ACCT655 Analytics for Financial Instruments (MSA)

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Project Report

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Executive Summary

As part of our stock selection criteria, we will be selecting US semiconductor stocks based on their Environmental, Social & Governance (ESG) ratings. We believe that for companies to maintain sustainable growth, they need to look beyond traditional financial measures and performance. We will be selecting 3 stocks with high-ESG score and compare against 3 stocks with low-ESG score as part of stocks selection. We noticed that stocks with high-ESG score is more sustainable with stable returns over time. Companies with low-ESG score although performs better in some years have higher standard deviation and is not sustainable.

In the analysis of portfolio, we construct a 2 assets portfolio with selected ESG stocks and US Treasury Bill to optimise returns. Next, we introduced the S&P 500 index as a 3rd asset for further diversification of risk but due to its lower Sharpe ratio than TXN stock the S&P500 was unable to further reduce portfolio risk. We created a google survey form to estimate risk aversion for investor followed by exploring how different level of risk aversion affect allocation between risk-free and risk assets. The report also shows how investor can achieve maximise their utility by allocating resource in risky asset.

1 Introduction

The objective of our project is to identify a selected portfolio of financial instruments and provide recommendations to the average investor regarding the allocation of one's capital in constructing the optimal portfolio based on different degrees of risk aversion.

The financial instrument we have selected are equity stocks listed on the US Stock Exchange. The US stock market is home to some of the biggest and most robust companies in the world, who many analysts have predicted huge growth potential over the years especially in certain sectors such as pharmaceutical as well as technology. As many of these companies also operate globally in many parts of the world, we believe that such investing in these instruments could potentially create a geographically well-diversified portfolio. Furthermore, the advent of the COVID19 pandemic has also caused a huge uplift of late into the US equity markets. This could be an indicator on the positive potential of the US market.

The US market is home to companies of many industries. For the purposes of our investment strategy, we will be focusing mainly on the semiconductor stocks. The US accounts for nearly half of the $418billion[1] in global semiconductor spending in 2019 and is home to the biggest semiconductor firms in the world. With unavoidable advances in technology and robotics in the years to come, we believe that there is healthy potential for growth in this sector.

As part of our stock selection criteria, we will be selecting US semiconductor stocks based on their Environmental, Social & Governance (ESG) ratings. We believe that for companies to maintain sustainable growth, they need to look beyond traditional financial measures and performance. It is important that companies also focus on other socially responsible areas such as preserving the environment and taking care of its employees.

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[1] https://www.fool.com/investing/stock-market/market-sectors/information-technology/semiconductor-stocks/

With reference to the ESG scores and trends which we have downloaded from the Wharton's database, we have selected the following 3 companies which we would like to incorporate as our main portfolio. They are namely Intel Corporation (INTC), Advanced Micro Devices (AMD) and ON Semiconductor Corporation (ON). We have also selected the following 3 companies in the same industry for comparison of their performance against our main portfolio. They are namely Broadcom Inc (AVGO), Xilinx Inc. (XLNX) and Qualcomm (QCOM). We will be analyzing the stock performance based on their returns for the period from 1st Jan 2014 to 30th June 2020 (see Section 3 of report). Based on our findings, we noticed that companies with positive ESG momentum outperformed companies with negative ESG momentum over this time horizon.

Upon selecting our stocks to be included in our portfolio, we have then also considered the inclusion of the S&P 500 index and risk free T-bills into our portfolio to form a 3-asset portfolio (see Section 4 of report). We will then attempt to construct various optimal/minimum variance and analyse their performance. By considering the varying risk aversion levels of different individuals, we have subsequently determined the spectrum of weightages to be invested into the risky portfolio and the risk-free T-bills. A highly risk averse investor will see itself investing 70.2% in T-bills and 29.8% into the risky portfolio. By adjusting the risk aversion level downwards, we see an increase in the allocation into the risky portfolio that is aligned with our expectation.

2 Literature Review

In the current market, the role of environmental, social and governance (ESG) impact stocks become more increasingly crucial as part of investment within the United States market. ESG factors is also included as part of analysis of selection process of securities within an investment portfolio to capture the sustainable long-term gains. This corresponds with the Corporate Social Responsibility (CSR) actions that the companies look into, where Companies would place focus and publish CSR reports on top of the impending annual reports to its investors.

A significant amount of research suggests a positive correlation between companies that do good and companies that do well financially. Out of 2,200 studies on ESG[1], 90% show either a positive relationship to corporate financial performance or at least no-negative relationship. ESG investment vehicles have experienced tremendous growth in recent years. For investors, one of the key questions is the risk/return trade-off for ESG investment. If the growing popularity of ESG investment has translated into market recognition of Companies' ESG practices, firms with good ESG practices may or may not be priced higher than their peers with poor ESG practices. Invests may pay premiums are not risk based but, rather, are associated with non-risk investor preferences[2]. As such, current price and future expected return are generally inversely related, the expected return from a company with good ESG practices may be lower than that of a company with bad ESG practices.

We have referred to literature by *Stark[2] (2018)* and noted that the reliance ESG scores depends on the investment horizon of the investors. Preference of stocks with higher-ESG would typically for long-term investments. We also noted another study of *How ESG Affect Equity Valuation, Risk, and Performance* by Zoltan Nagy[3] (2016), the ESG has a correlation with the

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[2]https://www.researchgate.net/publication/309181625_Environmental_social_and_governance_disclosure_integrated_reporting_and_the_accuracy_of_analyst_forecasts

[3] https://www.valuescopeinc.com/esg-valuation-considerations/

Intangible Value Assessment (IVA) ratings of the stocks and portfolio performance. In this research, it shows that stocks with Intangible Value Assessment (IVA) has the best active returns which relates to long-term returns.

We also referred to another research conducted by *Amundi (2020[4])* and he demonstrated that the portfolio constructed using ESG analysis outperforms portfolio with another methods of selection.

There is no evidence that investors need to sacrifice returns when they invest in good ESG companies globally compared with bad ESG stocks[3], investors seem to pay a slight premium for holding good ESG stocks in the North American market based on Sustainalytics' ESG Rating. An ESG factor appears to be distinct as it is only moderately correlated to size and investment but not correlated to other known factors, such as value and profitability.

With the details above, we have selected stocks using Environmental, Social and Governance (ESG) score.

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[4] https://research-center.amundi.com/page/Publications/Discussion-Paper/2020/ESG-Investing-in-Recent-Years-New-Insights-from-Old-Challenges

3   Comparative Analysis

3.1   Portfolio selection of High ESG Score: Intel Corporation (INTC), Advanced Micro Devices (AMD) and ON Semiconductor (ON)

Based on Table 3.1 where we took a time frame from 1-Jan-2010 to 30-June-2020, the mean return is positive with largely increasing and a low range of standard deviation of between 0 to 15. The skewness of INTC and ON is more symmetry as compared to AMD where it shows that there is indeed data asymmetry (closer to 0 is better). The kurtosis pattern is *platykurtic* where we noticed that the kurtosis for INTC and ON is negative which shows that distribution is flatter with closer mean and standard deviation.

Next, we will analyse the ESG score as independent variable of change in stock price as dependent variable. We noticed that the stock price has a positive impact on a time framework as it can be seen in ON stocks where the stock has been gradually increasing at 50.4% year-on-year which is in-line with the ESG Score which has increased 15.8% points. This shows that there is a positive impact of Environmental, Social and Governance (ESG) score which may have a time lag taken by market sentiment after the announcement of the ESG score to public. Further, we also noticed that INTC showed a fairly strong performance with a higher ESG range of about 85% points. Interestingly, over the years we noticed the INTC stock price has been increasing over the years which could be due to the market confidence of the stocks due to company's strategy which includes ESG factors. Consistently, we noted that the ESG scores for this group of company is largely stable.

The monthly return is also on the positive side where the month-on-month return is between 1% and 5%. This corresponds to the daily and annual returns, which shows that the stock is indeed is a good investment to be considered as part of portfolio. Based on Table 3.2, the daily

returns are also positive and a low standard deviation, which shows that there are certain traits within these companies.

One of the contributing factors that we see consistently is the high and strong ESG of these companies. Analysing the ESG, we have break down the details as follows which shows that the stocks are a good mix of stocks selection within the semiconductor industry. Analysing the details of these companies, we noticed, these companies have a common factor that performed well within the ESG where these companies are performing better that peers on ethical practices, water conservation, work health safety and diversity within the leadership.[5]

3.2 Portfolio comparative of low ESG Score: Broadcom Inc (AVGO), Qualcomm (QCOM) and Xilinx (XLNX)

Based on Table 3.3, for the same time frame from 1-Jan-2010 to 30-June-2020, the comparative portfolio has the mean return is positive with largely increasing but has a range of standard deviation of between 0 to 100. This shows that the data fluctuates on a high degree. The skewness of all the three comparative stocks of AVGO, QCOM and XLNX are data asymmetry (where the skewness is further than 0 point). The kurtosis pattern is *platykurtic* where we noticed that the kurtosis for AVGO is negative which shows that distribution is flatter with closer mean and standard deviation.

Next, we will look into the ESG score as independent variable of change in stock price as dependent variable. We noticed that the stock price has a positive impact on a time framework as it can be seen in ON stocks where the stock has been gradually increasing at 50.4% year-on-year which is in-line with the ESG Score which has increased 15.8% points. This shows that there is a positive impact of Environmental, Social and Governance (ESG) score which may

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[5] https://esg.censible.co/companies

have a time lag taken by market sentiment after the announcement of the ESG score to public. Further, we also noticed that INTC showed a fairly strong performance with a higher ESG range of about 85% points. Interestingly, over the years we noticed the INCT stock price has been increasing over the years which could be due to the market confidence of the stocks due to company's strategy which includes ESG factors. Consistently, we noted that the ESG scores for this group of company is largely stable.

After analyzing the two groups of selected semiconductor stocks of high ESG Score versus semiconductor stocks of low ESG Score, we have done a step further to look into the overall breakdown of the ESG (Environmental, Social and Governance) Score by its component to confirm our understanding of stock selections for the 6.5 year period:

Based on Table 3.5 and 3.6 we noticed that we noted that ESG Score breakdown of the selected stocks on high ESG corresponds to our understanding and the mix of the stocks within the high-ESG is a good mix where INTC performs the best in Social section, AMD performed the best in Environmental and ON performs the best Governance. Whilst the annual stock returns for the low-ESG performed slightly better, we noted that the returns are not sustainable and fluctuates on the long run with high standard deviation. This can be seen from the recent debacle of these companies that may have an impact on the share price where the lawsuits for those with ESG have series of lawsuits where all the low-ESG scores have on-going lawsuits in 2020:

- AVGO, Broadcom Inc has gotten into lawsuit which resulted in halts in trading and investigation by regulators.
- QCOM, Qualcomm has gotten into lawsuit with Federal Trade Commission of US due to Antitrust Law violation

- XLNX, Xilinx has gotten into lawsuit on infringement of Intellectual Property as defendant filed by another company.

Based on the above, the stocks with low-ESG is not sustainable as there has been many issues surrounding the company's legal suits. Based on the analysis, we notice that companies with positive ESG momentum has a better quality in stocks on a longer timeframe and outperformed companies with negative ESG momentum during the six-and-half-year-period from Jan-2014 to June-2020. The correlation matrix of these companies is within the good mix per Table 3.7.

3.3   Beta of each stock against S&P500

In order to observe the Beta of each stock (both high ESG and low ESG) against S&P 500, we run regressions using the monthly stock returns data of the 6 stocks and S&P500 Index, and the results are shown in Table 3.8. Based on the results, we can see that all Betas are larger than 1, meaning that they are all riskier than the market. More specifically, stock QCOM and XLNX have the lowest Beta, which are slightly more than 1, followed by stock INTC and AVGO. As for the remaining two stocks, AMD and ON, they have the highest Betas which are much larger than the others. In terms of Beta alone, we can tell that there is no uniform relationship between Beta and ESG scores.

3.4   Correlation between stocks

Although all 3 stocks are in the same industry, they are not perfectly correlated to each other. The heat map (Figure 3.7) shows the correlation is between 0.41 to 0.55 across the stocks pair. This suggests risk diversification is possible by forming a portfolio.

4 Assets Portfolio Formation and Optimisation

4.1 Two assets portfolio formation and optimisation

4.1.1 Risk-free rate

We consider the portfolio of risky instruments made up of 3 high ESG semiconductor stocks with risk free Treasury-bills. Since we are investing in US stocks, we use the average Treasure-bill rate in US over the period from 2010-01-01 to 2020-06-30 (0.7%) as our risk-free rate. The data source is Quandl Federal Reserve Economic Data:1-Year Treasury Constant Maturity Rate.

4.1.2 Formation of minimum-variance and optimal portfolio with 3 high ESG stocks

We create 1,000 imaginary portfolios and obtain weights of each stock and the corresponding expected annual return, risk of portfolio and Sharpe Ratio. By plotting the resulting frontier, and along the efficient frontier. To optimise the assets, we identify two special portfolios. Refer to Table 4.1 - Minimum Variance Portfolio and Optimal Portfolio - INTC, AMD and ON and Figure 4.1 – Plot of Resulting Frontier with Special Portfolios.[6]

Next, we analysed the two special portfolios return and standard deviation against each individual stock. The Minimum Variance Portfolio offers the lowest standard deviation among all stocks and dominates stocks INTC and ON. For the Optimal Portfolio, it offers higher returns and with moderate increase risk. It dominates stock ON. By forming the 2 assets portfolio, non-systematic risk can be diversified away providing the potential investment optimal returns with less volatility.

The portfolio allocation for ON is 2.12%, due to its low annual return and high standard deviation. Our team decided to replace it with TXN, another semiconductor stock with high ESG score from our reserve list. Its annual return, standard deviation and Sharpe ratio are

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[6] *Troy Engelhardt Optimal Portfolio S&P 500 Retrieved from https://yortug.github.io/ on Sep 2020*

21.3%, 26.9%, and 0.76 respectively. The analysis was reperformed to construct the optimal portfolio and the results are as follows: Annual return of the Optimal Portfolio had increased from 21.7% to 22.4%, standard deviation was reduced from 30.9% to 27.2% and Sharpe Ratio improved from 0.68 to 0.80. The final allocation for optimal portfolio is tabled in Table 4.4. TXN accounts for 78% in the Optimal Portfolio due to its higher Sharpe Ratio.

4.1.3 Estimating the Risk Aversion

Having computed the optimal portfolio, we now bring in the individual risk appetite. To estimate the risk appetite of the individual, we designed a form with a series of questionnaire to find out the risk aversion of an individual. There are 4 questions each leading to an answer. See 9.2 Google Questionnaire. The answers will be then mapped to a risk appetite score to establish the overall individual's risk appetite.

4.1.4 Combining risky portfolios with risk-free asset

For illustration purpose, we assume risk aversion score is 10. With risk aversion score we impute into the utility function for calculation on the portfolio utility. To cater the optimised portfolio with the risk aversion of individual, firstly, we construct a final portfolio with risky assets and our risk-free asset by creating 1000 portfolios starting with allocating 0% in risk portfolio and increase the weight by 0.01. This method allows us to obtain a capital allocation line with 1000 portfolios with 1000 different weights in risky assets. Next, we plot the capital allocation line for our plot. See Table 4.5 and Figure 4.2.

Then by plotting of the Utility as a Function of Allocation in Risky Portfolio (Figure 4.3) show us the utility initially increases and drops sharply after allocating more than 20% in risky assets. This is not surprising as the risk aversion score of 10 suggest the individual is more risk averse. Maximising the individual's utility, we will find the point of tangency with the CAL. With that it will provide us the customised portfolio allocation between risky and risk-free assets adjusted for risk aversion. The optimised allocated weights displayed in Figure 4.5. Overall, the

portfolio comprises 70.7% of T-bills and 29.3% in risky portfolio. Within the risky portfolio weights are 2.7% INTC, 3.8% AMD and 22.8% TXN.

4.2   Three assets portfolio formation and optimisation

4.2.1   Correlation between stocks and S&P 500 index

The S&P 500 index includes 500 leading companies and is widely regarded as the best single gauge of large-cap U.S. equities. To further diversify our portfolio, we added the S&P 500 index into the risky portfolio. Table 4.6 and Figure 4.6 show that INTC and TXN are highly correlated with the S&P 500 index ($\rho_{INTC,\ S\&P} = 0.70$, $\rho_{TXN,\ S\&P} = 0.74$). The strength of the relationship between AMD and the S&P 500 index is lower ($\rho_{AMD,\ S\&P} = 0.47$). This suggests that we may diversify the portfolio and reduce the risk by forming a portfolio composed of the three stocks and the S&P 500 index.

4.2.2   Formation of minimum-variance and optimal portfolio with 3 high ESG stocks and market portfolio

In the step of forming the Optimal Portfolio, we think that the S&P 500 index is similar to the stock. Therefore, we added the S&P 500 index into the risky portfolio as a fourth stock and calculated the Minimum Variance Portfolio and the Optimal Portfolio in the same way as two assets portfolio formation and optimisation. The result is shown in Table 4.7. The Minimum Variance Portfolio offers the lowest volatility among all the 1000 imaginary portfolios. This portfolio is dominated by the S&P 500 index because it has the lowest annual standard deviation among 4 stocks. The Optimal Portfolio was found by maximizing the Sharpe Ratio. This portfolio provides the Sharpe Ratio of 0.796, slightly lower than the 2 Assets-Optimal Portfolio (0.797). We expected that adding in the S&P 500 index would further diversify our portfolio and reduce the risk, but the result is contradicted to our expectation. This was

attributed to the low allocation in the S&P 500 index. Possible reasons include high correlation with TXN is 0.744 and coupled with lower Sharpe ratio (S&P: 0.602 vs TXN 0.764).

4.2.3 Combining risky portfolios with risk-free asset

We calculated the fraction of complete portfolio allocated to the risky portfolio and to T-bills in the same way as 2 assets portfolio formation and optimisation. The tangency point between the CAL and the indifference curve (Figure 4.8) provides the highest utility for individuals whose risk aversion rate is 10. From Figure 4.9, we can see that the final portfolio is composed of 70.3% of T-bills and 29.7% of risky portfolio. Within the risky portfolio weights are 1.9% INTC, 4.6% AMD, 21.1% TXN and 2.3% S&P 500. The expected return of the final portfolio is 9.8% and the annual standard deviation is 11.4%.

5   Risk-aversion Rate Survey

Risk-aversion rate is one of the key factors in forming our portfolio. In order to make our analysis more interactive and more meaningful, we use the survey on *moneyowl*[7] as reference and form our own survey in order to assess investors' risk-aversion levels. The Google questionnaire we have developed is attached to the appendix 9.2. Next, we build a matrix shown in Table 5.1 which assigns higher scores to answers that are more risk-averse, and lower scores to answers that are less risk-averse.

After obtaining scores for each of the survey questions, we then add up the scores together and use the final one as risk-aversion rate. By setting up connection to Google Sheet in our python codes, we can have access to the risk-aversion rate for each investor, and can read the rates by simply typing in the investor's name. In this way, we can provide investors with their optimal portfolio right after they fill out the questionnaire.

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[7] Questionnaire - Your Risk Ability Form adapted from https://www.moneyowl.com.sg/

6   Comparison

Now that we have had the 2-asset and the 3-asset optimal portfolio for risk-aversion rate of 10, we want to make a comparison concerning the composition of optimal portfolio among investors with different risk-aversion rates. As a result, we include two more investors with risk-aversion rate of 3 and 7 respectively, so as to see whether there exists any difference.

Figure 5.1 demonstrates the different Utility curves according to investors with different risk-aversion rates. We can see that for the same weight invested in risky portfolio, people who are less risk-averse, namely those with lower A, tend to have a higher utility, and this is in accordance with our expectations.

From Table 5.2, we can see that with the increase in risk-aversion rate, which means the investor is more risk-averse, the weights in T-bills and risky assets increase and decrease respectively. The expected return decreases as well, since we are now taking less risk. As for the utility, it decreases, which is in consistent with the conclusion drawn from the previous paragraph.

7   Conclusion & Limitation

Stocks with high ESG score has a consistent year-on-year increasing earnings trend over the years and performs better amongst the peers in the areas of ethical practices, social and governance. This can be seen from the high beta across the firms and low standard deviation. Whilst the annual stock returns for the low-ESG performed slightly better, we noted that the returns are not sustainable and fluctuates on the long run with high standard deviation. This can be seen from the recent debacle of these companies that may have an impact on the share price although there are years high returns. Based on our analysis, companies with positive ESG momentum has a better quality in stocks on a longer timeframe and outperformed companies with negative ESG momentum.

We noticed that the limitations of using ESG score as measurement of stock selection includes accuracy of ESG score measurement as benchmark as we noted there is no uniform ranking across the industry. We also noted that high ESG score does not guarantee high annual return. Investors should take note of the limitations above in selecting stocks based on high-ESG score. Based on our stocks selection is within the same industry, the stocks selection is not diversified for portfolio formation.

Measuring the risk appetite of investor, requires calibrated estimation through a series of questions and answer as illustrated in our simplified risk appetite survey. These qualitative answers are translated to a numeric score to compute the Aversion Score (A) for imputation into the model. One limitation is the difficulty to assess an investor risk appetite accurately, requiring well designed questions and answers in order to provide the best estimate of risk score for wide variety of investors.

The capital allocation line (CAL) is optimal risky portfolio is the same for all investor, regardless of risk aversion. At different tangency points of indifference curve and CAL shows different level of return and its associated risk. Overall, the investors risk aversion score will

determine the level return and portfolio risk. When we add S&P to form a 3 assets portfolio, we observe negligible reduction in risk of optimal portfolio. This was attributed to the low allocation (less than 2%) in S&P. Possible reasons include high correlation with TXN is 0.744 and coupled with lower Sharpe ratio (S&P: 0.602 vs TXN 0.764). One limitation for the selected stocks were from the same industry having correlation with each other. This meant limited diversification opportunities. With the passenger of time, new variables will be introduced, leading to changes in portfolio returns and risk. Eventually causing the portfolio to be sub-optimal. Periodic portfolio rebalancing is required to optimised return was not incorporated in the model.

8 References

1. *Investing in Semiconductor Stocks by Nicholas Rossolillo, 5 Oct 2020:*

   https://www.fool.com/investing/stock-market/market-sectors/information-technology/semiconductor-stocks/

2. *Environmental, social and governance disclosure, integrated reporting, and the accuracy of analyst forecasts by Andrew Stark and Christiana Bernandi, Oct 2016 https://www.researchgate.net/publication/309181625_Environmental_social_and_governance_disclosure_integrated_reporting_and_the_accuracy_of_analyst_forecasts*

3. *ESG Investing in Recent Years: New Insights from Old Challenges https://research-center.amundi.com/page/Publications/Discussion-Paper/2020/ESG-Investing-in-Recent-Years-New-Insights-from-Old-Challenges*

4. *ESG Valuation Considerations – Top Down or Bottom Up?, Jul 2020 https://www.valuescopeinc.com/esg-valuation-considerations/*

5. *ESG Score by Sustainalytics: https://www.sustainalytics.com/esg-ratings/*

6. *ESG Score by Censible: https://esg.censible.co/companies*

7. *Troy Engelhardt Optimal Portfolio S&P 500, Sep 2020 https://yortug.github.io/*

8. *Questionnaire -Your Risk Ability Form adapted from https://www.moneyowl.com.sg/*

9   Appendix

9.1   Tables and charts

Table 3.1 Stock performance analysis for High-ESG Score						
Stock ticker	Minimum	Mean	Maximum	Standard Deviation	Skewness	Kurtosis
INTC	13.0390	29.9364	67.2947	13.2692	0.7717	-0.4833
AMD	1.6200	11.3813	58.9000	12.1806	2.0116	3.5340
ON	5.8200	12.3516	26.8000	5.5082	0.9191	-0.4686

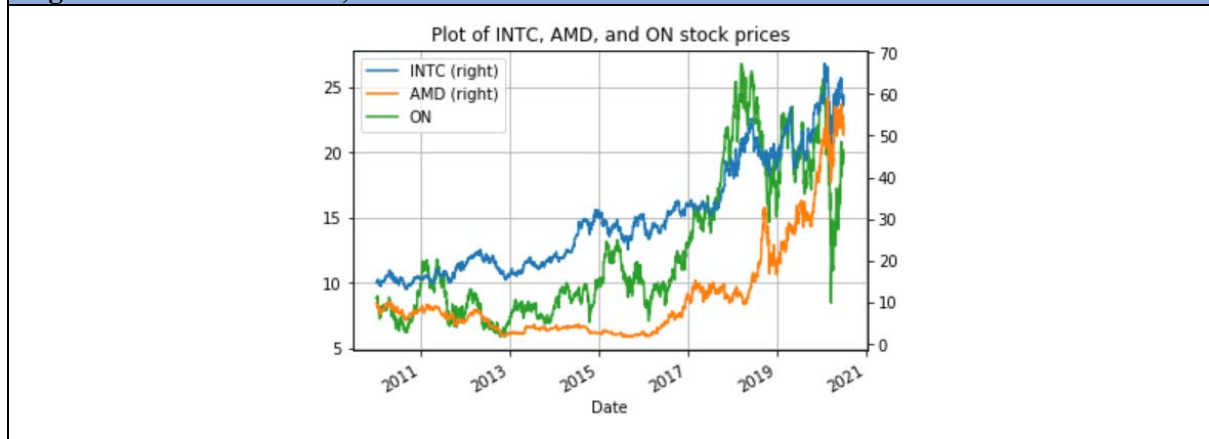| Table 3.2 Stock returns for High-ESG Score						
	Daily Returns		Monthly Returns		Annual Returns	
Stock ticker	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
INTC	0.0007	0.0176	0.0131	0.0639	0.1721	0.2791
AMD	0.0013	0.0364	0.0259	0.1582	0.3258	0.57796
ON	0.0007	0.0268	0.0124	0.1087	0.1684	0.4255

Figure 3.1 – Plot of INTC, AMD and ON Stock Prices

Figure 3.2 – High ESG Companies Yearly Average ESG Score

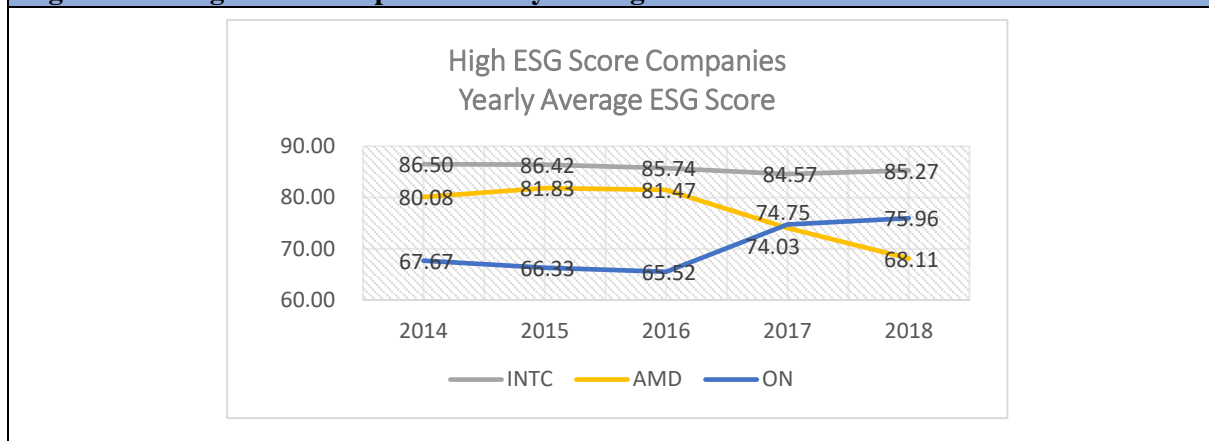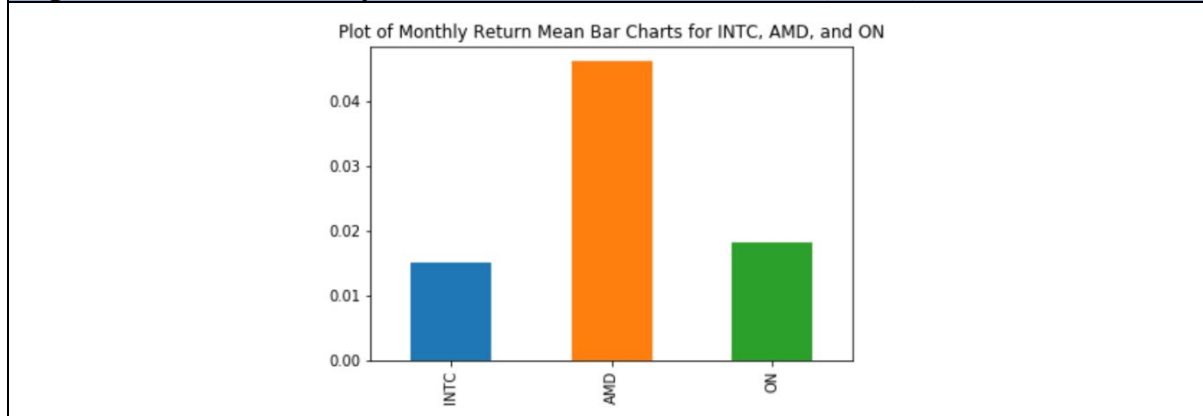**Figure 3.3 – Plot of Monthly Return Mean Bar Charts for INTX, AMD, and ON**

Plot of Monthly Return Mean Bar Charts for INTC, AMD, and ON

Table 3.3 Stock performance analysis for Low-ESG Score

Stock ticker	Minimum	Mean	Maximum	Standard Deviation	Skewness	Kurtosis
AVGO	13.4541	118.7957	313.1622	94.4947	0.4871	-1.2358
QCOM	24.1220	42.5688	93.9192	12.8314	0.5716	0.6685
XLNX	18.2415	39.3658	136.5468	25.9188	1.1256	0.4902

Table 3.4 Stock returns for High-ESG Score

Stock ticker	Daily Returns		Monthly Returns		Annual Returns	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
AVGO	0.0014	0.0228	0.0278	0.0818	0.2022	0.3018
QCOM	0.0006	0.0194	0.0120	0.0957	0.5857	0.6138
XLNX	0.0008	0.0190	0.0157	0.0765	0.2384	0.4524

Figure 3.4 –Plot of AVGO, QCOM, and XLNX Stock Prices

Plot of AVGO, QCOM, and XLNX stock prices

Figure 3.5 –Low ESG Companies Yearly Average ESG Score
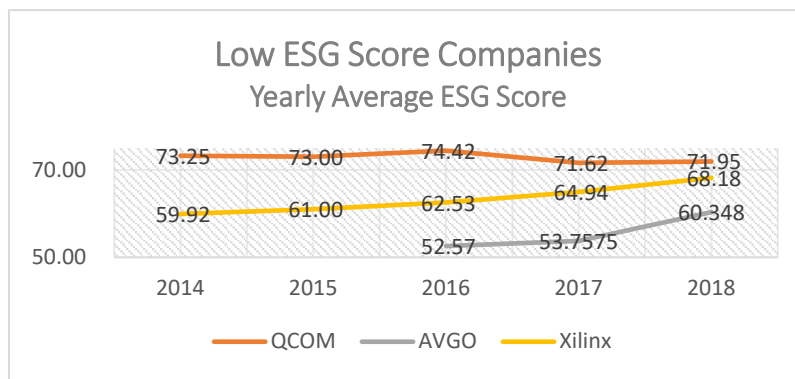
Figure 3.6 – Plot of Cumulative Compounded Log Returns over Time
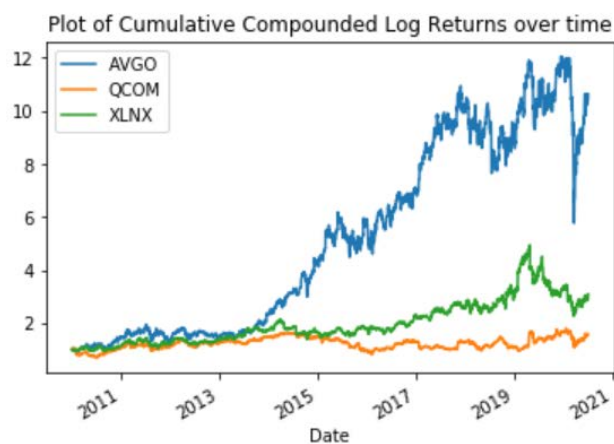
Table 3.5 – Average ESG Score Breakdown

	Environmental	Social	Governance
INTC	83.9212	89.8109	83.1009
AMD	83.2956	81.4765	64.9367
ON	67.68	64.9350	80.0317

Table 3.6 – Average ESG Score Breakdown

	Environmental	Social	Governance
AVGO	71.5216	63.9126	72.7111
QCOM	72.4729	76.5462	58.5852
XLNX	58.2550	64.4871	68.4043

Table 3.7 Correlation Matrix

	INTC	AMD	ON
INTC	1.0000	0.36525	0.55731
AMD	0.36525	1.0000	0.37449
ON	0.55731	0.37449	1.0000

Table 3.8 – Summary of beta of each stock against S&P500						
	INTC	AMD	ON	AVGO	QCOM	XLNX
Beta	1.1141	1.5449	1.5321	1.2691	1.0814	1.0721

Table 3.9 – Correlation Matrix between INTC, AMD and ON

```
              Correlation Matrix:
                    INTC       AMD        ON
              INTC  1.000000  0.412541  0.557632
              AMD   0.412541  1.000000  0.417455
              ON    0.557632  0.417455  1.000000
```

Figure 3.7 –Correlation Matrix Heatmap between INTC, AMD and ON

Correlation Matrix Heatmap of Each Stock's Daily % Change in Adj Close Price
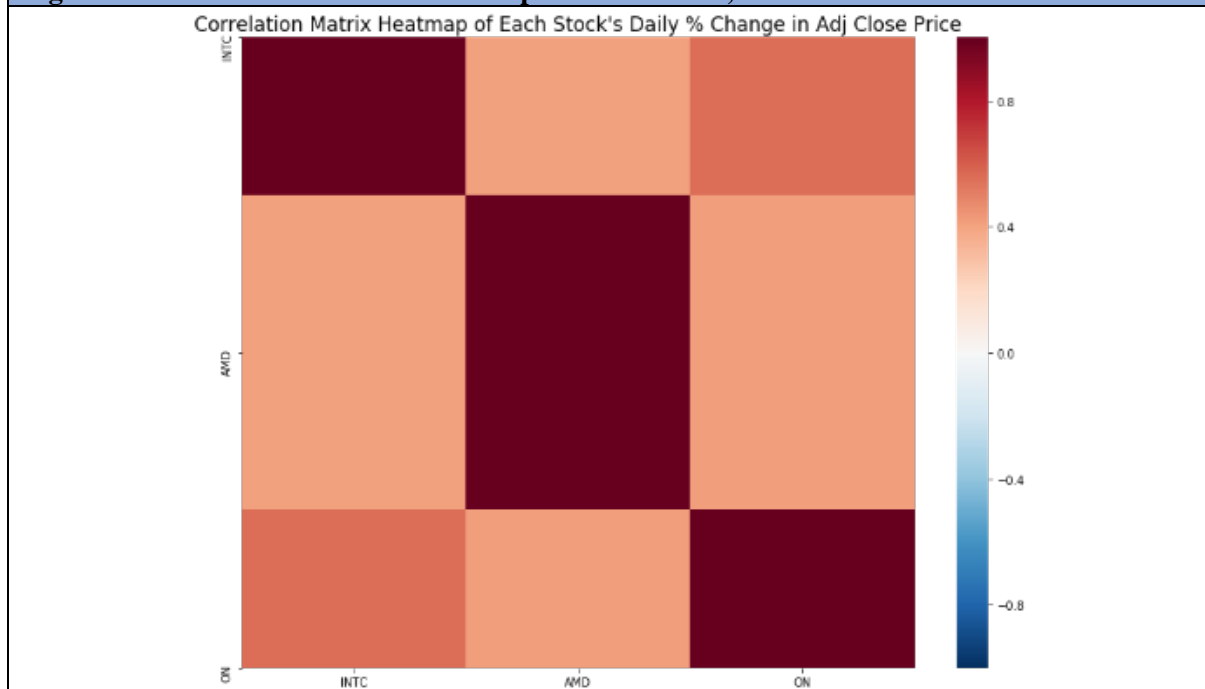
Table 4.1 – Minimum Variance Portfolio and Optimal Portfolio - INTC, AMD and ON

```
Minimum Variance Portfolio:
      Returns   Volatility  Sharpe Ratio  INTC weight  AMD weight  ON weight
885   0.172443  0.277205    0.595397      0.881857     0.004816    0.113327


Optimal Portfolio:
      Returns   Volatility  Sharpe Ratio  INTC weight  AMD weight  ON weight
124   0.217186  0.309013    0.678905      0.684938     0.29385     0.021212
```

Figure 4.1 – Plot of Resulting Frontier with Special Portfolios - INTC, AMD and ON

Resulting Frontier
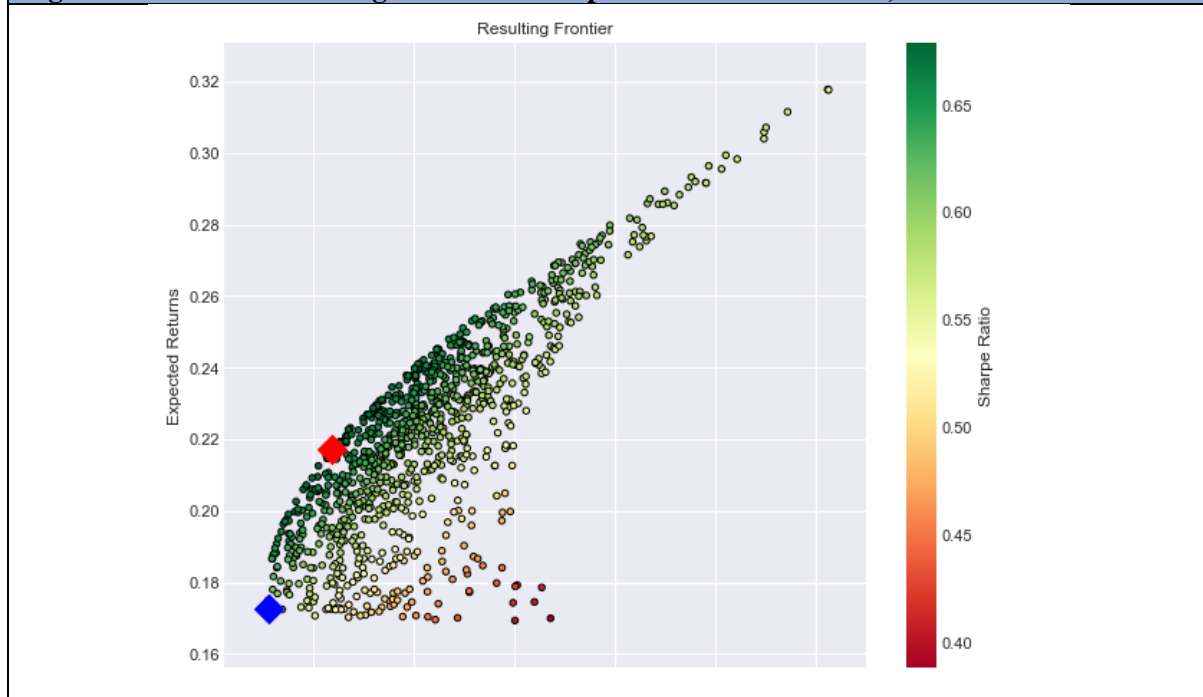
Table 4.2 - Two Assets (T-Bill and INTC, AMD, ON)- Optimal Portfolio			
Asset	Annual Return	Annual Std Dev	Allocation
INTC	17.2%	27.9%	69%
AMD	32.6%	57.8%	29%
ON	16.8%	42.5%	2%
2 Assets – Optimal Portfolio	21.7%	30.9%	100%

Table 4.3 – Minimum Variance Portfolio and Optimal Portfolio of INTC, AMD and TXN

```
Minimum Variance Portfolio:
      Returns  Volatility  Sharpe Ratio  INTC weight  AMD weight   TXN weight
473  0.194179   0.251824      0.741722     0.466434    0.002775     0.530791


Optimal Portfolio:
      Returns  Volatility  Sharpe Ratio  INTC weight  AMD weight   TXN weight
613  0.223949   0.271657      0.797158     0.091801    0.131283     0.776916
```

Table 4.4 - Two Assets (T-Bill and INTC, AMD, TXN)- - Optimal Portfolio			
Asset	Annual Return	Annual Std Dev	Allocation
INTC	17.2%	27.9%	9%
AMD	32.6%	57.8%	13%
TXN	21.3%	26.9%	78%
2 Assets – Optimal Portfolio	22.4%	27.2%	100%

Table 4.5 – Capital Allocation Line

```
     Weight_Risky  Returns  Volatility  Utility
0           0.001   0.0074      0.0000   0.0074
1           0.002   0.0076      0.0003   0.0076
2           0.003   0.0078      0.0005   0.0078
3           0.004   0.0080      0.0008   0.0080
4           0.005   0.0083      0.0011   0.0083
..            ...      ...         ...      ...
995         0.996   0.2229      0.2703  -0.1424
996         0.997   0.2231      0.2706  -0.1430
997         0.998   0.2233      0.2708  -0.1434
998         0.999   0.2235      0.2711  -0.1440
999         1.000   0.2237      0.2714  -0.1446

[1000 rows x 4 columns]
```
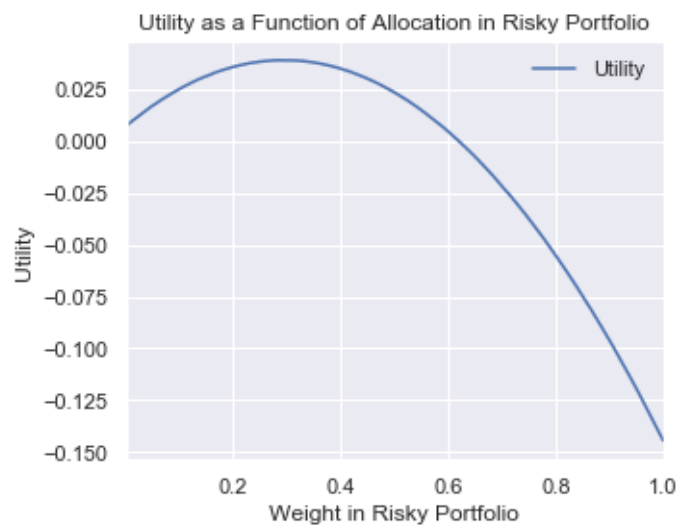
Figure 4.2 – Capital Allocation Line
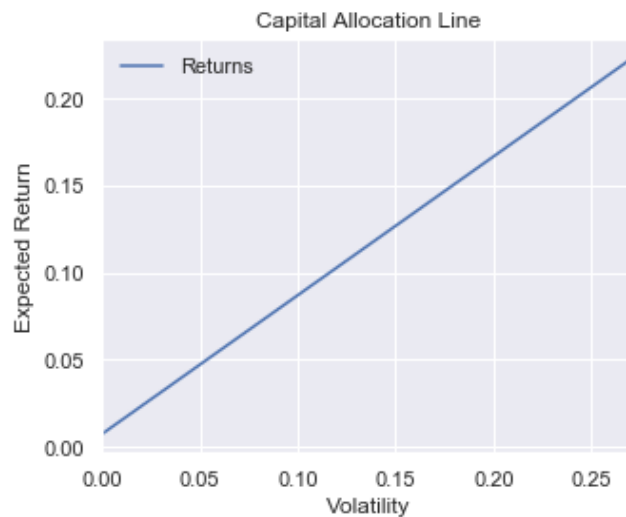
Figure 4.3 – Utility as a Function of Allocation in Risky Portfolio

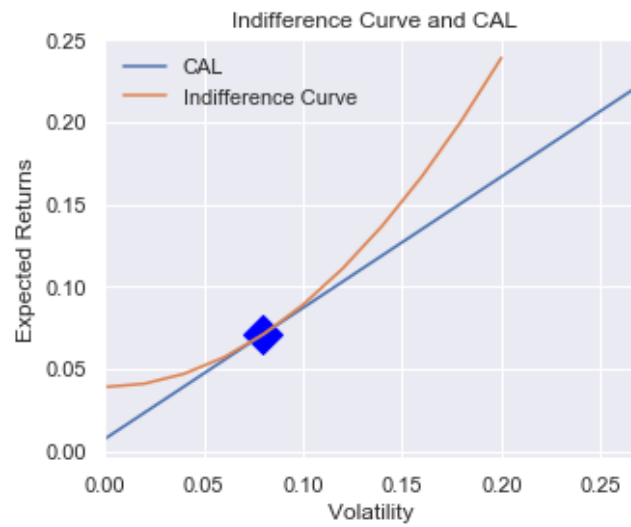**Figure 4.4 – Indifference Curve and CAL (2-assets optimizer)**

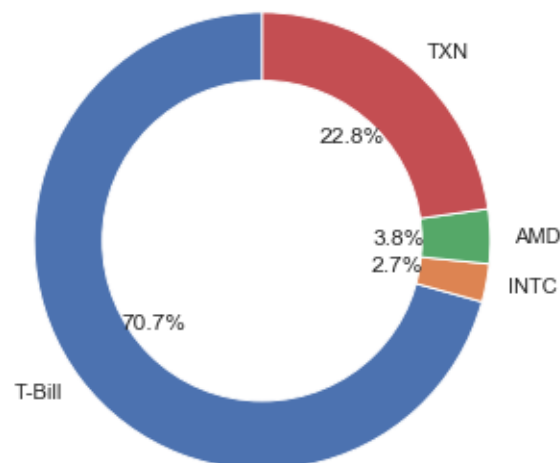**Figure 4.5 – Donut Chart of Asset Allocation (2-assets optimizer)**

Table 4.6 – Correlation Matrix between INTC, AMD, TXN and S&P 500 Index

```
Correlation Matrix:
          INTC       AMD       TXN       snp
INTC  1.000000  0.412541  0.691361  0.700182
AMD   0.412541  1.000000  0.464072  0.468837
TXN   0.691361  0.464072  1.000000  0.744135
snp   0.700182  0.468837  0.744135  1.000000
```

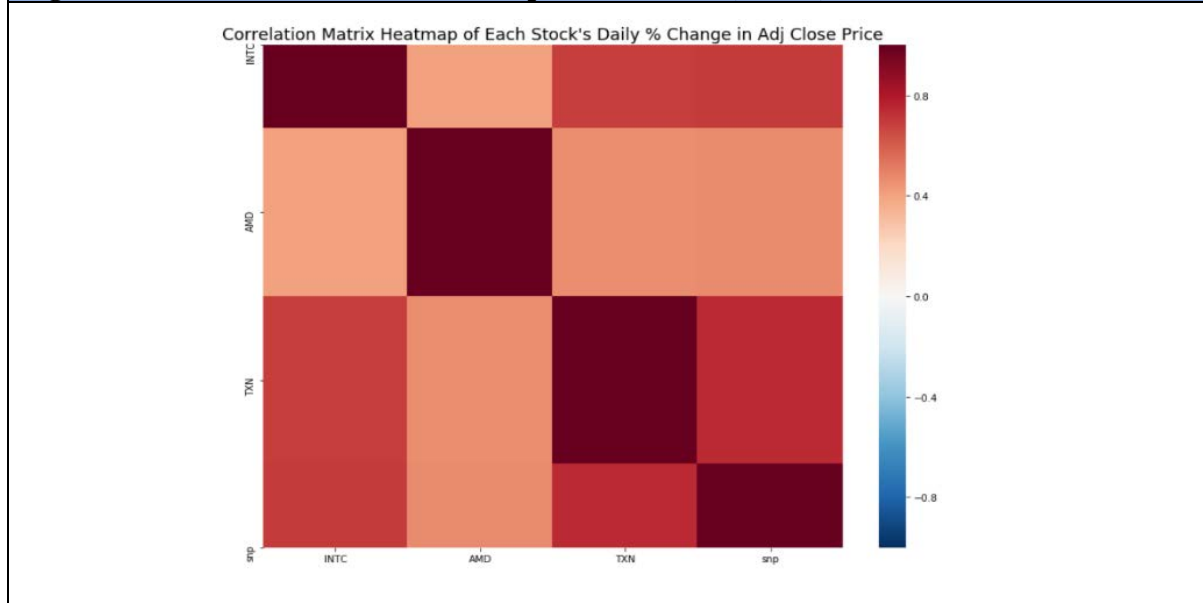**Figure 4.6 – Correlation Matrix Heatmap between INTC, AMD, ON and S&P 500 Index**

Correlation Matrix Heatmap of Each Stock's Daily % Change in Adj Close Price

Table 4.7 – Minimum Variance Portfolio and Optimal Portfolio - INTC, AMD, TXN and S&P 500 Index

```
Minimum Variance Portfolio:
      Returns  Volatility  Sharpe Ratio  INTC weight  AMD weight  TXN weight  \
118  0.143208    0.191805      0.708079     0.041022    0.061141    0.147607

      S&P 500 weight
118         0.75023


Optimal Portfolio:
      Returns  Volatility  Sharpe Ratio  INTC weight  AMD weight  TXN weight  \
773  0.219891    0.266939      0.796047     0.063681     0.15284     0.70698

      S&P 500 weight
773         0.076499
```

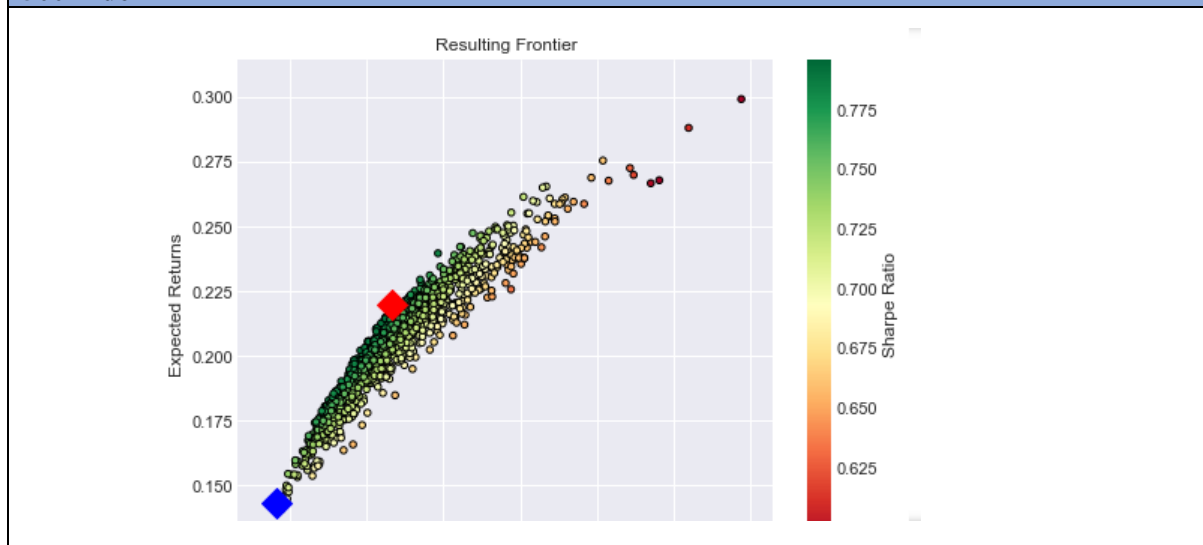**Figure 4.7 – Plot of Resulting Frontier with Special Portfolios - INTC, AMD, TXN and S&P 500 Index**
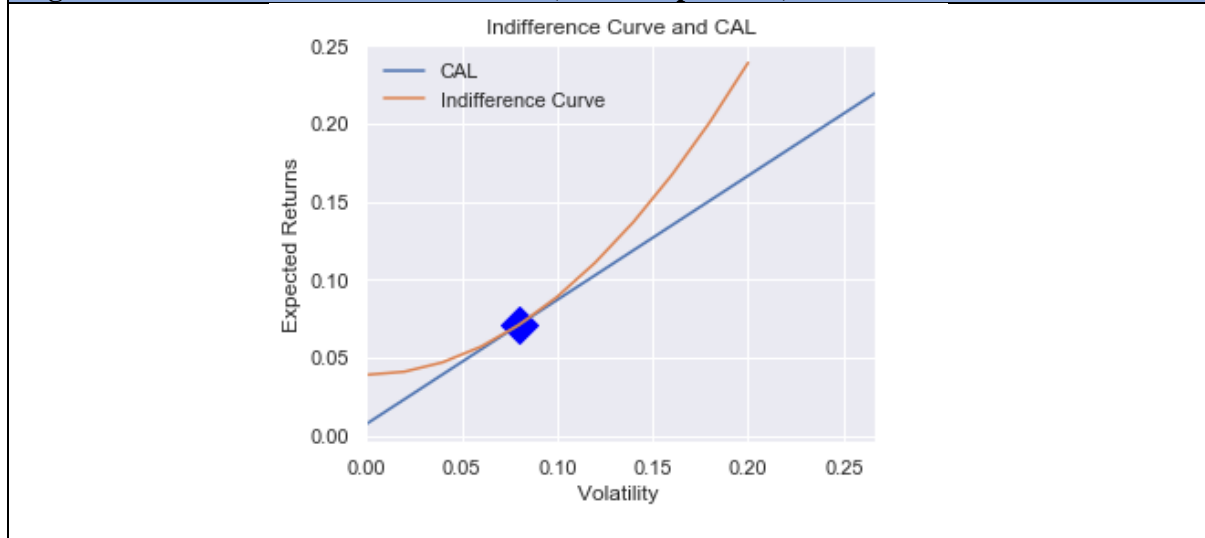

Resulting Frontier

| Table 4.8 – Three Assets (T-Bill, 3 High ESG Stocks, and S&P 500)- - Optimal Portfolio				
	Annual Return	Annual Std Dev	Sharpe Ratio	Allocation
INTC	17.2%	27.9%	0.590	
AMD	32.6%	57.8%	0.551	
TXN	21.3%	26.8%	0.764	
S&P 500	11.3%	17.5%	0.602	
3 Assets – Optimal Portfolio	22.0%	26.7%	0.796	

Figure 4.8 – Indifference Curve and CAL (3-assets optimizer)

Figure 4.9 – Donut Chart of Asset Allocation (3-assets optimizer)
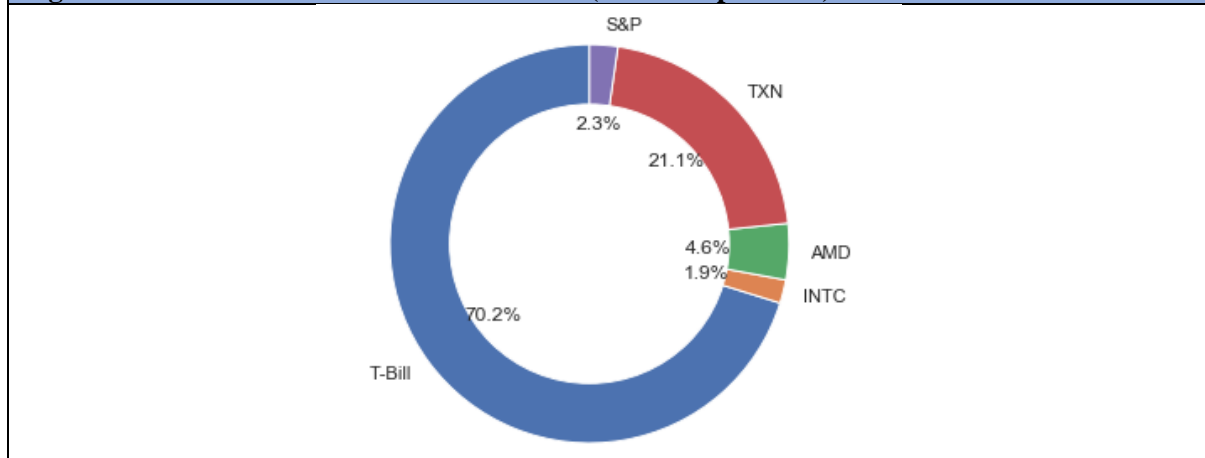
Figure 4.10 – Key Ratios of the Final Portfolio

```
Maximum value of Utility = 0.0527
Optimal weight in risky portfolio = 0.426
Expected return of complete portfolio = 0.098
Risk of optimal complete portfolio = 0.114
Sharpe Ratio of complete portfolio = 0.796
```

Table 5.1 – Risk Score Matrix

Risk Score Matrix	Value
Less than 4 years: Not suitable to invest	5
Up to 7 years: 25% Risky assets (75% T-bills)	4
Up to 11 years: 50% Risky assets (50% T-bills)	3
Up to 15 years: 75% Risky assets (25% T-bills)	2
More than 15 years: 100% Risky assets	1
Top up my investment	0
Do nothing	2
Sell my investment	3
Low	1
Medium	2
High	3
No stress at all!	0
0%	4
10%	3
20%	2
30%	1
More than 30%	0

Figure 5.1 – Utility as a Function of Allocation in Risky Portfolio for different Risk Aversion Score

Utility as a Function of Allocation in Risky Portfolio for different As
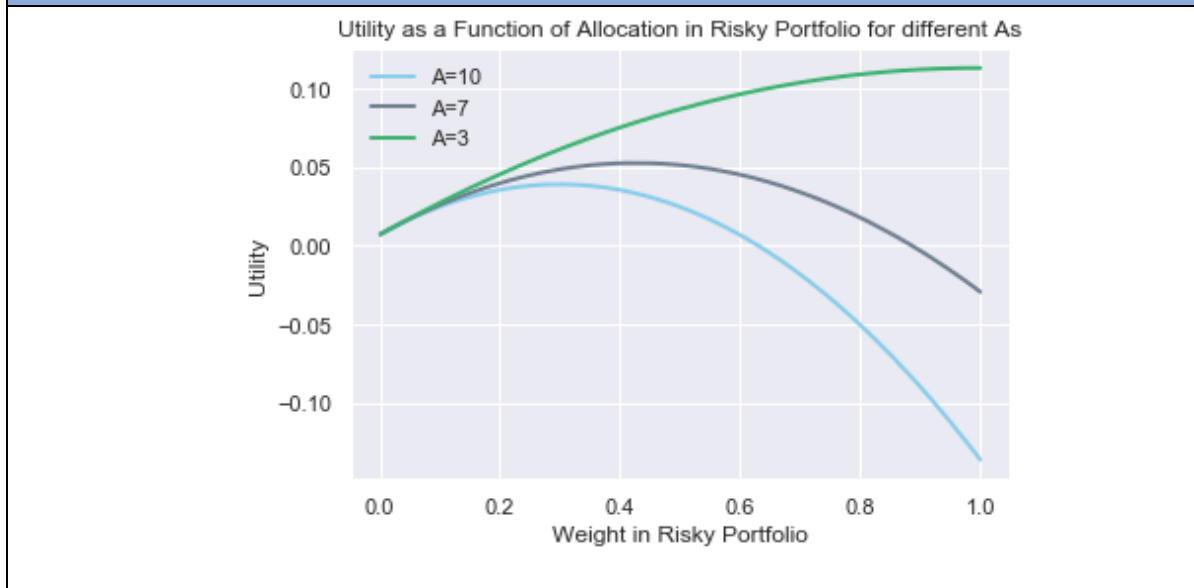
Table 5.2 – Comparison Table for investors with different risk-aversion rate

	Name	Risk-Aversion (A)	Weights of INTC	Weights of AMD	Weights of TXN	Weights of S&P500	Weights of Tbills	Maximum value of Utility	Expected return of complete portfolio
0	JiaYang	3.0	0.063299	0.151923	0.702738	0.076040	0.006	0.1131	0.219
1	ds	7.0	0.027128	0.065110	0.301173	0.032588	0.574	0.0527	0.098
2	trgfr	10.0	0.018977	0.045546	0.210680	0.022797	0.702	0.0392	0.071

9.2 Google Questionnaire

Link to google questionnaire: [Click here to Form](#)

Question 1. Stock markets can be very volatile in the short term but go up in the long term. You can have more risky assets if you have a longer time for recovery from a decline. Choose one of the potential Asset Allocation Guide.

○ Less than 4 years: Not suitable to invest

○ Up to 7 years: 25% Risky assets (75% T-bills)

○ Up to 11 years: 50% Risky assets (50% T-bills)

○ Up to 15 years: 75% Risky assets (25% T-bills)

○ More than 15 years: 100% Risky assets

Question 2. Investing carries risk. I am willing to accept temporary losses in the short term to achieve investment gains in the longer term.

○ Top up my investment

○ Do nothing

○ Sell my investment

Question 3. If your intended investment fluctuates significantly, your stress level will be:

○ Low

○ Medium

○ High

○ No stress at all!

Question 4. You understand the value of your investment portfolio will fluctuate over time. This means it will rise and fall in response to market movements. What is the maximum loss of value you could accept in any one-year period?

○ 0%

○ 10%

○ 20%

○ 30%

○ More than 30%