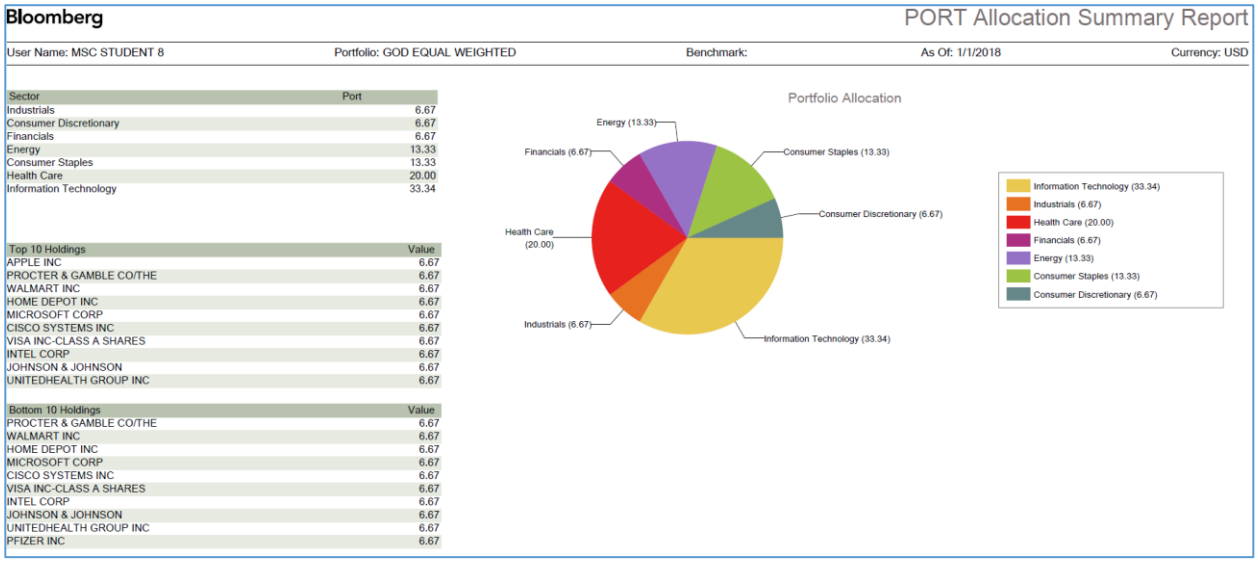


Table 11 Market Cap sector allocation summary (Appenedix 9.3)

The table above (Table 11) presents the information about the value proposition of the top 10 holdings for the Market Cap portfolio. Apple (17.99%) and Microsoft (14.62%) dominate this portfolio, followed by JP Morgan (8.22%), Johnson & Johnson (7.16%), Exxon Mobile (6.64%), Walmart (5.56%) and Visa (5.12%). Intel Corp (4.50%), United Health Group (4.49%) and Home Depot (4.44%) represent the bottom ten holders.



Bloomberg — PORT Allocation Summary Report

User Name: MSC STUDENT 8 | Portfolio: GOD EQUAL WEIGHTED | Benchmark: | As Of: 1/1/2018 | Currency: USD

Sector	Port
Industrials	6.67
Consumer Discretionary	6.67
Financials	6.67
Energy	13.33
Consumer Staples	13.33
Health Care	20.00
Information Technology	33.34

Top 10 Holdings	Value
APPLE INC	6.67
PROCTER & GAMBLE CO/THE	6.67
WALMART INC	6.67
HOME DEPOT INC	6.67
MICROSOFT CORP	6.67
CISCO SYSTEMS INC	6.67
VISA INC-CLASS A SHARES	6.67
INTEL CORP	6.67
JOHNSON & JOHNSON	6.67
UNITEDHEALTH GROUP INC	6.67

Bottom 10 Holdings	Value
PROCTER & GAMBLE CO/THE	6.67
WALMART INC	6.67
HOME DEPOT INC	6.67
MICROSOFT CORP	6.67
CISCO SYSTEMS INC	6.67
VISA INC-CLASS A SHARES	6.67
INTEL CORP	6.67
JOHNSON & JOHNSON	6.67
UNITEDHEALTH GROUP INC	6.67
PFIZER INC	6.67

Table 12 Equal Weighted sector allocation summary (Appendix 9.2)

Table 12 instead, presents the information about the value proposition of the top 10 holdings for the Equal Weighted portfolio. All the holders have the same share as dictated by the equal weighting approach.

Variance-Covariance matrix

	AAPL'	MSFT'	JPM'	JNJ'	XOM'	WMT'	V'	INTC'	UNH'	HD'	PFE'	CVX'	CSCO'	BA'	PG'
AAPL'	0.0643	0.0223	0.0225	0.0100	0.0151	0.0089	0.0201	0.0224	0.0177	0.0171	0.0131	0.0178	0.0226	0.0222	0.0094
MSFT'	0.0223	0.0497	0.0264	0.0123	0.0177	0.0106	0.0207	0.0282	0.0181	0.0177	0.0148	0.0197	0.0261	0.0212	0.0117
JPM'	0.0225	0.0264	0.0671	0.0165	0.0266	0.0123	0.0274	0.0278	0.0256	0.0242	0.0217	0.0297	0.0301	0.0323	0.0132
JNJ'	0.0100	0.0123	0.0165	0.0187	0.0128	0.0082	0.0135	0.0125	0.0130	0.0113	0.0135	0.0135	0.0136	0.0144	0.0096
XOM'	0.0151	0.0177	0.0266	0.0128	0.0329	0.0089	0.0172	0.0190	0.0172	0.0156	0.0156	0.0306	0.0198	0.0211	0.0116
WMT'	0.0089	0.0106	0.0123	0.0082	0.0089	0.0274	0.0097	0.0096	0.0102	0.0124	0.0096	0.0093	0.0118	0.0113	0.0089
V'	0.0201	0.0207	0.0274	0.0135	0.0172	0.0097	0.0563	0.0197	0.0180	0.0195	0.0169	0.0190	0.0215	0.0237	0.0110
INTC'	0.0224	0.0282	0.0278	0.0125	0.0190	0.0096	0.0197	0.0519	0.0170	0.0183	0.0157	0.0210	0.0268	0.0234	0.0111
UNH'	0.0177	0.0181	0.0256	0.0130	0.0172	0.0102	0.0180	0.0170	0.0506	0.0175	0.0176	0.0181	0.0182	0.0215	0.0095
HD'	0.0171	0.0177	0.0242	0.0113	0.0156	0.0124	0.0195	0.0183	0.0175	0.0384	0.0148	0.0173	0.0188	0.0208	0.0104
PFE'	0.0131	0.0148	0.0217	0.0135	0.0156	0.0096	0.0169	0.0157	0.0176	0.0148	0.0325	0.0166	0.0157	0.0177	0.0096
CVX'	0.0178	0.0197	0.0297	0.0135	0.0306	0.0093	0.0190	0.0210	0.0181	0.0173	0.0166	0.0437	0.0218	0.0232	0.0123
CSCO'	0.0226	0.0261	0.0301	0.0136	0.0198	0.0118	0.0215	0.0268	0.0182	0.0188	0.0157	0.0218	0.0631	0.0240	0.0119
BA'	0.0222	0.0212	0.0323	0.0144	0.0211	0.0113	0.0237	0.0234	0.0215	0.0208	0.0177	0.0232	0.0240	0.0549	0.0121
PG'	0.0094	0.0117	0.0132	0.0096	0.0116	0.0089	0.0110	0.0111	0.0095	0.0104	0.0096	0.0123	0.0119	0.0121	0.0194

Correlation Matrix

	AAPL'	MSFT'	JPM'	JNJ'	XOM'	WMT'	V'	INTC'	UNH'	HD'	PFE'	CVX'	CSCO'	BA'	PG'
AAPL'	1	0.3936	0.3430	0.2892	0.3282	0.2112	0.3348	0.3867	0.3096	0.3443	0.2862	0.3349	0.3548	0.3733	0.2663
MSFT'	0.3936	1	0.4569	0.4037	0.4391	0.2883	0.3910	0.5548	0.3614	0.4048	0.3675	0.4223	0.4662	0.4068	0.3773
JPM'	0.3430	0.4569	1	0.4644	0.5657	0.2864	0.4454	0.4708	0.4386	0.4766	0.4652	0.5476	0.4628	0.5327	0.3661
JNJ'	0.2892	0.4037	0.4644	1	0.5164	0.3603	0.4158	0.4023	0.4228	0.4236	0.5457	0.4718	0.3966	0.4509	0.5031
XOM'	0.3282	0.4391	0.5657	0.5164	1	0.2958	0.3996	0.4598	0.4208	0.4389	0.4757	0.8062	0.4348	0.4961	0.4592
WMT'	0.2112	0.2883	0.2864	0.3603	0.2958	1	0.2459	0.2548	0.2749	0.3834	0.3207	0.2696	0.2833	0.2904	0.3847
V'	0.3348	0.3910	0.4454	0.4158	0.3996	0.2459	1	0.3650	0.3365	0.4197	0.3952	0.3834	0.3616	0.4261	0.3314
INTC'	0.3867	0.5548	0.4708	0.4023	0.4598	0.2548	0.3650	1	0.3325	0.4091	0.3823	0.4400	0.4678	0.4392	0.3486
UNH'	0.3096	0.3614	0.4386	0.4228	0.4208	0.2749	0.3365	0.3325	1	0.3967	0.4347	0.3848	0.3230	0.4076	0.3025
HD'	0.3443	0.4048	0.4766	0.4236	0.4389	0.3834	0.4197	0.4091	0.3967	1	0.4187	0.4226	0.3818	0.4540	0.3802
PFE'	0.2862	0.3675	0.4652	0.5457	0.4757	0.3207	0.3952	0.3823	0.4347	0.4187	1	0.4413	0.3465	0.4197	0.3821
CVX'	0.3349	0.4223	0.5476	0.4718	0.8062	0.2696	0.3834	0.4400	0.3848	0.4226	0.4413	1	0.4150	0.4740	0.4212
CSCO'	0.3548	0.4662	0.4628	0.3966	0.4348	0.2833	0.3616	0.4678	0.3230	0.3818	0.3465	0.4150	1	0.4077	0.3387
BA'	0.3733	0.4068	0.5327	0.4509	0.4961	0.2904	0.4261	0.4392	0.4076	0.4540	0.4197	0.4740	0.4077	1	0.3709
PG'	0.2663	0.3773	0.3661	0.5031	0.4592	0.3847	0.3314	0.3486	0.3025	0.3802	0.3821	0.4212	0.3387	0.3709	1

Table 13 Variance-Covariance and Correlation matrices

According to the correlation matrix (Table 13), all the stocks returns are positively correlated. Only two securities show strong positive correlations, namely CVX and XOM, whose correlation is 0.8062. On the other hand, the rest of the securities show weak positive correlation (between 0.2 and 0.4), suggesting limited

5.5 Analysis by sector characteristics

Characteristics	Port	Bench	+\-
Wgt	100.00	100.00	0.00
Equity	**Port**	**Bench**	**+\-**
Dividend Yield	2.29	2.13	0.16
Price to Earnings Ratio (P/E)	21.67	21.25	0.42
Price to Cash Flow Ratio (P/CF)	14.26	14.46	-0.19
Price to Book Ratio (P/B)	3.71	3.91	-0.20
Total Debt to Common Equity	88.06	101.18	-13.12
Current Ratio	1.28	1.38	-0.10

Table 14 Characteristics summary report (Appendix 9.4)

The Market Cap portfolio is characterised by higher Price to Cash Flow Ratio (P/CF), Price to Book Ratio (P/B), Debt to Equity and Current Ratio compared to the Equal Weighted portfolio. However, the equal weighted portfolio has a higher Dividend Yield and Price to Earnings Ratio (P/E). According to the differences in the ratio figures presented in Table 14, a possible explanation for the Market Cap outperforming the Equal Weighted portfolio is that the market prefers companies with higher cash flows and valuable assets. This means that, in case of default, the company would have enough resources to pay out investors.

A further possible explanation for this outperformance is that the Market Cap portfolio seeks companies with a higher Debt to Equity ratio. This means that market portfolio is drawn to companies which use debt as a leveraging tool to boost their growth. Moreover, the Current Ratio of the Market Cap portfolio indicates the companies' ability to write off their debt through liquid assets.

Although the PE ratio is a good indicator of level of profitability within a company, it is not a decisive figure, if not taken together with the analysis of other ratios. Thus, a higher value in the equal portfolio does not directly suggests its superiority.

	Wgt			Dividend Yield			Price to Earnings Ratio (P/E)			Price to Cash Flow Ratio (P/CF)		
	Port	Bench	+/-	Port	Bench	+/-	Port	Bench	+/-	Port	Bench	+/-
GOD EQUAL WEIGHTED	100.00	100.00	0.00	2.29	2.13	0.16	21.67	21.25	0.42	14.26	14.46	-0.19
Consumer Discretionary	6.67	4.44	2.22	1.88	1.88	0.00	26.32	26.32	0.00	19.44	19.44	0.00
HOME DEPOT INC	6.67	4.44	2.22	1.88	1.88	0.00	26.32	26.32	0.00	19.44	19.44	0.00
Consumer Staples	13.33	9.68	3.65	2.52	2.46	0.07	22.92	22.86	0.06	13.07	12.58	0.49
PROCTER & GAMBLE CO/THE	6.67	4.12	2.54	2.98	2.98	0.00	23.31	23.31	0.00	17.78	17.78	0.00
WALMART INC	6.67	5.56	1.11	2.07	2.07	0.00	22.55	22.55	0.00	10.34	10.34	0.00
Energy	13.33	10.92	2.41	3.55	3.58	-0.02	30.07	28.38	1.68	12.35	12.22	0.13
CHEVRON CORP	6.67	4.28	2.38	3.45	3.45	0.00	41.49	41.49	0.00	12.97	12.97	0.00
EXXON MOBIL CORP	6.67	6.64	0.03	3.66	3.66	0.00	23.58	23.58	0.00	11.78	11.78	0.00
Financials	6.67	8.22	-1.55	1.91	1.91	0.00	15.25	15.25	0.00	16.60	16.60	0.00
JPMORGAN CHASE & CO	6.67	8.22	-1.55	1.91	1.91	0.00	15.25	15.25	0.00	16.60	16.60	0.00
Health Care	20.00	16.02	3.98	2.40	2.39	0.01	20.96	21.12	-0.15	15.09	15.47	-0.37
JOHNSON & JOHNSON	6.67	7.16	-0.49	2.38	2.38	0.00	21.72	21.72	0.00	17.55	17.55	0.00
PFIZER INC	6.67	4.36	2.30	3.53	3.53	0.00	17.75	17.75	0.00	13.85	13.85	0.00
UNITEDHEALTH GROUP INC	6.67	4.49	2.17	1.30	1.30	0.00	24.56	24.56	0.00	14.38	14.38	0.00
Industrials	6.67	4.24	2.42	1.93	1.93	0.00	26.05	26.05	0.00	13.43	13.43	0.00
BOEING CO/THE	6.67	4.24	2.42	1.93	1.93	0.00	26.05	26.05	0.00	13.43	13.43	0.00
Information Technology	33.34	46.48	-13.14	1.84	1.71	0.13	19.73	20.49	-0.76	14.21	14.62	-0.41
APPLE INC	6.67	17.99	-11.32	1.45	1.45	0.00	18.58	18.58	0.00	13.89	13.89	0.00
CISCO SYSTEMS INC	6.67	4.24	2.42	2.95	2.95	0.00	18.43	18.43	0.00	13.45	13.45	0.00
INTEL CORP	6.67	4.50	2.16	2.33	2.33	0.00	13.16	13.16	0.00	9.45	9.45	0.00
MICROSOFT CORP	6.67	14.62	-7.96	1.86	1.86	0.00	25.51	25.51	0.00	16.35	16.35	0.00
VISA INC-CLASS A SHARES	6.67	5.12	1.55	0.61	0.61	0.00	33.19	33.19	0.00	26.02	26.02	0.00

Table 16 Portfolio Characteristic Report - Equal Weighted & Market Cap (Appendix 9.4)

	Price to Book Ratio (P/B)			Total Debt to Common Equity			Current Ratio		
	Port	Bench	+/-	Port	Bench	+/-	Port	Bench	+/-
GOD EQUAL WEIGHTED	3.71	3.91	-0.20	88.06	101.18	-13.12	1.28	1.38	-0.10
Consumer Discretionary	87.05	87.05	0.00	1,006.25	1,006.25	0.00	1.23	1.23	0.00
HOME DEPOT INC	87.05	87.05	0.00	1,006.25	1,006.25	0.00	1.23	1.23	0.00
Consumer Staples	4.08	4.04	0.04	61.52	61.25	0.28	0.85	0.84	0.01
PROCTER & GAMBLE CO/THE	4.33	4.33	0.00	63.56	63.56	0.00	0.91	0.91	0.00
WALMART INC	3.85	3.85	0.00	59.76	59.76	0.00	0.81	0.81	0.00
Energy	1.77	1.80	-0.04	25.76	25.07	0.69	0.94	0.92	0.02
CHEVRON CORP	1.62	1.62	0.00	28.61	28.61	0.00	1.04	1.04	0.00
EXXON MOBIL CORP	1.94	1.94	0.00	22.28	22.28	0.00	0.85	0.85	0.00
Financials	1.60	1.60	0.00	270.95	270.95	0.00			
JPMORGAN CHASE & CO	1.60	1.60	0.00	270.95	270.95	0.00			0.00
Health Care	4.34	4.46	-0.11	62.89	60.55	2.34	1.00	1.03	-0.03
JOHNSON & JOHNSON	5.07	5.07	0.00	47.54	47.54	0.00	1.32	1.32	0.00
PFIZER INC	3.55	3.55	0.00	72.35	72.35	0.00	1.43	1.43	0.00
UNITEDHEALTH GROUP INC	4.72	4.72	0.00	64.60	64.60	0.00	0.70	0.70	0.00
Industrials	162.21	162.21	0.00	991.53	991.53	0.00	1.18	1.18	0.00
BOEING CO/THE	162.21	162.21	0.00	991.53	991.53	0.00	1.18	1.18	0.00
Information Technology	4.62	5.59	-0.97	62.43	73.97	-11.54	2.20	2.03	0.16
APPLE INC	6.47	6.47	0.00	86.30	86.30	0.00	1.28	1.28	0.00
CISCO SYSTEMS INC	2.89	2.89	0.00	54.80	54.80	0.00	2.87	2.87	0.00
INTEL CORP	3.01	3.01	0.00	44.06	44.06	0.00	1.60	1.60	0.00
MICROSOFT CORP	7.37	7.37	0.00	95.35	95.35	0.00	3.12	3.12	0.00
VISA INC-CLASS A SHARES	8.69	8.69	0.00	67.44	67.44	0.00	1.90	1.90	0.00

Table 15 Portfolio Characteristic Report - Equal Weighted & Market Cap (Continued) (Appendix 9.4)

In order to identify why the Market Cap portfolio is characterised by the higher ratios as mentioned above, we analyse how the sectors and companies impact these ratios. The Information Technology sector contributes the most to the price to cash flow and price to book value through Visa (8.69%), Microsoft (7.37%) and Apple (6.47%). The second highest contribution is the Health Care sector with J&J (5.07%). With regards to the Debt to Equity ratio, the Information Technology is the most contributing with Microsoft (95.35%), Apple (86.30%) and Visa (67.44%). On the other hand, Microsoft (3.12%), Cisco (2.87%) and Intel (1.60%) contribute the most to the current ratio figure.

5.6 Scenarios

In order to examine the general performance of the portfolios, we performed a simulation of a possible 10% fall in terms of the equities' prices.

User Name: MSC STUDENT 8	Portfolio: GOD EQUAL WEIGHTED		As-of Date: 1/1/2018			Currency: USD
Detail						
	(Equities down 10%)	(Equities down 10%)	(Equities down 10%)			
GOD EQUAL WEIGHTED	-343,025.25	-9.07	3,438,599.25	3,781,624		100.00
Consumer Discretionary	-14,801.71	-5.87	237,298.00	252,100		6.67
HOME DEPOT INC	-14,801.71	-5.87	237,298.00	252,100	1,330.13	6.67
Consumer Staples	-17,326.64	-3.44	486,872.75	504,199		13.33
PROCTER & GAMBLE CO/THE	-6,407.88	-2.54	245,691.81	252,100	2,743.79	6.67
WALMART INC	-10,918.76	-4.33	241,180.94	252,100	2,552.91	6.67
Energy	-79,504.78	-15.77	424,694.62	504,199		13.33
CHEVRON CORP	-40,611.35	-16.11	211,488.36	252,100	2,013.74	6.67
EXXON MOBIL CORP	-38,893.44	-15.43	213,206.27	252,100	3,014.10	6.67
Financials	-33,312.88	-13.21	218,786.83	252,100		6.67
JPMORGAN CHASE & CO	-33,312.88	-13.21	218,786.83	252,100	2,357.39	6.67
Health Care	-39,936.70	-5.28	716,362.44	756,299		20.00
JOHNSON & JOHNSON	-9,553.98	-3.79	242,545.72	252,100	1,804.32	6.67
PFIZER INC	-11,281.53	-4.48	240,818.17	252,100	6,960.23	6.67
UNITEDHEALTH GROUP INC	-19,101.18	-7.58	232,998.53	252,100	1,143.52	6.67
Industrials	-24,463.33	-9.70	227,636.38	252,100		6.67
BOEING CO/THE	-24,463.33	-9.70	227,636.38	252,100	854.84	6.67
Information Technology	-133,679.22	-10.60	1,126,947.88	1,260,627		33.34
APPLE INC	-24,900.43	-9.87	227,327.86	252,228	1,490.45	6.67
CISCO SYSTEMS INC	-23,903.71	-9.48	228,195.98	252,100	6,582.24	6.67
INTEL CORP	-35,858.15	-14.22	216,241.55	252,100	5,461.43	6.67
MICROSOFT CORP	-25,738.69	-10.21	226,361.02	252,100	2,947.16	6.67
VISA INC-CLASS A SHARES	-23,278.24	-9.23	228,821.47	252,100	2,211.01	6.67

Table 17 Scenario 1 - Equal Weighted Portfolio 10% fall (Appendix 9.5)

Table17 illustrates the fall of 10% in terms of the equities' prices. The total loss amounts to about $343,000. The most affected sectors are *Energy (-15.77%), Financials (-13.21%)* and *Information Technology (-10.60%).*

User Name: MSC STUDENT 8	Portfolio: GOD MARKET CAP		As-of Date: 1/1/2018			Currency: USD
Detail						
	(Equities down 10%)	(Equities down 10%)	(Equities down 10%)			
GOD MARKET CAP	-378,866.22	-9.41	3,647,445.75	4,026,312		100.00
Consumer Discretionary	-10,506.65	-5.87	168,440.55	178,947		4.44
HOME DEPOT INC	-10,506.65	-5.87	168,440.55	178,947	944.16	4.44
Consumer Staples	-13,908.71	-3.57	375,825.41	389,734		9.68
PROCTER & GAMBLE CO/THE	-4,220.67	-2.54	161,829.44	166,050	1,807.25	4.12
WALMART INC	-9,688.04	-4.33	213,995.98	223,684	2,265.15	5.56
Energy	-69,013.11	-15.70	370,697.25	439,710		10.92
CHEVRON CORP	-27,788.22	-16.11	144,710.44	172,499	1,377.89	4.28
EXXON MOBIL CORP	-41,224.89	-15.43	225,986.83	267,212	3,194.78	6.64
Financials	-43,724.50	-13.21	287,166.62	330,891		8.22
JPMORGAN CHASE & CO	-43,724.50	-13.21	287,166.62	330,891	3,094.18	8.22
Health Care	-32,495.82	-5.04	612,359.00	644,855		16.02
JOHNSON & JOHNSON	-10,920.94	-3.79	277,248.56	288,169	2,062.48	7.16
PFIZER INC	-7,863.65	-4.48	167,859.28	175,723	4,851.54	4.36
UNITEDHEALTH GROUP INC	-13,711.22	-7.58	167,251.16	180,962	820.84	4.49
Industrials	-16,582.54	-9.70	154,303.97	170,887		4.24
BOEING CO/THE	-16,582.54	-9.70	154,303.97	170,887	579.45	4.24
Information Technology	-192,634.92	-10.29	1,678,653.12	1,871,288		46.48
APPLE INC	-71,499.51	-9.87	652,753.06	724,253	4,279.69	17.99
CISCO SYSTEMS INC	-16,203.20	-9.48	154,683.31	170,887	4,461.79	4.24
INTEL CORP	-25,797.05	-14.22	155,568.36	181,365	3,929.06	4.50
MICROSOFT CORP	-60,118.23	-10.21	528,714.81	588,833	6,883.72	14.62
VISA INC-CLASS A SHARES	-19,016.94	-9.23	186,933.56	205,951	1,806.27	5.12

Table 18 Scenario 2 - Market Capitalisation Portfolio 10% fall (Appendix 9.6)

Table 18 illustrates the fall of 10% in terms of equities' prices. The total loss amounts to about $378,000. The most affected sectors are *Energy (-15.70%), Financials (-13.21%)* and *Information Technology (-10.29%).*

6 Comparison and Discussion

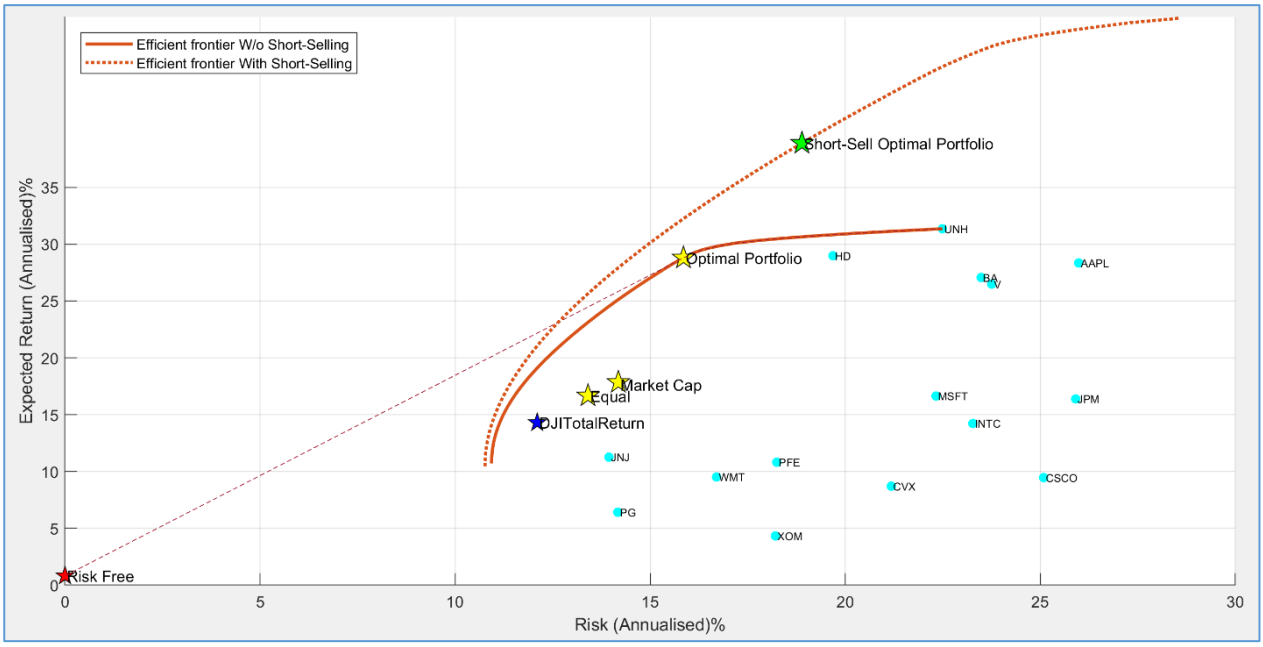


Figure 1 Efficient frontiers' and portfolios' graphical representation

The above figure (Figure 1) shows the graphical representation of all four portfolios: Market Cap, Equal Weighted, Optimal Portfolio and the Optimal Portfolio with Short-Selling, and where they are located compared to the index portfolio (DJIA Total Return). The graph suggests that the Market Cap portfolio outperforms both the Equal Weighted one and the benchmark portfolio of all 30 stocks on the index. However, neither of these portfolios outperforms, the suggested optimal portfolio, with the maximum Sharpe ratio. Furthermore, the graph implies that by implementing short-selling with a constraint of 10%, Short-Selling outperforms all the other aforementioned portfolios. The efficient frontier with short-selling is also significantly higher. This reflects the higher amount of portfolio options on the frontier itself.

The following sections compare the different portfolios and attempt to provide an explanation for the observed results.

6.1 Market Cap vs Equal weighted portfolio

The risk and return figures for each portfolio are displayed in the table below:

Optimal Portfolio	*Risk*	*15.85%*
	Return	28.79%
Market-Cap Portfolio	Risk	14.18%
	Return	17.85%
Equal Portfolio	Risk	13.41%
	Return	16.67%
DJIA Portfolio (Benchmark)	Risk	12.10%
	Return	14.30%
Short-Sell Optimal Portfolio	Risk	18.89%
	Return	38.89%

Table 19 Risk and Return for each portfolio

The above table (Table 19), alongside the corresponding representation in Table1 and Table 2 portfolio outperforms the Equal Weighted one in this case. This contradicts the previously introduced literature investigating the portfolio performance of the two methodologies (See page 7) and the studies performed by DeMiguel, Garlappi and Uppal (2009), who suggest that the gain from the optimal diversification is more than offset by estimation error.

Equal weighted portfolio

Ticker	**Weights%**
AAPL	6.67
MSFT	6.67
JPM	6.67
JNJ	6.67
XOM	6.67
WMT	6.67
V	6.67
INTC	6.67
UNH	6.67
HD	6.67
PFE	6.67
CVX	6.67
CSCO	6.67
BA	6.67
PG	6.67

Table 20 Equal Weighted Portfolio Weights

Market Cap portfolio

Ticker	**Weights%**
AAPL	17.97
MSFT	14.61
JPM	8.21
JNJ	7.15
XOM	6.63
WMT	5.55
V	5.11
INTC	4.50
UNH	4.49
HD	4.44
PFE	4.36
CVX	4.34
CSCO	4.28
BA	4.24
PG	4.12

Table 21 Market Cap Portfolio Weights

The Market Cap portfolio is dominated by Apple and Microsoft with a share of 17.97% and 14.61% respectively. These two stocks account for almost one-third of the portfolio's distribution. From Appendix 9.3, it is evident that these two stocks are also main contributors to the portfolio's return (AAPL: 77.64%, MSFT: 42.58%). Appendix 9.1 discloses the companies' specific features of these two stocks. For example, Apple and Microsoft show the highest leverage, compared to the other companies in the portfolio. Apple has a significant amount of its assets invested in long term investment and receivables (51.9%), whereas Microsoft keeps most of its assets (53.2%) in highly liquid cash deposits or short-term investments. These characteristics could deem these two companies attractive to investors who seek businesses with a strong balance sheet. The accumulated assets could be a signal of the companies' intent to invest in future projects, which could influence their future growth.

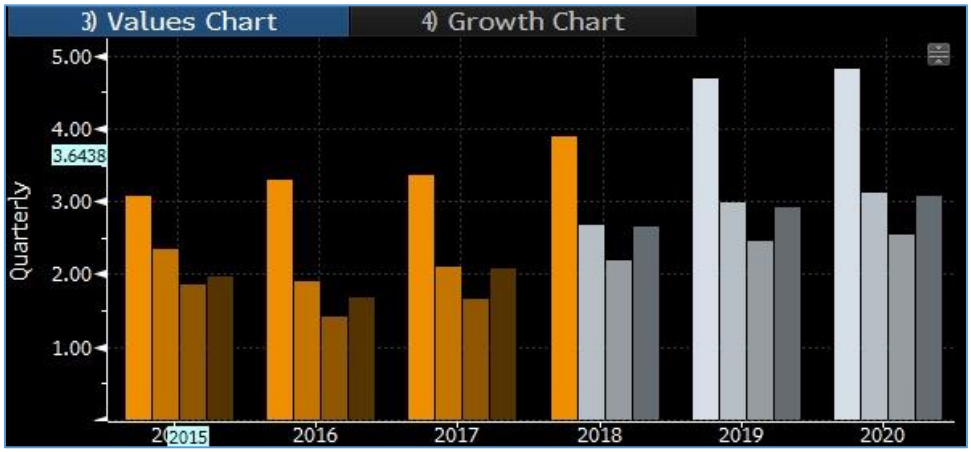


Figure 2 AAPL US EPS Growth rate

Figure 3 MSFT US EPS Growth rate

Additionally, Apple has shown a five-year growth rate of 9.55% and Microsoft of 4.49%. Moreover, both their EPS values are expected to increase over the coming 3 years (Figure 2 and Figure 3).

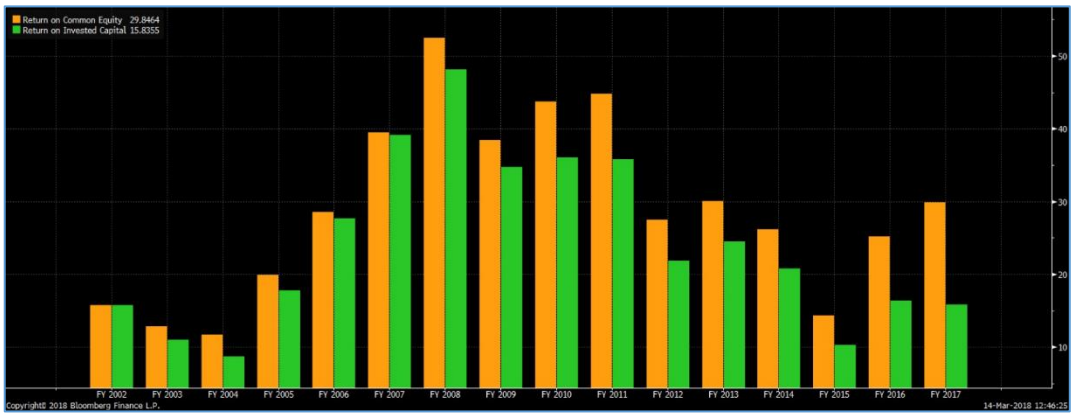


Figure 4 MSFT US ROE & ROI

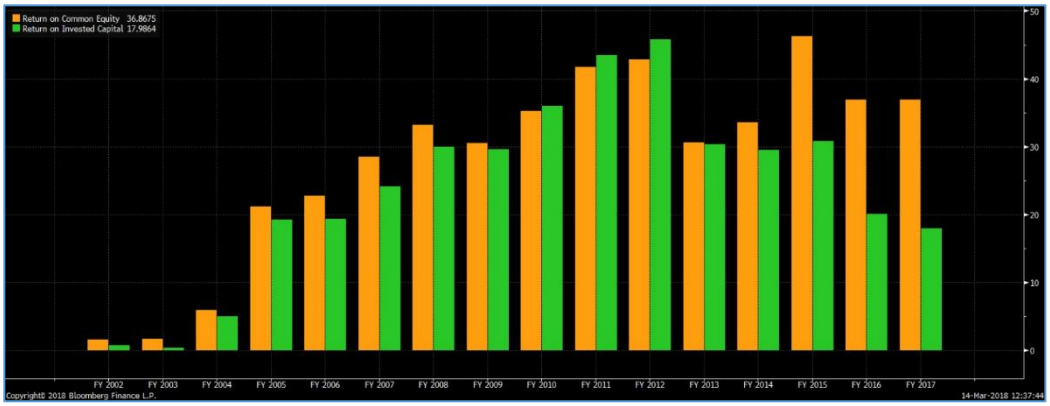


Figure 5 AAPLE US ROE & ROI

The Return on equity (ROE) and Return on investment (ROI) ratios (Figure 4 and Figure 5) of the companies could provide a good picture of the revenue strategies of the companies. The following figures reveal that Apple historically relied upon both investment (green) and equity (orange) to fund its projects while in the past four years it has shifted towards relying on its equity only. Microsoft on the other hand has mostly relied on its equity (orange) to fund projects and investment (green). These observations are consistent with the companies' debt/equity ratio being lower than 50%.

A further Apple stocks' appealing feature recognised by investors is that dividend pay-outs have been continuously growing since their introduction in 2012 (Healy, 2018).

6.2 Optimal vs Market Cap portfolio

Although the Market Cap portfolio outperforms the one obtained with the equal weighted approach, it is itself not located on the efficient frontier (Figure 1). The optimal portfolio, which maximizes returns while offering the lowest level of risk, outperforms the Market Cap portfolio. The reason for this is may be identified in the fact that the optimal portfolio only includes 6 out of the 15 selected stocks. Table 22 shows the composition of this portfolio.

Optimal Portfolio Weights %	
AAPL	14.1484
V	10.8620
INTC	2.8121
UNH	29.8089
HD	36.0357
BA	6.3329

Table 22 Optimal portfolio Weights

As Table 22 shows, the optimal portfolio heavily invests in HD's and UNH's stocks. From Appendix 9.1, it is striking to see that HD has a leverage ratio of nearly 61%. This suggests that it heavily relies on debt to finance its operations and create value.

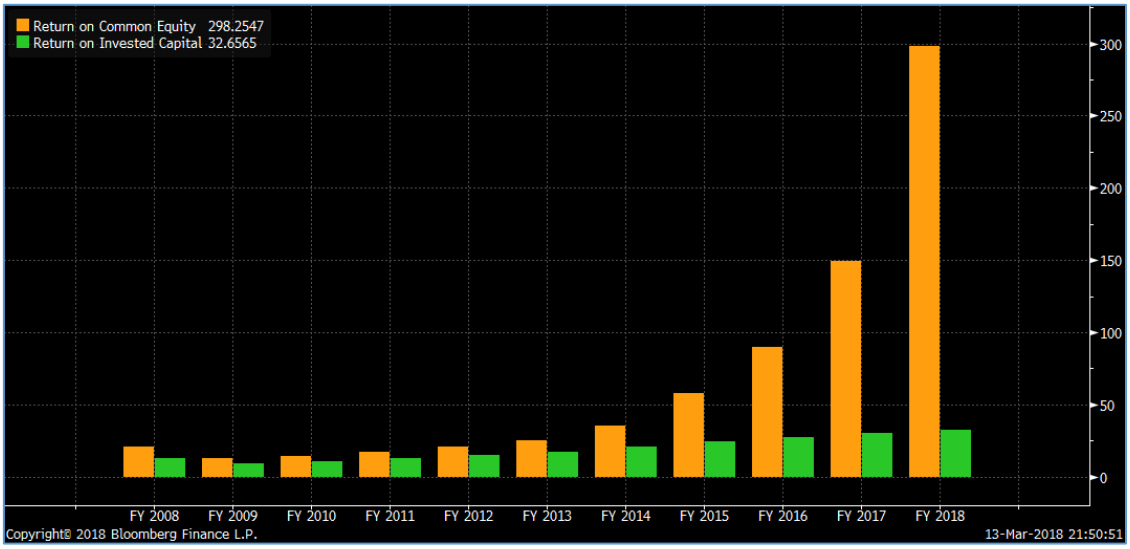


Figure 6 HD US Equity: ROE and ROI ratios

Yet, despite this, HD has a high return on equity (ROE) ratio that has reached a peak between 2016 and 2018 (Figure 6).). Furthermore, its retained earnings represent about 83% of its balance sheet.

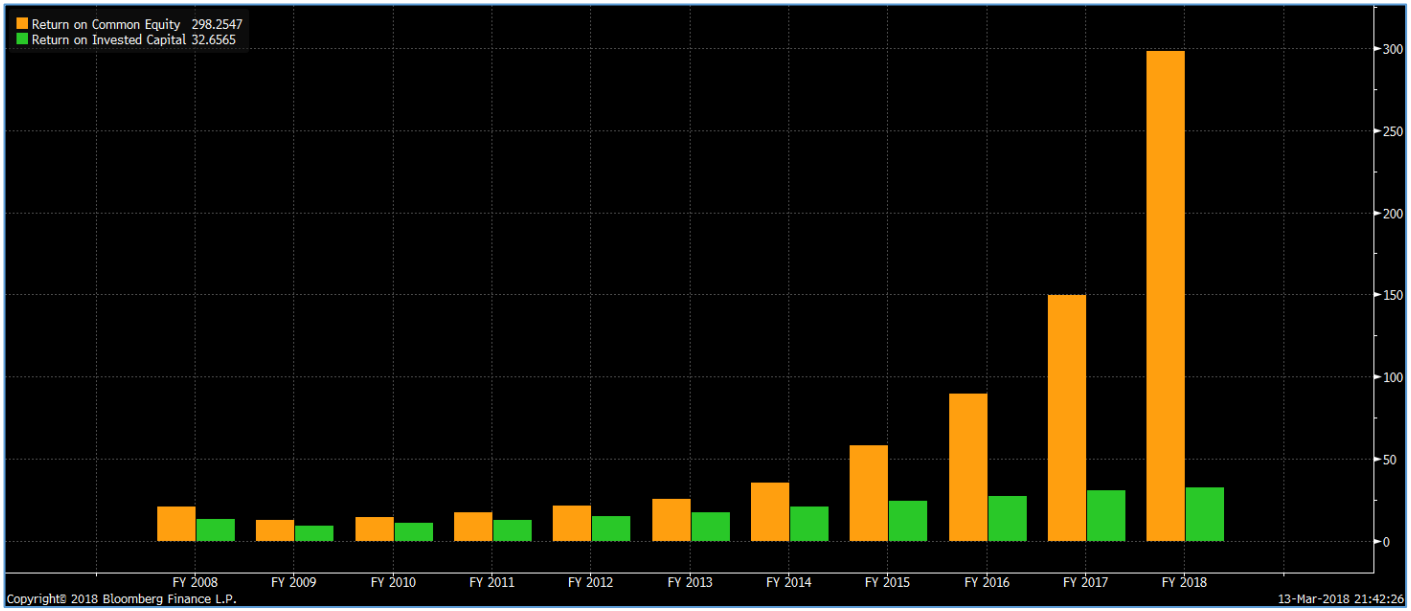


Figure 7 UNH US Equity: ROE and ROI ratios

On the other hand, UNH is the only company that is active only in the US market. Also, a significant amount of its assets is held up in long term commitments and about 35% of its balance sheet is retained as earnings. Similarly to HD, it has an increasing ROE over the years (Figure 7).

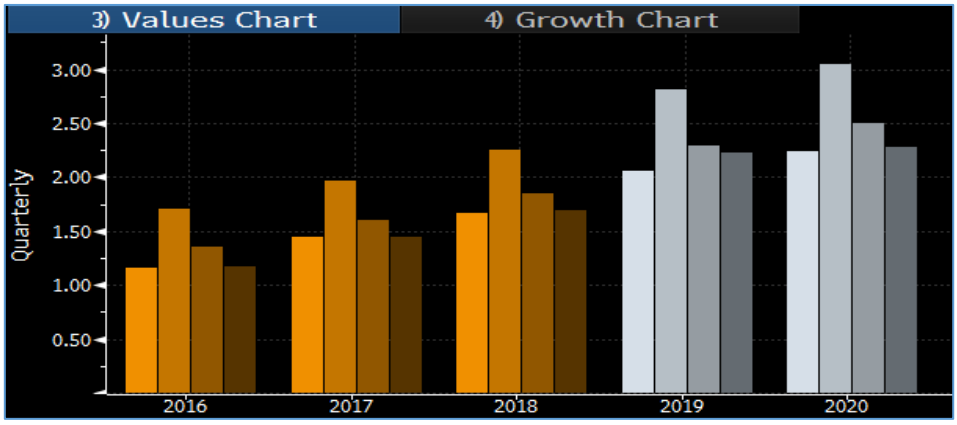


Figure 8 Projected EPS Growth of UNH US Equity

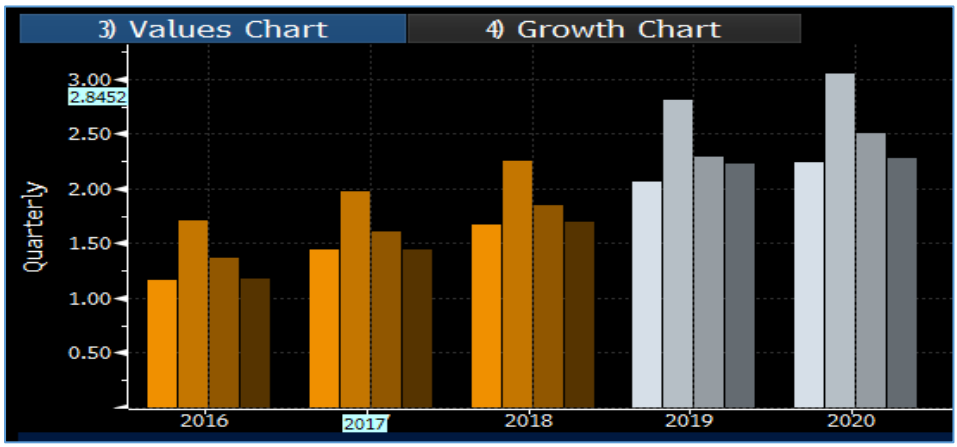


Figure 9 Projected EPS Growth of HD US Equity

Both companies significantly grew in the past 5 years (UNH growth: 12.06% and HD growth: 17.21%) (Figure 8 and Figure 9). According to US News (Duggan, 2018), HD has shown favourable growth in the past months, due to the increase in professional customer demand driven by the aging of houses and the falling interest rates, leading to more home re-modelling needs.

Investors explain the recent growth's increase of UNH with its good investment diversification strategy across multiple projects, such as Medicare Advantage, Medicaid and their Optum segment. Furthermore, this company is said to profit from their good cashflows management and upcoming tax reforms that would bring them additional benefits (Grant, 2018). This suggest a favourable growth environment for UNH in the coming years, brought by regulators' involvement.

It is important to notice that models for portfolio optimisation, including the mean-variance one, suffer the estimation risk problem. Simaan (1997) defines it as the problem arising from the assumption that investors have access to correct estimates. In practice, this is not the case. Indeed, information on some companies is often restricted or requires a fee for access. Thus, it is essential to note that current results assume investors having full access to complete information estimates.

6.3 Optimal Portfolio with Short-Selling vs Optimal portfolio

Finally, the Short-selling portfolio outperforms the optimal one, as previously seen. Its construction was constraint so that a maximum of 10% of each stock can be short-sold. The table below shows the weights associated with the 15 stocks in the Short-selling portfolio.

Short-sell portfolio Weights

Ticker	**Weights %**
AAPL	20.1638
MSFT	-4.1538
JPM	-10
JNJ	7.5407
XOM	-10
WMT	-0.8161
V	19.8154
INTC	8.2352
UNH	40.9160
HD	50.4488
PFE	-10
CVX	-10
CSCO	-10
BA	17.8499
PG	-10

Table 23 Short-sell portfolio Weights

The Short-selling portfolio shorts the maximum allowed amount of JPM, XOM, WMT, PFE, CVX, CSCO, and PG (all of which were also excluded from the optimal portfolio in the previous section). This is due to the fact that these companies offered relatively low or negative growth rates over the past years compared to the other stocks (JPM:2.28%, XOM: -21.28%, WMT: -3.51%, PFE: 5.33%, CVX: -33.54%, CSCO: 5.63%, PG:-0.51%). The Short-sell portfolio, similarly to the optimal one, mostly concentrates on HD and UNH. However, it also shows significant investment in AAPL. Its high performance could be explained by the high weights associated with these value-adding companies and their good future.

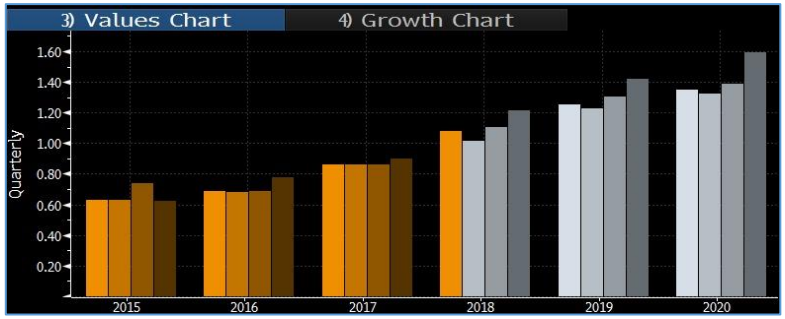


Figure 10 V US EPS Growth

Figure 11 BA US EPS Growth

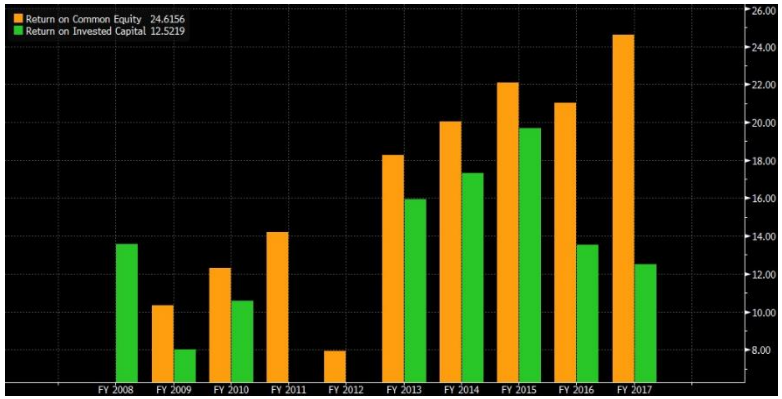


Figure 13 Visa ROE & ROI

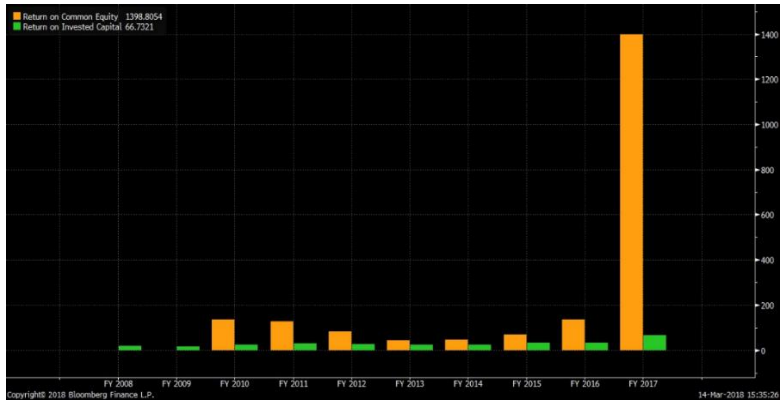


Figure 12 Boeing ROE & ROI

Compared to the other portfolios, the Short-selling portfolio allocates a higher percentage towards Visa and Boeing. Visa focuses its assets on long term investments, whereas Boeing keeps them in short term assets, such as inventory (See Appendix9.1). Over the past 5 years the Visa and Boeing EPS growths reached 16.39% and 16.40%, respectively (Figure 10 and Figure 11). Both companies show high ROE over the years, reaching their ultimate peak in 2017 (Figure 13 and Figure 12).

Although the Short-selling portfolio appears to be the best performing one, it is also important to recognise that it has minimal constraints set in place. In that sense, in has no consideration for transaction costs of buying and selling, and no implications for income tax.

7 Conclusion

The main result of the conducted analysis is that the Market Capitalisation weighted portfolio outperforms the one constructed using the naïve approach. This is inconsistent with the widely known research on portfolio performance (Bolognesi, Torluccio and Zuccheri, 2012; Bailey, 1992). The primary reason for our findings can be identified in the chosen market index's calculation method. The Dow Jones Industrial Average Total Return index is constructed using a geometric average approach, where the prices of stocks are divided by a Divisor, which considers the size and dividends of the companies. According to Brennan and Schwartz (1985) and Rothstein (1972), this suggests that it mirrors a continuously rebalanced portfolio, where prices follow a smooth curve. Sutcliffe (2006) points out that this index tends to overstate price falls and understate price raises. Additionally, he asserts that geometric indices are generally inappropriate for static portfolios and are more suitable for rebalancing ones.

Furthermore, in order to find the best risk adjusted portfolio we considered the optimal portfolio with the maximum Sharpe ratio on the efficient frontier. As a result, we discovered that also the optimal portfolio outperformed the equally weighted one. This is inconsistent with the academic research on naïve portfolio strategy. One explanation for this is the low amount of stocks included in the portfolio. The financial theory (Davies, 2017) suggests that the naïve strategy is suitable for 15 to 30 securities. In this case, however, we are using only 15 stocks. Hence, we have less data, smaller time series and lower variability estimates.

From an investment strategy perspective, the best performing portfolio, based on risk adjusted return, is the portfolio with the short-selling. Even though this constraint has been applied without accounting for factors like transactions costs and taxation, this is still consistent with DeMiguel et al (2009). These authors suggest that short-selling has the same effect as shrinking for the extreme variables on the covariance matrix of prices. This in turns, allows for a smaller estimation risk and boosts the portfolio's performance.

8 Bibliography

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9 Appendix

9.1 Companies' Information

9.2 Equal weighted portfolio Bloomberg report

See “App 9-2 Equal weighted portfolio Bloomberg report” pdf file

9.3 Market Cap weighted portfolio Bloomberg report

See “App 9-3 Market Cap weighted portfolio Bloomberg report” pdf file

9.4 Comparison of both portfolios Bloomberg report

See “App 9-4 Comparison of both portfolios Bloomberg report” pdf file

9.5 Scenario 1: 10% decrease Bloomberg report Equal weighted portfolio

See “App 9-5 Scenario 1 10% decrease Bloomberg report Equal weighted portfolio” pdf file

9.6 Scenario 2: 10% decrease Bloomberg report Market Cap portfolio

See “App 9-6 Scenario 2 10% decrease Bloomberg report Market Cap portfolio” pdf file

9.7 Matlab code

See “App 9-7 Matlab code” matlab file

```
% To run script import DJITotal Return
%DJITRMarketCap (15x3)
%MidPricesDividends
T = MidPricesDividends
symbol = T.Properties.VariableNames(2:16)'
dailyReturn = tick2ret(T{:,2:16})
p = Portfolio('AssetList', symbol, 'RiskFreeRate', 0.00820683665)
% dailyReturn(dailyReturn == 0) = NaN;
p = estimateAssetMoments(p, dailyReturn)
p.AssetMean = (((1+p.AssetMean).^260.75)-1)
p.AssetCovar = p.AssetCovar*260.75
cor = corrcoef(dailyReturn)
p = setDefaultConstraints(p)
w1 = estimateMaxSharpeRatio(p)
[risk1, ret1] = estimatePortMoments(p, w1)

f = figure
grid on
tabgp = uitabgroup(f)
tab1 = uitab(tabgp, 'Title', 'Efficient Frontier Plot')
ax = axes('Parent', tab1)
[m, covar1] = getAssetMoments(p)
scatter(ax,sqrt(diag(covar1)), m, 'oc', 'filled')
xlabel('Risk (Annualised)%')
ylabel('Expected Return (Annualised)%')
text(sqrt(diag(covar1))+0.0005,m,symbol,'FontSize',7)

hold on
pwgt = estimateFrontier(p,100)
[risk2, ret2] = estimatePortMoments(p, pwgt);
s2 = plot(risk2,ret2, 'DisplayName','Without Short-sales', 'LineWidth',2)
plot(risk1,ret1,'p','markers',15,'MarkerEdgeColor','k','MarkerFaceColo','y')
text(risk1+ 0.0005,ret1,'Optimal Portfolio')
plot(0, p.RiskFreeRate,'p','markers',12,'MarkerEdgeColor','k','MarkerFaceColo','r')
text(0 + 0.0005,p.RiskFreeRate,'Risk Free')
yticklabels(yticks*100)
xticklabels(xticks*100)
grid on
```

```
iReturn =
((1+(mean(price2ret((table2array(DJITotalReturn(:,2))+table2array(DJITotalReturn(:,3)))/2)))).^
260.75)-1
iVar = var(price2ret((table2array(DJITotalReturn(:,2))+table2array(DJITotalReturn(:,3)))/2))
mret = iReturn;
mrsk = sqrt(iVar*260.75)
plot(mrsk, mret,'p','markers',12,'MarkerEdgeColor','k','MarkerFaceColo','b')
text(mrsk + 0.0005, mret,'DJITotalReturn')


hold off

tab2 = uitab(tabgp, 'Title','Optimal Portfolio Weight')
columnname = {'Ticker','Weight (%)'}
columnformat = {'char', 'numeric'}
data = table2cell(table(symbol(w1>0), w1(w1>0)*100))
uit = uitable(tab2, 'Data', data, 'ColumnName', columnname, 'ColumnFormat', columnformat,
'RowName', [])
uit.Position(3) = 450
uit.Position(4) = 350

hold on
p = setInitPort(p, 1/p.NumAssets);
[ersk, eret] = estimatePortMoments(p, p.InitPort);
plot(ersk,eret,'p','markers',15,'MarkerEdgeColor','k','MarkerFaceColo','y')
text(ersk+ 0.0005,eret,'Equal')
hold off

tab3 = uitab(tabgp, 'Title','Equal Weight Portfolio')
columnname1 = {'Ticker','Weight (%)'}
columnformat1 = {'char', 'numeric'}
data2 = table2cell(table(symbol(p.InitPort>0), p.InitPort(p.InitPort>0)*100))
uit = uitable(tab3, 'Data', data2, 'ColumnName', columnname1, 'ColumnFormat', columnformat1,
'RowName', [])
uit.Position(3) = 450
uit.Position(4) = 350

hold on
t = setBudget(p, 0, 1);
twgt = estimateFrontier(t, 100);
[trsk, tret] = estimatePortMoments(t, twgt);
plot(trsk,tret,'--')
hold off
```

```
hold on
marketsum = sum(table2array(DJITRMarketcap(:,3)))
cap_weights = table2array(DJITRMarketcap(:,3))/marketsum
q = setInitPort(p, cap_weights)
[mrsk, mret] = estimatePortMoments(q, q.InitPort);
plot(mrsk,mret,'p','markers',15,'MarkerEdgeColor','k','MarkerFaceColo','y')
text(mrsk+ 0.0005,eret + 0.01,'Market Cap')
hold off

tab4 = uitab(tabgp, 'Title','Market Cap Portfolio')
columnname1 = {'Ticker','Weight (%)'}
columnformat1 = {'char', 'numeric'}
data3 = table2cell(table(symbol(q.InitPort>0), q.InitPort(q.InitPort>0)*100))
uit = uitable(tab4, 'Data', data3, 'ColumnName', columnname1, 'ColumnFormat', columnformat1,
'RowName', [])
uit.Position(3) = 450
uit.Position(4) = 350

hold on
l = setBounds(p, -0.1, 1)
lwgt = estimateFrontier(l, 100);
[lrsk, lret] = estimatePortMoments(l, lwgt);
s1 = plot(lrsk,lret,':', 'DisplayName','With Short-sales', 'LineWidth',2)
sswgt = estimateMaxSharpeRatio(l)
[ssrisk, ssret] = estimatePortMoments(l, sswgt)
plot(ssrisk,ssret,'p','markers',15,'MarkerEdgeColor','k','MarkerFaceColo','g')
text(ssrisk + 0.0005,ssret,'Short-Sell Optimal Portfolio')
legend ([s2 s1],{'Efficient frontier W/o Short-Selling','Efficient frontier With Short-Selling'})
legend('Location', 'northwest')
hold off

tab5 = uitab(tabgp, 'Title','Short-Sell Sharpe Portfolio')
columnname1 = {'Ticker','Weight (%)'}
columnformat1 = {'char', 'numeric'}
data4 = table2cell(table(symbol, sswgt*100))
uit = uitable(tab5, 'Data', data4, 'ColumnName', columnname1, 'ColumnFormat', columnformat1,
'RowName', [])
uit.Position(3) = 450
uit.Position(4) = 350
```

9.8 Matlab import data

See “DJITotalReturn”, “DJITR Market cap”, “MidPricesDividends” excel files

9.9 Annualised Means of Stock Returns

Stock Name	Annualised Mean
AAPL'	0.28
MSFT'	0.17
JPM'	0.16
JNJ'	0.11
XOM'	0.04
WMT'	0.09
V'	0.26
INTC'	0.14
UNH'	0.31
HD'	0.29
PFE'	0.11
CVX'	0.09
CSCO'	0.09
BA'	0.27
PG'	0.06

9.10 Efficient frontier points

Risk	Return
10.93%	10.71%
10.93%	10.92%
10.94%	11.13%
10.94%	11.34%
10.94%	11.55%
10.95%	11.76%
10.96%	11.96%
10.97%	12.17%
10.98%	12.38%
10.99%	12.59%
11.00%	12.80%
11.02%	13.01%
11.03%	13.22%
11.05%	13.42%
11.07%	13.63%
11.09%	13.84%
11.12%	14.05%
11.14%	14.26%
11.16%	14.47%
11.19%	14.67%
11.22%	14.88%
11.25%	15.09%
11.28%	15.30%
11.31%	15.51%
11.35%	15.72%
11.38%	15.93%
11.42%	16.13%
11.46%	16.34%
11.50%	16.55%
11.54%	16.76%
11.58%	16.97%
11.63%	17.18%
11.67%	17.39%
11.72%	17.59%
11.77%	17.80%
11.82%	18.01%
11.87%	18.22%
11.92%	18.43%
11.98%	18.64%
12.03%	18.85%
12.09%	19.05%
12.15%	19.26%
12.21%	19.47%
12.27%	19.68%
12.33%	19.89%
12.39%	20.10%
12.45%	20.31%
12.52%	20.51%
12.58%	20.72%
12.65%	20.93%
12.71%	21.14%
12.78%	21.35%
12.85%	21.56%
12.92%	21.76%
12.99%	21.97%
13.07%	22.18%
13.14%	22.39%
13.21%	22.60%
13.29%	22.81%
13.36%	23.02%
13.44%	23.22%
13.52%	23.43%
13.60%	23.64%
13.68%	23.85%
13.76%	24.06%
13.84%	24.27%
13.92%	24.48%
14.00%	24.68%
14.09%	24.89%
14.17%	25.10%
14.26%	25.31%
14.34%	25.52%
14.43%	25.73%
14.52%	25.94%
14.61%	26.14%
14.70%	26.35%
14.79%	26.56%
14.88%	26.77%
14.98%	26.98%
15.07%	27.19%
15.17%	27.39%
15.26%	27.60%
15.36%	27.81%
15.46%	28.02%
15.56%	28.23%
15.66%	28.44%
15.77%	28.65%
15.89%	28.85%
16.01%	29.06%
16.14%	29.27%
16.31%	29.48%
16.54%	29.69%
16.83%	29.90%
17.21%	30.11%
17.73%	30.31%
18.41%	30.52%
19.22%	30.73%
20.16%	30.94%
21.26%	31.15%
22.49%	31.36%

9.11 Short-Sell Frontier points

Risk	Return
10.76%	10.46%
10.77%	10.86%
10.77%	11.25%
10.78%	11.65%
10.80%	12.05%
10.81%	12.45%
10.84%	12.85%
10.86%	13.24%
10.89%	13.64%
10.93%	14.04%
10.96%	14.44%
11.00%	14.84%
11.05%	15.24%
11.10%	15.63%
11.15%	16.03%
11.21%	16.43%
11.27%	16.83%
11.33%	17.23%
11.40%	17.62%
11.47%	18.02%
11.54%	18.42%
11.62%	18.82%
11.70%	19.22%
11.78%	19.62%
11.86%	20.01%
11.95%	20.41%
12.05%	20.81%
12.14%	21.21%
12.24%	21.61%
12.34%	22.00%
12.44%	22.40%
12.55%	22.80%
12.66%	23.20%
12.78%	23.60%
12.89%	23.99%
13.01%	24.39%
13.13%	24.79%
13.26%	25.19%
13.38%	25.59%
13.51%	25.99%
13.65%	26.38%
13.78%	26.78%
13.92%	27.18%
14.06%	27.58%
14.20%	27.98%
14.34%	28.37%
14.49%	28.77%
14.64%	29.17%
14.79%	29.57%
14.94%	29.97%
15.10%	30.37%
15.25%	30.76%
15.41%	31.16%
15.57%	31.56%
15.73%	31.96%
15.90%	32.36%
16.07%	32.75%
16.24%	33.15%
16.41%	33.55%
16.58%	33.95%
16.76%	34.35%
16.94%	34.75%
17.12%	35.14%
17.30%	35.54%
17.48%	35.94%
17.67%	36.34%
17.85%	36.74%
18.04%	37.13%
18.23%	37.53%
18.42%	37.93%
18.61%	38.33%
18.81%	38.73%
19.01%	39.12%
19.21%	39.52%
19.41%	39.92%
19.61%	40.32%
19.82%	40.72%
20.02%	41.12%
20.23%	41.51%
20.44%	41.91%
20.65%	42.31%
20.87%	42.71%
21.08%	43.11%
21.30%	43.50%
21.52%	43.90%
21.73%	44.30%
21.96%	44.70%
22.18%	45.10%
22.42%	45.50%
22.67%	45.89%
22.93%	46.29%
23.21%	46.69%
23.51%	47.09%
23.82%	47.49%
24.24%	47.88%
24.81%	48.28%
25.52%	48.68%
26.34%	49.08%
27.28%	49.48%
28.54%	49.87%