Investment Strategy

Our approach to investing was a top-down approach. This involved the selection of broad asset classes first and then selecting the individual securities after that (Bodie et al., 2021). We decided to divide our portfolio across risky and risk-free assets, with 90% in risky assets and 10% in risk free assets. We had three main sections in the risky part of the portfolio. The first of these is our bond section which is composed of different bond ETFs. Our second section is composed of different stock ETFs. Finally, our third section are our different individual stock selections that were selected from U.S, Australia, and New Zealand equity markets.

We analysed multiple different brokerages (Sharesies, Hatch, Stake etc) in New Zealand and decided upon Hatch given the volume of shares that would be traded in some of our transactions. To trade on Hatch, the $900,000 NZD allocated to risky assets would need to be converted to USD. When converting to USD there is a 0.5% fee charged by Hatch for every dollar converted (Hatch, n.d.). This comes to:

$$USD = (0.706394281 - (0.706394281 * 0.005)) * 900{,}000$$
$$USD = \$632{,}576.08$$

(PoundSterlingLIVE, 2021).

with a total exchange fee of $3,178.77. In addition to this, Hatch charges $3 up to 300 shares, and $0.01 for every share traded after for both buying and selling (Hatch, n.d.).

Based on our personal risk tolerance, we decided to divide 60% of the $632,576.08 USD towards our stock index and bond ETFs and the remaining 40% towards our individual stock selection. In total this gave $379,545.65 towards stock and bond ETFs and $253,030.43 towards individual stock selection. The weights of the stock and bond ETF portfolios were determined from the Markowitz Portfolio Optimization Model as well as the weights of the different securities within each of the bond and stock portfolios (Markowitz, 1952).

To keep track of our investments we had a master Excel spreadsheet which we used to record price movements of actively traded securities over the investment period, and cash flows. We automated our spreadsheet so that every time a transaction occurred (such as buying stock or receiving dividends), the returns tables were updated to reflect the performance of the assets. **Appendix A** shows the transactions for purchasing some bond ETFs while **Appendix B** shows how this was collated into a returns table using Excel filters.

Security Selection

We were skeptical to include any risk-free assets in our portfolio due to observing very low interest rates but chose to invest 10% into a term deposit as a method of diversification and accounting for foreign exchange risk. The best term deposit rate in New Zealand at the time of investment was ASB's 0.15% annual rate for 30-day deposits (ASB, 2021). From here our risky asset allocation of 90% of the remaining funds was split with 60% over passively managed ETFs and 40% over actively traded stocks. We then conducted research into fund managers, past performance, and financial metrics, to select potential securities. Following this, individual security weightings were optimised by maximising the Sharpe ratio by varying the weightings in each class. This was employed through Excel using the method described by Bodie et al (2021) in Chapter 7.

Our original bond ETF selections included seven Vanguard ETFs spread over government, corporate, and mortgage-backed funds. We chose Vanguard ETFs primarily due to their minute expense ratios. According to Morningstar (2020) the average asset weighted expense ratio for ETFs is 0.45%, whereas Vanguard has a 0.10% average asset weighted expense ratio, with some of our selections being even lower (such as the 0.05% ETR for VGSH). Other factors we considered when selecting these ETFs included investment periods, historical performance, price compared to net asset value, and tracking difference to underlying indices.

After calculating the weighting of securities to maximise the Sharpe ratio we ended up investing in only four Vanguard ETFs, two government funds and two corporate funds. These funds were VGSH, VGIT, VCIT, and VCLT (Vanguard, 2021). We invested in all of these funds at a premium with the lowest being VGSH and VGIT at a $0.01 premium, and VCLT being the highest at a $0.44 premium. All of these are well managed funds which on average track within 0.15% their underlying indices (Vanguard, 2021).

The selection of our six potential stock ETFs followed a similar process. We first looked for stock ETFs with low total expense ratios which again led to Vanguard funds. The Vanguard ETFs selected included VTI, VGK, VT, and VWO (Vanguard, 2021). We also looked into some iShares funds due to their reputation as fund managers and the range of ETFs they have on offer. The iShares ETFs of interest to us were ENZL and EWA which track the MSCI New Zealand and MSCI Australia indices respectively (iShares, 2021). There were no index funds offered by Vanguard that cover the New Zealand and Australia stock market individually. A priority of ours was to invest in ETFs globally and over a wide array of different regions to minimise country-specific political and liquidity risk. We also again assessed tracking differences, historical performance, and price to net asset value. Although most ETFs trade close to their NAV, we thought it was important to make sure we looked into reasons behind abnormally high premiums/discounts.

After calculating the weightings of ETFs to maximise the Sharpe ratio for our stock ETF segment we invested in three ETFs; VTI, VT, and ENZL. Both Vanguard ETFs have average asset weighted expense ratios less than 0.10% while iShares' ENZL has an average asset weighted expense ratio of 0.51% (Vanguard, 2021; iShares, 2021). Both Vanguard stocks were purchased at a premium, $0.08 for VTI and $0.14 for VT (Vanguard, 2021). ENZL was purchased at a $0.27 discount (iShares, 2021). All three ETFs track well to their underlying indices with the lowest tracking difference being VTI at 0.02% and the highest being ENZL at 0.77% (Vanguard, 2021; iShares, 2021).

For the individual stock portion of our portfolio, we wanted to invest in very few stocks to maximise the potential returns given the large majority of our portfolio is made up of extremely diversified index ETFs. Our original stock selection was focused on historical performance but also considered company financials despite only holding the stocks for a short period. The key financial measures we used to select stocks were: price to 52 week high/low ratio, earnings per share, price to earnings ratio, leverage ratio, and net income.

A summary of all the initial securities selected can be seen in **appendix C**.

Risk Diversification

To manage the risk of our investment we constructed an efficiently diversified portfolio to ensure minimal risk for our expected return. To do this we began with calculating the weekly percentage change in price (weekly return) of each ETF. This was done using the closing price of each stock collected from Yahoo (n.d.). If stocks were in a currency other than USD, we would convert the price of the stock to USD using the foreign exchange rate on the 6th of April. Dividends were not incorporated into the return calculations. The data spanned from the 6th of April 2015 to the 6th April 2021 providing us a six year time horizon. With this, we were able to compute an expected weekly return by finding the average return of all the weekly returns during this period:

$$E(r_i) = \frac{1}{N}\sum_{i=1}^{n} \quad R_i$$

With the expected return calculated, we also calculated the variance of each ETF and its covariance with other securities within its respective portfolio. Despite having calculated the weekly return and variance we decided to use the yearly return and variance by multiplying the variance/covariances and expected returns by 52.

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{n} \quad (R_i - E(r_i))^2$$

$$\sigma^2{}_P = w^2{}_A\sigma^2{}_A + w^2{}_B\sigma^2{}_B + 2w_A 2w_B Cov(r_A, r_B)$$

From this we created a covariance matrix and altered the weights using the solver tool through Excel to find a weighted average expected return and standard deviation that maximises the Sharpe Ratio.

$$max\frac{1}{\sigma_P}\textstyle\sum_{i=1}^{n} \quad w_i E(r_i) - r_f$$

$$subject\ to$$
$$\sum_{i=1}^{n} \quad w_i = 1,$$
$$w_i \leq .5$$

The solver tool was used to maximise the Sharpe ratio subject to the following constraints:

- The sum of the portfolio weights must equal 1
- An individual ETF weight must be less than or equal to 0.5

The reasoning behind the second constraint was to create a portfolio with at least 3 individual ETF securities. Without it, the Excel solver would create portfolios where one security would often have a weighting greater than 0.9.

After calculating the portfolio weights, the expected return of the portfolio was calculated by multiplying each individual ETF weight by its expected return:

$$E(r_P) = \sum_{i=1}^{n} \quad w_i E(r_p)$$

This is also the risk premium in our case due the risk-free rate being close to zero:

$$E(r_p) = E(r_i) - r_f$$
$$E(r_p) = E(r_i) - 0$$
$$Risk\ Premium = E(r_p)$$

These optimal weightings for both the bond and stock portions were then combined and weight adjusted returns were calculated by multiplying the weekly return by the weighting for each security. This gave a set of weekly returns for each portfolio from which we could calculate the expected return, variance, and covariances. From here the above process was repeated to find the optimal weight of a combined bond and stock ETF portfolio.

The weightings for VGK, VWO and EWA were all zero in our optimized portfolios so these were excluded from our portfolios at this point. The remaining resultant weightings are shown in **Appendix D**. The bond ETF portfolio had a maximum Sharpe ratio of 0.1875 while the stock

ETF portfolio had a maximum Sharpe ratio of 0.6474. Combined, the portfolio had a maximum Sharpe ratio of 0.649.

We also diversified our portfolio based on some other quantitative characteristics to minimise other forms of risk such as interest rate risk, political risk, and liquidity risk. Bodie et al. (2021) suggests that bonds (or funds in our case) exhibit greater sensitivity to interest rate fluctuations as maturity lengthens. Because of this, short term ETFs tend to have lower risk but bear lower returns, on the other hand longer term ETFs fluctuate with high volatility in the short term but have the potential for greater returns. With this in mind we included ETFs targeted at different investment periods to be able to take advantage of favourable interest rate changes while reducing risk through maturity diversification. Scully (2010) states that trading volume is a measure of success in ETFs and hence can be an indicator of liquidity in the secondary market. This study however also mentions low trading volume and net assets does not necessarily result in lower liquidity and also depends on liquidity of the underlying assets. Hence, to manage liquidity risk we looked at ETFs with high trading volumes (at least 100,000 daily) and high net assets (at least $10 million) to maximise liquidity and ensure we could exit the ETF within a short time horizon. Lastly, we included securities over multiple regions (US, NZ, and global) to manage political and regional specific risk.

Stock Selectivity

Given that both the stock index portfolio and bond ETF portfolio were distributed accordingly in order to maximize their Sharpe ratio, it seemed fitting to apply a more experimental approach to the process of individual stock selection. This is because the index and bond ETF portfolio are already efficiently diversified across the respective markets that each individual ETF represents, therefore any individual stock selection would already overlap with that of the stock index ETFs. As a result, the individual stock selection only fitted 15 stocks across New Zealand, Australia, and United States equity markets. This variety in stocks diminished as the period of investment went on as stocks were liquidated based on their return.

To begin with, each individual stock was carefully selected based on their underlying financials. We looked at multiple financial ratios and figures to investigate if they created an overall promising view of the underlying value of each stock. These financial figures included:

P/E ratio: The price to earnings ratio is calculated by dividing the stock price by the earnings per share (Fridson & Alvarez, 2011). The ratio is an important indicator of the value of a stock and how it is priced by the market when compared with similar companies (Fridson & Alvarez, 2011). If a stock has similar underlying financials to another company (earnings growth rate, rate of return), then the stock with the lower price to earnings ratio can be considered better value for the price paid (Fridson & Alvarez, 2011). When analyzing our individual stocks, we compared their respective P/E ratios to the industry average as a gauge of whether a stock might be underpriced.

Price to Book Ratio: Another important financial ratio is the price to book ratio which assesses the market value of the firm in comparison to its book value. Stocks that are overpriced will tend to manifest a very high price to book ratio (Graham, 2006). Graham (2006) suggests avoiding stocks with a ratio greater than 1.5 although provided a large portion of a company’s value is derived from intangible assets, a more appropriate ratio may be 2.5.

Revenue and Profit: When looking at the revenue and profits generated by each individual stock's financials, it was important that each firm had generated a consistent profit for at least 3 years and had promising year on year revenue growth. This means that the firm has a solid business model that is generating a return. Any stock that had generated a loss recently was not selected.

Balance Sheet: Stocks with excessive amounts of debt-to-equity ratios were ignored as they would likely generate a smaller return in the future due to excessive interest payments.

Cash Flow Statement: The statement of cash flows was compared to both the balance sheet and income statement. Firms which had increased the amount of debt that they had taken on from previous years were investigated to see how much was contributed to investing activities and whether this investment was generating increasing returns for the company.

Current Price relative to 52 Week High/Low: Stocks that had a current price that was closer to the 52-week low hypothetically have a higher probability of increasing in price in the future. This is assuming the underlying financials are sound and therefore the stock is momentarily underpriced by the market. Firms with unsound financial statements are closer to the 52-week low due to their financial vulnerabilities. Stock prices that are closer to their 52-week high, are likely to experience a decrease in the price of their stock as it converges to their average price. This is assuming some new information hasn't changed the average price according to the efficient market hypothesis (Bodie et al., 2021).

After each individual stock was screened for its financial solidity, it was placed into the individual stock portfolio. As mentioned earlier, the Sharpe ratio and efficient portfolio diversification was largely ignored as this strategy was employed in the stock index and bond ETFs. The individual stock strategy was largely experimental.

The efficient market hypothesis states that stock prices will follow a random walk with unpredictable price changes (Bodie et al., 2021). Despite this, the returns on any stock will remain stable and converge to the mean over time (Elton & Gruber, 1973). As Bodie at al. (2021) mentions, the returns on a stock will become approximately normally distributed as the time period of data increases. The approximation to a normal distribution is the fundamental reasoning behind our strategy. When the returns of a stock are normal, we can theoretically estimate the probability of the stock price increasing/decreasing in the future. This will give us an indicator of when is the best time to purchase or sell shares to maximise returns. To do this, we need an estimator of the expected return of the stock and an estimator of the standard deviation.

To calculate the expected return of a stock, we calculated the beta of the stock. This was done by collecting the returns of the stocks from the 6th of April 2018 to the 6th of April 2021. In addition to this we used the daily returns of the stocks respective market index etf to use as the returns for the market. For example, Meridian Energy (MEL) would use the iShares ENZL ETF which acted as the New Zealand Expected Market Return. With both sets of returns, we calculated the covariance between the stock and the market returns and divided by the variance of the market returns to obtain a beta coefficient.

$$\beta_i = \frac{Cov(r_i, r_m)}{\sigma_m}$$

From this we used the Beta coefficient of the stock and the CAPM model to obtain an estimated expected return for the stock (Bodie et al., 2021).

$$E(R_t) = t * [R_f + \beta_i(E(R_m) - R_f)]$$

Because the risk free rate was negligible and considered to be 0.

$$E(R_t) = t * [\ \beta_i(E(R_m)\ )]$$

With a daily expected return for the individual stock, we then multiplied by 7 to obtain the weekly expected return

$$E(R_i)_{weekly} = 7 * E(R_i)$$

Our method of calculating the standard deviation involved collecting the daily returns of each stock from the 6th April 2018 to the 6th April 2021. We then used excel to calculate the standard deviation of the daily returns and then multiplied this value by the square root of 7 to obtain the weekly standard deviation (Bodie et al., 2021).

$$\sigma_{weekly} = \sigma_{daily} * \sqrt{7}$$

With both the Expected weekly return and the standard deviation we can then theoretically calculate the probability of a change in the price of a stock. This is done by first calculating the cumulative return from the date of purchase. This is a simple percentage change formula:

$$Cumulative\ Return = X = \frac{Current\ Price - Original\ Buy\ Price}{Original\ Buy\ Price}$$

This cumulative return then operates as the acting weekly return which is then standardised to obtain a Z-score from which the p-value can be calculated.

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$$

It is important to note that after a week, the standard deviation needs to be adjusted to reflect the additional period of time for variation. This would typically be done as follows:

$$\sigma_{2-week} = \sigma_{1-week} * \sqrt{2}$$

Given the time period of investment however, it was better to use an adjusted standard deviation that limited out to a specific value over time. This was done using the following formula:

$$\sigma_t = [((\sigma_{weekly} * \sqrt{t}\ ) - \sigma_{weekly}) * \frac{1}{\sqrt{t}}] + \sigma_{weekly}$$

This adjusted standard deviation would have a much smaller incremental change that wouldn't result in stocks being held too long given the large increases that come from the typical proportionate change of the square root of 't'.

Once a stock had a probability (p-value) of a 10% chance of decreasing in price, it reached a limit where the stock had disproportionately lowered to a point where it would be more beneficial to cut losses and sell. Note that this is up for debate and the stock could be held indefinitely if the underlying financials of the company are sound, as given enough time, it may see an eventual increase in price beyond its buy in. A stock with a probability (p-value) of a 5% increase in price has reached a limit where the probability of increasing is much less than the probability of it decreasing and should therefore be sold to maximise returns.

When a stock is sold due to a large negative or positive return, the sold stock would be reduced to a weight of 0. The funds received were then reallocated to the remaining stocks in the portfolio. The weight of the redistributed funds that each stock received was based on its probability of an increase in price. This was done through the summation of each stock's p-value based on their current purchase price. Each stock’s respective p-value was then divided by this sum to get their weight of the redistributed funds.

$$w_i = \frac{p_i}{\sum_{x=1}^{n} \quad p_x}$$

Therefore, stock’s with a higher probability of a price increase would get a higher allocation of the redistributed funds.

$$p_i > 0.95$$
$$p_i < 0.05$$

Note that each stock began with an equal weighting from the 6th of april and this weighting only changed as stocks were sold. While it was possible to do a covariance matrix for the 15 stocks and obtain portfolio weights that maximize the Sharpe ratio, we opted for a more experimental process. This ensured that each stock was guaranteed a portfolio weight greater than 0.

This experimental strategy assumes that the returns of each individual stock forms a normal distribution.

Performance of Portfolio

Bonds - Appendix E

From the 6th of April 2021 to the 15th May, our bond portfolio increased in market value from $104,788.70 to $105,026.38. This represents a capital gain of $237.68. The dividends received from the bond ETFs totaled $162.93. This created a total yield of $397.61 over the investment period or 0.38% of the original market value. When accounting for fees, the total profit is reduced by $36.52 to create a total figure of $364.09 or a return of 0.35% on the original market value.

Of the four bond ETFs, VCIT had the largest return on original market value with a 6-week percentage return of 0.94%. Second to this was VGIT with a yield of 0.45%, followed by VGSH with a 6-week return of 0.27%. The only bond ETF to generate a negative return was VCLT with a negative yield of -0.81%. Despite generating a lower percentage return of 0.45%, VGIT contributed to 60.3% of the profit due to its larger portfolio weight. The second biggest contributor was VCIT with 41.6% of the profit. Even though VCIT only had the third highest weighted average, it generated the highest percentage return of 0.94%. WCLT, which generated a negative return of -0.81% offset the return of $64.06 from VGSH with its total loss of -$71.05. (Note: All the returns of individual bond ETFs include dividends received over the investment period).

VCIT, which generated the highest capital appreciation of 0.76% over the investment term, performed above its expected 6-week return of 0.142%. This was the same for VGIT which outperformed its expected return of 0.06% by 0.3 percentage points. VGSH with a real return of 0.033%, performed closest to its expected return of 0.013% relative to other bond ETFs and their expected returns. VCLT, which had a negative capital appreciation of -1.07%, underperformed against its expected 6-week return of 0.283% by -1.35 percentage points.
VCLT had the biggest percentage point difference (-1.35), then VCIT (0.618), followed by VGIT (0.3), and finally VGSH (0.02). This is to be expected given the individual standard deviation of each ETF. The higher volatility associated with longer term bond ETFs accounts for the percentage point differences shown. It is important to remember when comparing each ETFs actual return to its expected return, the estimated expected return is only based on capital returns and does not incorporate dividends.

The expected 6-week return of the combined portfolio was 0.079% excluding dividends. Our actual combined portfolio generated a return of 0.23% excluding dividends. This equated to 0.15 percentage points above the expected return. Our combined portfolio return, when divided by a standard deviation of 0.4215%, returned a p-value less than 1 standard deviation away from the mean indicating that this is a reasonably expected result.

Stock Index - Appendix F

Over the investment period, the stock index portfolio composed of VTI, VT, and ENZL, increased in market value from $274,512.87 on the 6th of April to $279,318.24 on the 15th May. The appreciation in market value totaled $4,753.77 with no dividend yield over the investment period. This represented an increase in capital value of 1.73% over the investment period. Deducting transaction fees of $51.60 from the capital appreciation creates a theoretical profit of $4753.77 if the entire stock index portfolio were to be liquidated on the 15th of May. Of the three stock indexes, VT experienced the largest percentage increase in capital with a 1.81% capital appreciation. VTI and ENZL both had a 1.77% and 1.70% increase in market value respectively. However due to having a lower weighted average in the stock index portfolio, VT contributed to 17.8% of the total profit, while VTI, which had the highest weighted average, contributed to just over half of the total profit.

VTI's expected weekly return of 0.24% resulted in an expected 6-week return of 1.46% when adjusting for the investment period. Relative to the actual investment returns, VTI performed above its expected average by 0.31 percentage points.

With an expected weekly return of 0.18% and an expected 6-week return of 1.08%, ENZL also performed above its expected average for the investment period. With a real return of 1.70%, ENZL outperformed its expected average by 0.62 percentage points.

The biggest performer was VT, with an expected 6-week return of 1.05%, VT's real return of 1.81% meant the stock index performed a total of 0.76 percentage points above its expected return.

The combined portfolio had an expected weekly return of 0.21% with an expected 6-week return of 1.27%. This would have created a hypothetical profit of $3,434.70 when accounting for fees. Over the investment period, the actual return of 1.73% was 0.48 percentage points higher than the expected 6-week return. This above average return meant $1,367.67 or 39.8% of additional profit was generated relative to the expected return. Based on a standard deviation of 1.95%, the above average return was less than 1 standard deviations away from the mean and therefore a reasonably realised return.

Individual Stock Selection - Appendix G

Composed of 15 different stocks, the individual stock portfolio increased in market value to $268,305.36 on the 15th of May from its original starting market value of $252,766.33. This represents a total capital gain of $15,539.03 for the investment period or a yield of 6.16%. Because of the buying and selling of stock and the constant changes in the asset weights, it is unreasonable to compare this yield to an expected return.

Looking at all the stocks individually and analysing their performance we can identify that Fortescue Metals Group generated the biggest return on investment. Generating a total profit of $13,130.85 on the $22,013.53 invested and a yield of 59.65%. The second-best return on investment was Macquarie Group with a yield of 34.34% and a profit of $9556.34 generated over the investment period.

The worst performer of the portfolio was A2 Milk Limited. At a low price of $4.67 (USD) on the 10th of May, A2 Milk's proportion in the portfolio was liquidated for $18,829.72 with a total of $29,929.11 invested. This created a loss of -$8188.55 and a total yield of -30.41%, by far the worst performer of the stocks. Overall, the total cost of trading fees was $581.71 for the stock selection portfolio.

Combined Portfolio - Appendix H

When looking at the combined portfolio of both the stock ETF and the bond ETF portfolios, we can sum the profits of each to get a combined return. This amounts to a total profit of $5,117.86 or a 1.35% return on the original $379,545.65 invested. When comparing this to the expected 6-week return of 0.94%, the actual return on the combined portfolio is 0.41 percentage points higher. With a combined standard deviation of 1.44, the excess return generated during this period is less than 1 standard deviation away from the mean indicating that this return is not an abnormality.

Combining the bond and stock ETF portfolios, along with the individual stock portfolios, we generated a total profit of $20,656.88. This equates to a total return of 3.27% of the original market value of $632,067.90 over the 6-week investment period. We can compound this rate to get an estimate of the effective annual return (Bodie et al., 2021).

$$(1 + EAR)^{6/52} = 1.0323$$
$$EAR = 1.0323^{52/6} - 1$$
$$EAR = 32.16\%$$

At an exchange rate of 1.3723 USD = 1NZD, this converts to a total of $891,375.87 NZD (PoundSterlingLIVE, n.d.). Given that we originally exchanged $900,000 NZD, this leaves a negative -0.95%. To calculate the total cost of foreign exchange rate changes, we can compare our negative return with what we would have received if the exchange rate remained unchanged. At the exchange rate of 1.43 that we originally converted at, our total USD funds would be converted to a total of $933,522.45. This would have equated to a $33,522.45 return or 3.72% yield. This corresponds to a total foreign exchange cost of $42,146.58.

Combining our risky portfolio returns with our risk-free return of $100,007.00 leaves us with a total fund value of $991,382.87. This amounts to a -$8,617.13 return or -0.86% yield.

Lessons and Why

An important lesson learnt from both our stock and bond ETF portfolios is that the total profit generated is dependent upon the weight that a particular ETF has within the portfolio. An equity security which generates a higher percentage return will generate a lower nominal profit the lower its weight within the portfolio. This was exhibited by our bond ETF portfolio when VGIT contributed the most to the profit return despite having the second highest return of 0.44%, simply because it had the highest weight within the portfolio.

Diversification is essential for maximising the return/risk trade-off. A portfolio that has been diversified according to the Sharpe ratio will generate the best ratio of reward for each unit of risk it takes on. Despite this, a diversified portfolio will not always maximise returns. This is because the return on a diversified portfolio is based on the weighted average returns of the securities that comprise said portfolio. This was evident in our stock ETF portfolio where VT generated a return of 1.81% however the combined portfolio return amounted to 1.76%. If VT had a portfolio weight of 1, the return of the portfolio would equal 1.81% but would experience increased susceptibility to volatility.

Despite changes in the foreign exchange having a significant impact on our total return, the total effect of the negative return was lessened from the risk-free asset being in New Zealand. Because the term deposit was localised it was unaffected by the exchange rate depreciation. This reduced the negative return from -0.95% to only -0.86%, showing the importance of having different assets in different currencies to mitigate foreign exchange risk. Other tools can be utilised such as forward exchange rates or potentially holding assets until exchange rates become more favourable.

Can you do Better

General

When calculating the expected return and variances of our stock and bond ETF portfolios, we did not incorporate dividends into the return data. This potentially gave us misleading judgement as to the true expected return and variance. The result of this would be even more compounded when accounting for the calculation of covariances and maximising of the Sharpe ratio. This would have resulted in incorrect portfolio weights which don't minimise risk and maximise return. This is especially true for the bond ETF portfolio where dividends are paid out monthly.

To prevent one ETF taking up too much of the portfolio we restricted the maximum weight an ETF could have to 0.5. This reduced the maximum Sharpe ratio, creating incorrect portfolio weights that are not optimised. Considering that index ETFs are extremely diversified, it may have been more beneficial to exclude this restriction and eliminate portfolios that are inefficient given the other ETFs within the portfolio.

Individual Stock Portfolio

With our individual stock portfolio, we avoided using a covariance matrix to determine portfolio weights and chose to start with equal portfolio weighting for each stock in the portfolio. In future, we could utilise a covariance matrix and determine a portfolio that maximises the Sharpe ratio as a reference for the starting portfolio weights.

Throughout the investment period no new shares were bought and no previously sold shares were rebought. This reduced the diversification of the portfolio and led to the concentration of funds in the remaining shares. This meant that any share that experienced an abnormally low return later on in the investment term would have an increasing impact on the total portfolio return. In future, this could be mitigated by purchasing new shares to ensure the number of stocks within the portfolio stays at 15 minimum. If we were to use our experimental strategy as a determinant of when to purchase new shares, we would not be able to use the cumulative return as there is no purchase price that we can calculate the cumulative return from. Because of this another metric would have to be used.

When using the p-values to determine the portfolio weighting, more weight would be applied to underperforming stocks. This became an issue when stocks would reach an abnormally low return at which they would have to be sold. As time went on, stocks historically underpriced during the investment period were allocated more of the redistributed funds and then, when sold, generated a larger loss than would be the case had these funds been allocated elsewhere. This was no more evident than in the case of A2 Milk, which had a historically high p-value over the investment term and hence had a large amount of reinvestment ($10,060.60) directed towards it. When it sold at its abnormal price of $4.68 (USD) on the 10th May, the stock realised a loss of -$8,188.55. Given that stocks with larger negative returns had an increased probability of increasing in price in the future, it made sense hypothetically to allocate more funds to these stocks to maximise returns however this fell short when selling the stock at a specified p-value. In the future this effect could be removed by changing the determination of portfolio weights from being based on the p-value as it was during our experimental strategy. This effect could also be removed by lowering or eliminating the maximum downside return although this could prove even more costly in the future if the stock never returns to its original buy in price.

During our experimental strategy, we used the return on the original buy-in price as a value for ‘X’ to determine the p-value. This became a problem when more shares of the same stock were purchased at a different price. The p-value was still being determined by the original buy-in price on the 6th of April. This becomes a problem when an abnormal price causes a sell action. Shares that were bought at a lower or a higher price would be yet to see this abnormal return but would still be sold thereby reducing potential gains or increasing losses. In the future we could use the weighted-average price to calculate the return for X, or create separate probability tables each time a share is bought at a different price.

Fama & French (1992) suggest that size and book-to-market equity have a much higher explanatory power of the expected return when compared to Beta. The reasoning behind this is that firms with poor prospects are characterised by low stock prices and a high book-to-market equity ratio, and therefore have higher expected stock returns relative to low book-to-market equity ratio firms (Fama & French, 1992). In our individual stock selection, we used Beta as an estimate for the expected return of each individual stock however this suggests that other variables such as size and book-to-market equity could be used to get an estimated stock market return.

Appendix A.

Date	Name	Ticker	Type (Bond, Stock, Index)	Buy/Sell Price	Quantity	Fees	Dividends
6-Apr	Vanguard Short Term Treasury ETF	VGSH	BOND_ETF	$ 61.51	-448	$ (4.48)	$ -
6-Apr	Vanguard Intermediate Term Treasury ETF	VGIT	BOND_ETF	$ 67.42	-778	$ (7.78)	$ -
6-Apr	Vanguard Intermediate Term Corporate Bond ETF	VCIT	BOND_ETF	$ 93.26	-180	$ (3.00)	$ -

Appendix B.

Ticker	Yield	Dividends	Fees	Total Yield
VGSH	$ 8.96	$ 64.06	$ (8.96)	$ 64.06
VGIT	$ 186.72	$ 48.24	$ (15.56)	$ 219.40
VCIT	$ 127.80	$ 29.88	$ (6.00)	$ 151.68
VCLT	$ (85.80)	$ 20.75	$ (6.00)	$ (71.05)
Total	$ 237.68	$ 162.93	$ (36.52)	$ 364.09

Appendix C.

VGSH	Vanguard Short Term Treasury ETF
VCSH	Vanguard Short Term Corporate Bond ETF
VGIT	Vanguard Intermediate Term Treasury ETF
VCIT	Vanguard Intermediate Term Corporate Bond ETF
VCLT	Vanguard Long Term Corporate Bond ETF
VGLT	Vanguard Long-Term Treasury ETF
VMBS	Vanguard Mortgage-Backed Securities ETF
VTI	Vanguard Total Stock Market Index Fund
VT	Vanguard Total World Stock Index Fund
ENZL	iShares MSCI New Zealand ETF
MEL	Meridian Energy
FPH	Fisher & Paykel
ATM	A2 Milk Company - NZ
RIO	Rio Tinto Group
FMG	Fortescue Metals Group
MQG	Macquarie Group
AGG	AngloGold Ashanti Limited
KLA	Kirkland Lake Gold Limited
EVN	Evolution Mining Limited
AGL	AGL Energy Limited
SSR	SSR Mining Inc
BKW	Brickworks Limited - AX
REGN	Regeneron Pharmaceuticals
KGC	Kinross Gold Corporation
ORCL	Oracle Corporation

Appendix D.

Weightings	
Risky	0.9
ETFs	0.6
Bond ETFs	0.2765
VGSH	0.2628
VGIT	0.5
VCIT	0.1605
VCLT	0.0767
Stock ETFs	0.7235
VTI	0.5
VT	0.1707
ENZL	0.3293
Individual Stocks	0.4
MEL	0.0666
FPH	0.0666
ATM	0.0666
RIO	0.0666
FMG	0.0666
MQG	0.0666
AGG	0.0666
KLA	0.0666
EVN	0.0666
AGL	0.0666
SSR	0.0666
BKW	0.0666
REGN	0.0666
KGC	0.0666
ORCL	0.0666
Risk Free	0.1

Appendix E.

Bond Summary	Ticker	06/04/2021		15/05/2021	Percentage Return	Expected 6-Week Return	% Point Differen ce
Market Value							
Vanguard Short-Term Treasury Index Fund ETF	VGSH	$27,556.48		$27,565.44	0.03%	0.01%	0.02%
Vanguard Intermediate-Term Treasury Index Fd ETF	VGIT	$52,452.76		$52,639.48	0.36%	0.06%	0.29%
Vanguard Intermediate-Term Corporate Bond ETF	VCIT	$16,786.80		$16,914.60	0.76%	0.14%	0.62%
Vanguard Long-Term Corporate Bond Index Fund ETF	VCLT	$7,992.66		$7,906.86	-1.07%	0.28%	-1.36%
Plus Dividends							
Vanguard Short-Term Treasury Index Fund ETF	VGSH	$0.00		$64.06			
Vanguard Intermediate-Term Treasury Index Fd ETF	VGIT	$0.00		$48.24			
Vanguard Intermediate-Term Corporate Bond ETF	VCIT	$0.00		$29.88			
Vanguard Long-Term Corporate Bond Index Fund ETF	VCLT	$0.00		$20.75			
Total		$104,788.70		$105,189.31			
			Less Fees	$36.52			
			Less 06/04	$104,788.70			
			Profit	$364.09			
			Return	0.38%			

Appendix F.

Stock Index Summary	Ticker	06/04/2021		15/05/2021	Percentage Return	Expected 6-Week Return	% Point Difference
Market Value							
Vanguard Total Stock Market Index Fund	VTI	$137,246.40		$139,669.92	1.77%	1.46%	0.31%
Vanguard Total World Stock Index Fund	VT	$46,859.79		$47,707.59	1.81%	1.05%	0.76%
iShares MSCI New Zealand ETF	ENZL	$90,406.68		$91,940.73	1.70%	1.08%	0.62%
Plus Dividends							
Vanguard Total Stock Market Index Fund	VTI	$0.00		$0.00			
Vanguard Total World Stock Index Fund	VT	$0.00		$0.00			
iShares MSCI New Zealand ETF	ENZL	$0.00		$0.00			
Total		$274,512.87		$279,318.24			
			Less Fees	$51.60			
			Less 06/04	$274,512.87			
			Profit	$4,753.77			
			Return	1.73%			

Appendix G.

Individual Stocks Summary	Ticker	06/04/2021				15/05/2021		
		Market Value	**Redistributions**	**Funds at Sale**	**Fees**	**Market Value**	**Profit**	**Return**
Meridian Energy	MEL	$16,865.39	$0.00	$19,439.16	$90.94	$0.00	$2,482.83	14.72%
Fisher & Paykel	FPH	$16,866.60	$1,026.15	$20,787.50	$22.26	$0.00	$2,872.49	16.05%
A2 Milk Company - NZ	ATM	$16,868.51	$10,060.60	$18,829.72	$89.16	$0.00	-$8,188.55	-30.41%
Rio Tinto Group	RIO	$16,858.92	$3,808.78	$26,677.12	$15.00	$0.00	$5,994.42	29.00%
Fortescue Metals Group	FMG	$16,860.11	$5,153.42	$35,185.60	$41.22	$0.00	$13,130.85	59.65%
Macquarie Group	MQG	$16,803.59	$11,027.25	$0.00	$18.00	$37,405.18	$9,556.34	34.34%
AngloGold Ashanti Limited	AGG	$16,866.10	$20,826.52	$0.00	$23.62	$31,185.82	-$6,530.42	-17.33%
Kirkland Lake Gold Limited	KLA	$16,848.25	$7,470.42	$0.00	$19.75	$28,176.40	$3,837.98	15.78%
Evolution Mining Limited	EVN	$16,868.68	$6,734.29	$0.00	$72.58	$30,354.97	$6,679.42	28.30%
AGL Energy Limited	AGL	$16,861.61	$1,702.88	$17,092.28	$51.07	$0.00	-$1,523.28	-8.21%
SSR Mining Inc	SSR	$16,860.90	$10,395.10	$0.00	$25.85	$27,637.96	$356.11	1.31%
Brickworks Limited - AX	BKW	$16,858.81	$19,560.28	$0.00	$28.15	$29,386.66	-$7,020.88	-19.28%
Regeneron Pharmaceuticals	REGN	$16,753.80	$12,924.34	$0.00	$18.00	$28,961.52	-$734.62	-2.48%
Kinross Gold Corporation	KGC	$16,863.50	$17,917.15	$0.00	$48.11	$29,332.50	-$5,496.26	-15.80%
Oracle Corporation	ORCL	$16,861.56	$8,862.19	$0.00	$18.00	$25,864.34	$122.59	0.48%
Total		$252,766.33				$268,305.36		
Profit						$15,539.03	$15,539.02	
Return						6.15%		

Appendix H.

Overall Summary	06/04/2021		15/05/2021	Percentage Return	Expected 6-Week Return	% Point Difference
Market Value						
Bond ETF Portfolio	$104,788.70		$105,026.38	0.23%	0.08%	0.15%
Stock ETF Portfolio	$274,512.87		$279,318.24	1.75%	1.26%	0.49%
Individual Stock Portfolio	$252,766.33		$268,305.36			
Dividends						
Bond ETF Portfolio			$162.93			
Total	$632,067.90		$652,812.90			
		Less Fees	$88.12			
		Less 06/04	$632,067.90			
		Profit	$20,656.88			
		Return	3.27%			
		Market Value (NZD)	$891,375.87			
		Add Term Deposit	$100,007.00			
		Market Value (NZD)	$991,382.87			
		Total Deficit	-$8,617.13			
		Return	-0.86%			

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