Market Timing Tactical Asset Allocation

INSEAD Masters in Finance (MFIN17M) – DRAFT Master Project

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ABSTRACT

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# Introduction

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# Replication of A Quantitative Approach to Tactical Asset Allocation

## Summary of the paper

In July 2006, Mebane Faber began to circulate a working paper entitled A Quantitative Approach to Tactical Asset Allocation which was subsequently published by The Journal of Wealth Management in Spring 2007. In February 2009 Faber updated his paper to include data from 2006-2008 and then again updated the paper in February 2013 to include data from 2009-2012 as well as test the approach on alternative asset classes and allocations.

The purpose of Faber’s research was “to present a simple quantitative method that improves risk adjusted returns across various asset classes” (Faber 2013). Testing over 5 asset classes from 1973-2012, his approach improved risk adjusted returns in every asset class tested and when applied to an equal weighted asset allocation, resulted in equity like returns with bond like volatility and drawdowns.

The quantitative system used by Faber is based on one of the most well known trend following strategies commonly used by CTAs which uses a 200 day moving average to signal when to be long or move to safety. It met his criteria of being a simple, mechanical price based signal with non optimised parameters for all asset classes. Faber, testing with monthly data, adapted his approach to use the monthly equivalent 10 month simple moving average to signal when to get long or move to cash. The rules were simple; buy when the monthly price is greater than the 10 month simple moving average and sell and move to cash when the monthly price crossed below the 10 month simple moving average.

When applied to individual asset classes, the timing system consistently resulted in improved absolute returns, risk adjusted returns and max drawdowns. On average between 1973-2008 the timing system “increased returns by approximately 20%, decreased volatility by 20%, improved the Sharpe Ratio by 0.20 and reduced the maximum drawdown by nearly 50%” (Faber, 2009).

The results showed the simple moving average based market timing system could also be applied to global tactical asset allocation to significant improve the performance and risk metrics compared to a standard buy and hold strategy. The timing system had better absolute returns of 10.48% (vs 9.92% for the buy and hold), lower volatility of 6.99% (vs 10.28%) resulting in an improved Sharpe ratio of 0.73 (vs 0.43). Crucially for investors, the max drawdown of the timing model was only -9.54% (vs -46.00%) meaning that investors never experienced the pain of giving back more than 10% of their equity. Lastly in the 40 years of data between 1973-2012, the timing strategy remarkably only had 1 year of negative performance, which was a respectable -0.59%.

## Data used

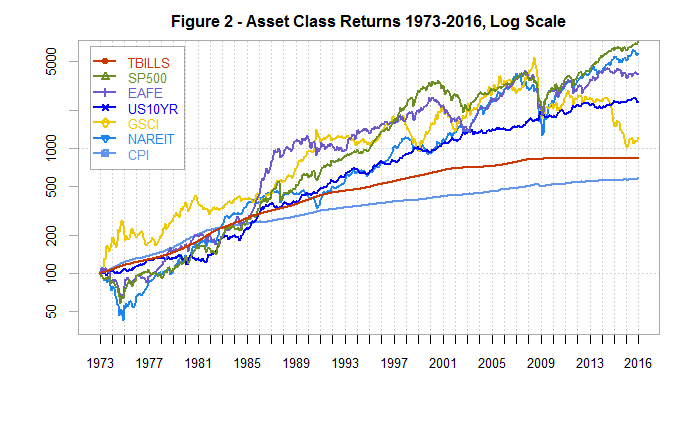
Faber applied his quantitative approach to five asset classes – Domestic (US Large Cap) Equities, Foreign Developed Equities, US Bonds, Commodities and Real Estate. He chose publicly traded indices representing these asset classes and obtained monthly total return data series from Global Financial Data to use in his framework. The actual indices chosen were Standard and Poor’s 500 Index (S&P 500), Morgan Stanley Capital International Developed Markets Index (MSCI EAFE), United States Government 10yr Treasure Bonds (US10YR), Goldman Sachs Commodity Index (GSCI) and the National Association of Real Estate Investment Trusts Index (NAREIT).

Global Financial Data is a paid data provider unwilling to make their data available for academic purposes. Data used in this paper has been obtained from a variety of sources. S&P500, NAREIT, EAFE, GSCI total return index data are available on Bloomberg. To represent Fixed Income, 10yr US Government Bond Yields were obtained from FRED and a total return index that takes into consideration both capital appreciation and income has been created following the methodology of Morningstar. A similar index was created using 3 month US Treasury Bond Yields to represent risk free returns. Overall differences in performance results are minimal and outlined in appendix [X]. Although there are small discrepancies I am confident the datasets are close enough to the original data that the results in the paper are valid.

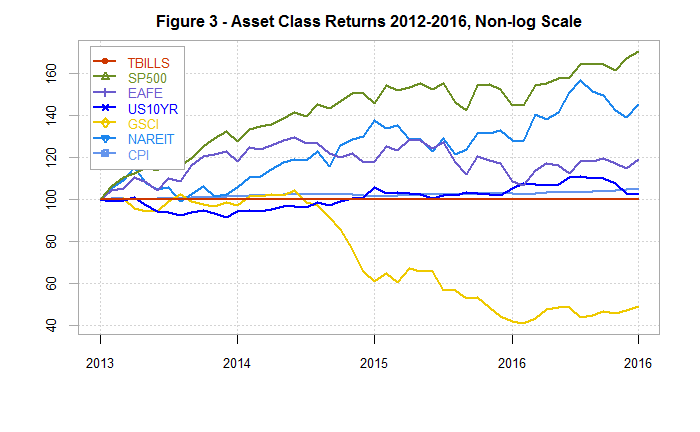
[put summary table similar to SA]

## Asset returns including data 2013-2016

Faber first charts the asset class returns to see the routes they travelled from start to finish. The replication of this chart below and comparing it to Faber’s Figure 3 (page 16) between 1973-2012 visually confirms the data obtained closely matches the data Faber original used provided by Global Financial Data. Extending this chart to the end of 2016, we can see what has happened over the last 4 years of returns.



It is clear to see most assets have continued to deliver positive returns however commodities (GSCI) has continued to underperform since it’s all time high in 2008. Zoomed in and rebasing at 2012 to confirm its much more obvious.



Replicating performance statistics over the same set of asset classes we get very similar results to Faber’s research confirming the visual check above that the data is accurate.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure 4 - Asset Class Maximum Drawdowns 1973-2012** | | | | | | |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | 5.42% | 9.77% | 9.19% | 8.12% | 8.34% | 9.64% |
| Volatility | 0.95% | 15.71% | 17.60% | 8.47% | 20.55% | 18.16% |
| Sharpe (??%) | 0.00 | 0.26 | 0.20 | 0.30 | 0.13 | 0.22 |
| MaxDD | 0.00% | -50.95% | -56.40% | -15.75% | -67.65% | -68.18% |
| Inflation CAGR | 4.33% | 4.33% | 4.33% | 4.33% | 4.33% | 4.33% |

Extending this to include 2013-2016:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure 6 - Asset Class Maximum Drawdowns 1973-2016** | | | | | | |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | 4.93% | 10.18% | 8.75% | 7.41% | 5.85% | 9.65% |
| Volatility | 1.00% | 15.30% | 17.21% | 8.33% | 20.52% | 17.81% |
| Sharpe (5.41%) | 0.00 | 0.33 | 0.21 | 0.28 | 0.04 | 0.25 |
| MaxDD | 0.00% | -50.95% | -56.40% | -15.75% | -80.90% | -68.18% |
| Inflation CAGR | 4.04% | 4.04% | 4.04% | 4.04% | 4.04% | 4.04% |

Looking at the effect of the last four years on Faber’s research:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure 7 - Changes to Asset Class Maximum Drawdowns 1973-2016** | | | | | | |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | -0.49% | 0.41% | -0.44% | -0.71% | -2.49% | 0.01% |
| Volatility | 0.05% | -0.41% | -0.39% | -0.14% | -0.03% | -0.35% |
| Sharpe (5.41%) | 0.00 | 0.06 | 0.01 | -0.02 | -0.09 | 0.03 |
| MaxDD | 0.00% | 0.00% | 0.00% | 0.00% | -13.25% | 0.00% |
| Inflation CAGR | -0.29% | -0.29% | -0.29% | -0.29% | -0.29% | -0.29% |
|  |  |  |  |  |  |  |
|  | | | | | | |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | -8.87% | 4.95% | -4.58% | -9.41% | -29.69% | 0.00% |
| Volatility | 5.26% | -2.49% | -2.27% | -1.30% | -0.15% | -1.77% |
| Sharpe (5.41%) | 0.00 | 0.21 | 0.01 | -0.14 | -0.70 | 0.10 |
| MaxDD | 0.00% | 0.00% | 0.00% | -0.25% | 19.59% | 0.44% |
| Inflation CAGR | -6.05% | -6.05% | -6.05% | -6.05% | -6.05% | -6.05% |

[move tables to appendix and rewrite below]

A few noticeable changes stand out:

* Adding 4 more years of data to nearly 40 years of existing data, has reduced the CAGR for commodities CAGR from 8.34% to 5.85%, roughly a 30% reduction drop. The stats also confirm what we see visually with commodities max drawdown increasing to 80%.
* TBILL CAGR have dropped – which makes sense considering near zero rates recently.

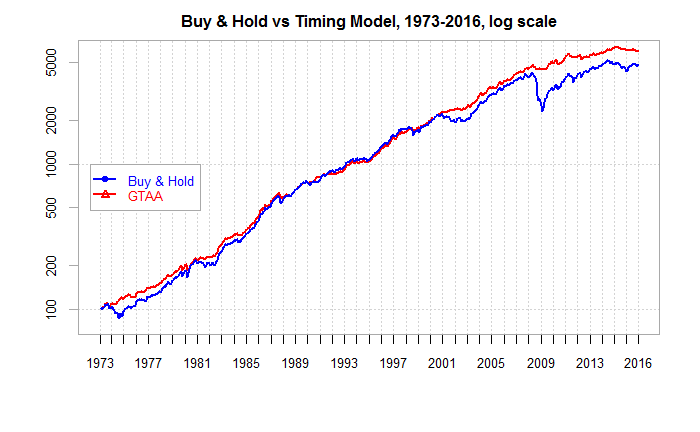
## Replication of Global Tactical Asset Allocation including 2013-2016

Looking at the percent of time invested including the most recent years:

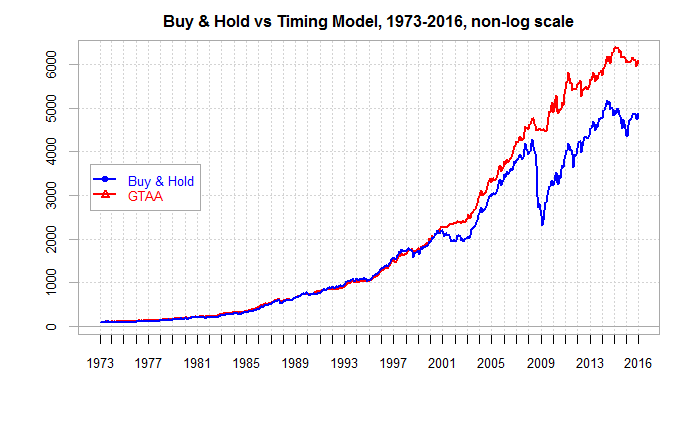
|  |  |  |  |
| --- | --- | --- | --- |
| **Figure 11 - Percent of the Time Invested, 1973-2016** | | | |
| Number of Positions | % Invested | # of Months | % of Months |
| 0 (all cash) | 0% | 6 | 1.13% |
| 1 | 20% | 32 | 6.05% |
| 2 | 40% | 62 | 11.72% |
| 3 | 60% | 118 | 22.31% |
| 4 | 80% | 192 | 36.29% |
| 5 | 100% | 119 | 22.50% |
| TOTAL |  | 529 | 100.00% |

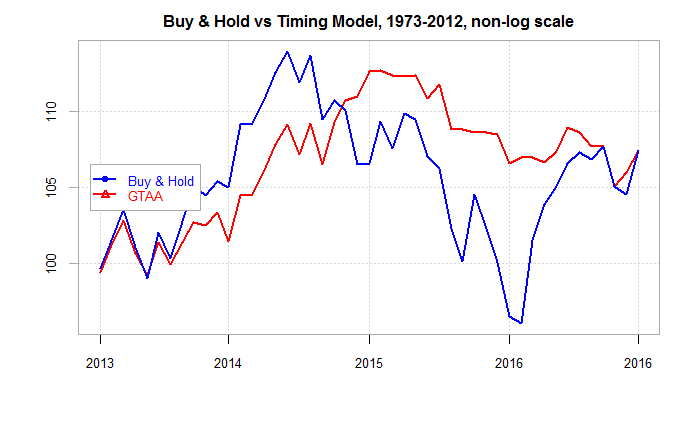
The strategy is invested approx. [71% - get exact] of time which is in line with expectations from previous periods.

Looking at the GTAA model extended to include the most recent years



Looking at non log chart for the extended data.





Buy and hold outperformed earlier, then GTAA outperformed with less downside before BH caught up. Look at drawdowns and standard deviation to highlight this point.

|  |  |  |
| --- | --- | --- |
| **Summary Annualised Returns for B&H vs Timing Model, 1973-2016** | | |
|  | Buy & Hold | GTAA |
| Return | 9.25% | 9.80% |
| Volatility | 10.09% | 6.87% |
| Sharpe | 0.35 | 0.59 |
| MaxDD | -46.10% | -9.56% |
| Inflation CAGR | 4.04% | 4.04% |

|  |  |  |
| --- | --- | --- |
| **Summary Annualised Returns for B&H vs Timing Model, 1973-2012** | | |
|  | Buy & Hold | GTAA |
| Return | 9.93% | 10.57% |
| Volatility | 10.28% | 7.01% |
| Sharpe | 0.41 | 0.68 |
| MaxDD | -46.10% | -9.56% |
| Inflation CAGR | 4.33% | 4.33% |

|  |  |  |
| --- | --- | --- |
| **Summary Annualised Returns for B&H vs Timing Model, 2013-2016** | | |
|  | Buy & Hold | GTAA |
| Return | 2.67% | 2.44% |
| Volatility | 7.78% | 4.92% |
| Sharpe | -0.35 | -0.60 |
| MaxDD | -15.62% | -6.74% |
| Inflation CAGR | 1.25% | 1.25% |

|  |  |  |
| --- | --- | --- |
| **Summary Annualised Returns for B&H vs Timing Model, 2007-2016** | | |
|  | Buy & Hold | GTAA |
| Return | 2.67% | 3.89% |
| Volatility | 13.23% | 6.55% |
| Sharpe | -0.21 | -0.24 |
| MaxDD | -46.10% | -9.22% |
| Inflation CAGR | 1.81% | 1.81% |

[recalc / confirm Shape calcs negative]

Reviewing the performance of the last 4 and 10 years, the absolute returns of both the buy and hold and timing strategy haven’t been as great as the previous years. Compared to the 30 year period before where both strategies were returning approx. 10%, CAGR for both buy and hold and timing model have been 2-4%, far below expectations based on previous periods. This during a time when major benchmarks such as the S&P and Dow Jones are making regular news headlines for new all time highs. [show rolling performance/alpha vs S&P?] Although long term results have been very respectable with an overall CAGR of approx. 10% and a max drawdown of -10%, it’s easy to imagine investors questioning their choice of strategy during these recent years.

# Analysis of performance

## Diversification and Modern Portfolio Theory

One of the core drivers of the absolute returns of the strategies within Faber’s paper is diversification. “Diversification is often spoken of as the only free lunch in investing” (Jennings and Payne, 2016) and has the ability to enhance returns without necessarily increasing risk. The proverb “don’t put all your eggs in one basket” explains it succinctly; invest in a portfolio of different assets and you’ll always have less (or at most equal) risk to the riskiest asset on its own. The benefits of diversification aren’t secret and have been acknowledged for thousands of years. Even the bible, thought to have been written by Solomon around 900BC, tells the reader to “divide your investments among many places, for you do not know what risks might lie ahead” (Ecclesiastes 11:2). Today some successful hedge fund managers see diversification as “the single most important factor to influence the overall long term results” (Clenow 2013, p. 52).

In 1952 Dr Harry Markowitz published his seminal paper Portfolio Selection (Markowitz 1952) introducing practitioners to a mathematical framework that explained the well-known benefits of portfolio diversification. Stating rational investors desired returns and disliked variance, he hypothesised the E-V rule used to create efficient portfolios of diversified securities. Although admitting that diversification could not completely eliminate all variance, by using the E-V rule an investor is able to derive an optimal portfolio of assets with either the lowest risk for a given level of expected return or the highest expected return for a given level of risk. Markowitz’s paper notes that although the E-V rule identifies diversification as a driver for more efficient portfolios, it requires the right kind of diversification with a selection of securities with low covariance among themselves. Markowitz’s work contributed to what is known today as Modern Portfolio Theory and eventually won him a Nobel prize in 1990.

Modern Portfolio Theory has several criticisms however. The risk, return and correlation inputs into the model are based on expected values assumed to stay constant over time and returns are assumed to follow a Gaussian/normal distribution. Risk in modern portfolio theory is represented by variance, however its questionable whether rational investors will still dislike variance when an asset is moving in their desired direction. Modern portfolio theory manages risk through diversification however it ignores that during extreme market panic, correlations tend towards one.

[insert chart of correlations between 5 asset classes].

Global financial market crises in the 1987 (Black Monday), 1998 (Russian Crisis), 2001 (Dot Com Bubble and September 11) and 2008 (Global Financial Crisis/Subprime Mortgage Crisis) have shown that in these times markets tend to behave as one (Sandoval Jr and Franca 2010). In its these periods that diversification does little to reduce downside risk and where trend following market timing strategies can add value to a diversified portfolio.

Trend following is a simple concept – identify a trend and follow it. When things move against you or when the trend is no longer there, take your profits or cut your losses. The strategy has had plenty of criticism over the years especially from classical economists supporting efficient markets. However strong performance numbers, especially during periods of extreme equity markets drawdowns, has seen the use of trend following rapidly grow as an investment strategy over the last 40 years.

Greyserman and Kaminski (2014) analyse the performance of trend following from 1223 to 2013 using a simple trend following strategy over a unique dataset for 84 markets in equity, fixed income, foreign exchange and commodity markets. They find trends exist in market prices due to fundamental, technical and behaviour reasons but ultimately conclude that trend followers don’t care about the underlying reason and just want to ride the trend whenever the opportunity arrives. They find the driver of performance in a trend following strategy to be the ability to cut losses and take profits rather than the entry signal to get into the trend. Covel (2009) identifies that trend following traders use mechanical trading systems to gain this ability to cut losses and take profits. Mechanical trading systems are based on an objective set of rules and remove discretionary decisions subject to emotion and behavioural biases.

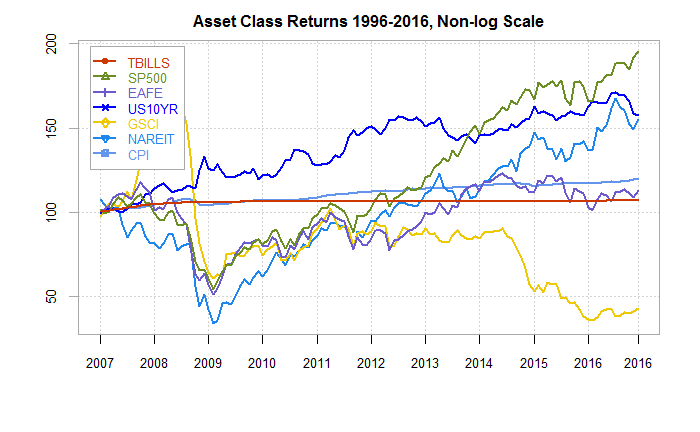
Ultimately trend following strategies are risk reduction techniques. They remove exposure to a position during long periods of drawdown without necessarily penalising overall long term returns. A simple mechanical trend following strategy helps to avoid cognitive biases humans exhibit when making trading decisions such as anchoring bias, loss aversion, illusion of control. By managing the downside, returns that are usually negative skewed with excess kurtsis are changed in positive skewed. [insert charts comparing buy and hold vs timing returns to show mean/skew/kurtosis]. Faber (2007) identifies that most common asset classes experience painful drawdowns with multiple examples of 40-100% drawdowns. Trend following reduces volatility and by being out of markets during substantial periods of decline avoids long painful drawdowns for the investor.

Faber’s simple five asset class equal weighted asset allocation, even on a buy and hold basis, presents evidence of the benefits of diversification. The trend following timing overlay manages risk and results in reduction of volatility from 20% to 10%. Crucially the timing signal reduces portfolio drawdowns to the point that the investor only experience one down year since 1973, with that being -1%. Trend following isn’t about achieving superior absolute returns – it’s about avoiding the painful drawdowns which can destroy many previous years of gains. This combined with the power of compounding may result in equal or even better absolute returns, however more importantly consistently provides improved risk adjusted returns.

## Recent Performance and the Financialisation of Commodities

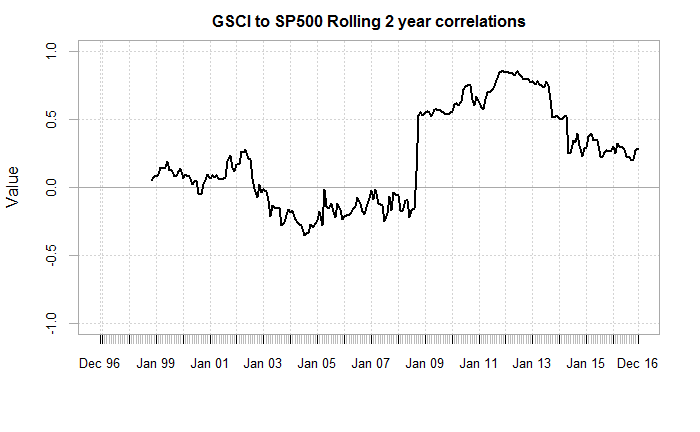
It’s apparent since Faber originally published his first working paper in 2006, performance numbers of the equal weighted 5 asset class buy and hold portfolio haven’t been as impressive. With the global financial crash in 2008, CAGR between 2006-2016 dropped to 2.54% compared to the 11.27% seen between 1973-2006. Volatility also increased from 8.92% to 13.18% and perhaps most painfully felt by investors, the model had its biggest drawdown ever experiencing a drawdown of 46.1% which was more than double compared to the previous periods max drawdown of 19.61%. The Sharpe ratio from 1973-2006 of 0.53 dropped to 0.14 in the following 10 years. [recalc Sharpe with new code]. Was Faber’s model overfitted or can this performance of the last 10 years be explained elsewhere?

Reviewing the individual returns of each asset class, it’s clear that commodities were the worst performing asset class and dragged the overall performance of the diversified portfolio down. Since 2006, commodities have a CARG of -8.71%, volatility higher than all other asset classes of 23.6%, as well as a max drawdown of 80.9% in a period where equity and bond returns have continued to show a positive CAGR despite also suffering drawdowns in 2008 where they lost over half their value.



With hindsight if commodities were excluded from the portfolio, the returns would have been considerably better [insert returns for 2006-2016 period with only 4 asset classes vs 5 assets. Then insert summary of period 1973-2006 to see difference].

It’s not the first financial crash in this period yet performance numbers were much more effected by the performance of commodities. Why? It appears commodity correlations have increased like never seen before. [recreate correlation charts of commodities vs all other assets since 1973]



A popular topic in research around the time of Faber’s first white paper was the strong diversifying performance of commodities. Two years before Faber first released his first working version, Gorton and Rouwenhorst released a working paper of Facts and Fantasies About Commodity Futures (2004) highlighting commodities as an ideal diversifier for equity and bond portfolios. They showed that an equal weighted index of commodity futures between 1959 and 2004 produced equity-like returns, slightly lower risk than stocks as measured by standard deviation and less downside risk due to positively skewed returns with relatively high kurtosis. With a negative correlation with both stocks and bonds over most horizons, they concluded commodities as being an especially effective in providing diversification over both stock and bond portfolios.

Following this, in 2006 Ibbotson Associates released a report for PIMCO titled Strategic Asset Allocation and Commodities [2006] that analysed the role of commodities within a strategic asset allocation setting. Comparing the returns from 1970 to 2005 of a composite commodity index against US and International stocks, US and International Bonds, Treasury Bills and Inflation, they found that commodities were the top performing asset. During periods of high inflation commodities had the highest arithmetic and compounded returns by a wide margin and in periods of low margin they still returned double digit returns. Ibbotson Associates also identified that commodities had the lowest average correlation to the other asset classes, concluding that including commodities in an asset allocation improved the risk return characteristics of the efficient frontier.

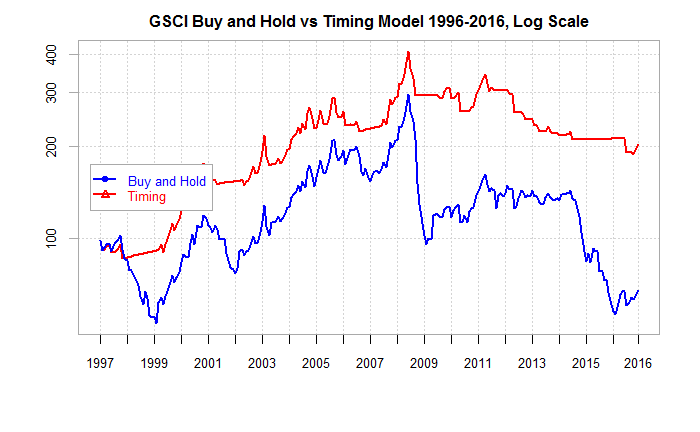
These papers combined with other literature (Erb and Harvey, 2004) drove increased long only investment into commodities financial instruments by managers looking to improve risk adjusted portfolio performance. Hundreds of billions of dollars (Irwin and Sanders, 2011 and Bhardwaj, Gorton and Rouwenhorst, 2014) of inflows into commodity investments created structural changes later termed financialisation by Domanski and Heath (2007)

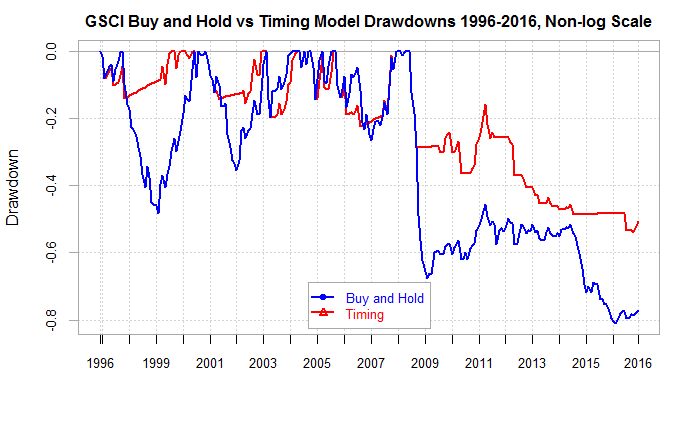
As a result of financialisation, it was thought commodities were no longer driven purely by commodity fundamentals and rather by macroeconomic views of investment managers, increasing correlations among commodities and other asset classes. Zaremba (2015) provides one of the more intuitive explanations for this increase in correlation. With an increased number of financial investors holding on to a similar asset allocation of stocks, bonds and commodities, any external shock causing severe capital outflows will enforce selling of all asset classes in the portfolio at the same time to free up capital, causing correlation to rise. A resulting theme in recent research [Silvennoinen and Thorp 2009, Cheung and Miu 2010, Bhardwaj, Gorton, and Rouwenhorst 2014] reviews financialisation and the recent performance of the commodities sector since financialisation and raised the idea that commodities should no longer be included in a diversified investment portfolio. They conclude that commodities may no longer provide diversifying protection in future times of financial distress similar to the global financial crisis of 2008.

Today there are arguments for both including and excluding commodities in an asset allocation. On one hand commodity correlations have returned towards pre 2008 financial crisis levels and there is a wealth of recent research [Bhardwaj, Gorton, Rouwenhorst 2015, Levine, Ooi and Richardson 2016] reporting commodities to have strong returns during periods of growth and high inflation as well as low correlation with stocks and bonds over long horizons, concluding that despite the most recent years performance commodity futures are still likely to add diversification protection to a portfolio of assets under these regimes.

On the other hand, many (Zaremba 2015, Lombardi and Ravazzolo 2013) have argued that the diversification benefits of commodity may not be valid anymore. Due to the structural changes from the financialisation of commodities, increased correlations especially during macro market shocks, it has been argued that commodities no longer offer diversification protection for a portfolio with stocks and bonds during a financial crisis. Antonacci (2017) also argues that due to the nature of commodity markets changing from financialisation, the papers using data before this period succumb to aggregation bias and will have less forecasting power for the period following financialisation.

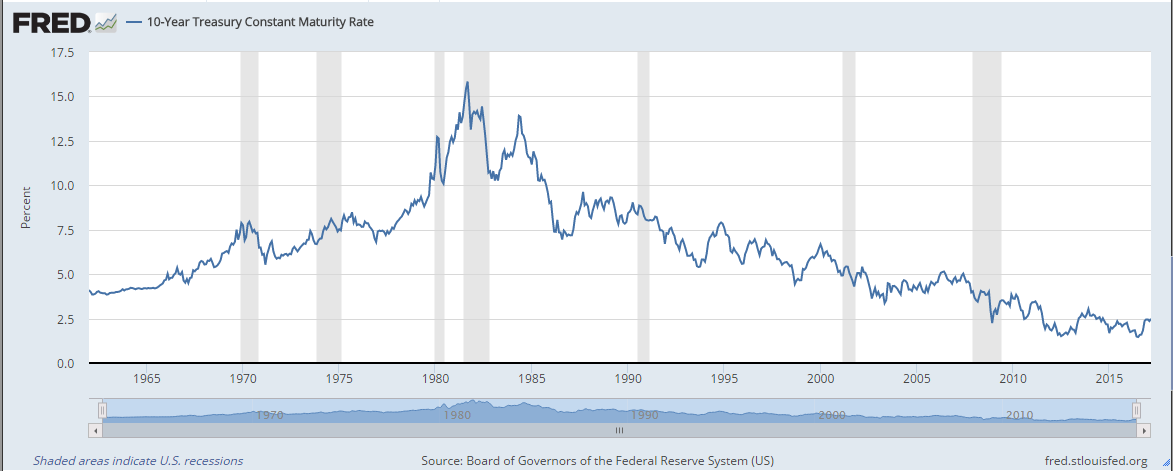
Without being able to predict the future and prove which argument is correct, it’s perhaps now a good time to review the performance of the timing model between 2006-2016. Like the buy and hold portfolio, returns were less (3.9% vs 11.6%) however volatility reduced resulting in a far less decrease of the Sharpe ratio than expectations. Most importantly for investors, the max drawdown stayed in line with expectations and was only -9.2% during the financial crisis. Its apparent that the trend following timing strategy may mitigate some of the negative impact of financialisation during crises, removing the investor from commodities during sharp drawdowns. Potentially entering a period where expectations are that inflation and growth will increase, supports including commodities in the diversified portfolio. The timing strategy allows the investor to gain any potential upside under these regimes, whilst protecting the investor somewhat in a future financial crisis, where it’s not unreasonable to expect correlations to again increase towards one for all asset classes.





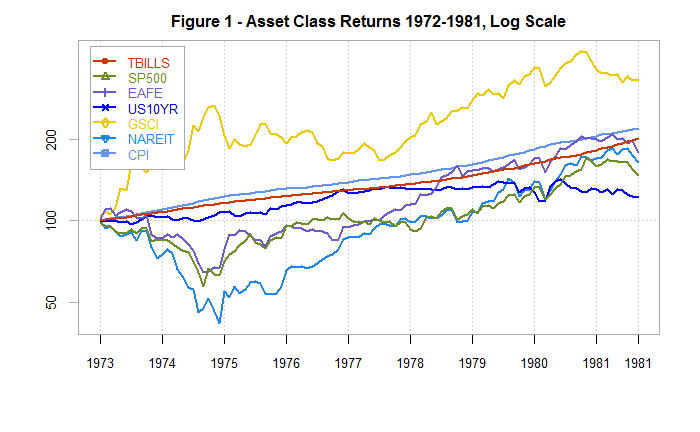
## Performance under rising interest rates

It’s well acknowledged that the world has just experienced one of the longest bull markets for fixed income. US Government 10 year Bond yields have steadily fallen from all times highs of approx. 16% in 1981 to approx. 2% today. This has resulted in a 30+ year bull market for bond returns.



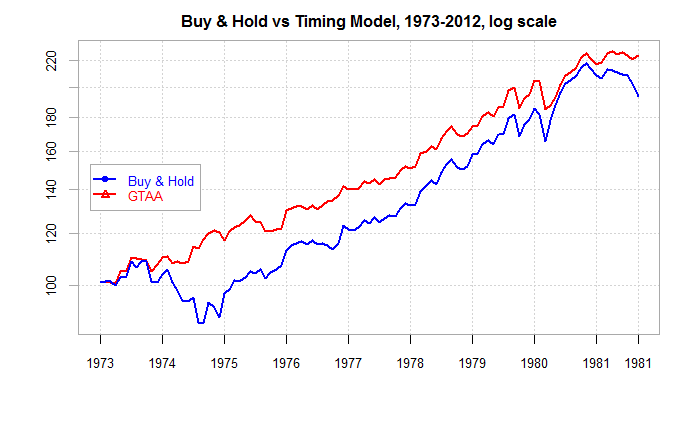
[enter own chart with yield and US10YR returns]

Inflammatory headlines are common, especially regarding CTA or trend following performance in a rising rates cycle. Due to its relative increasing and relative popularity, some investors are concerned that trend following strategies only generate positive risk adjusted returns during periods of falling rates. To analysis potential performance under a rising rates regime, let’s review the period 1973-1981 where it was a clear rising rates environment.



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | 8.27% | 4.54% | 6.82% | 2.24% | 14.50% | 5.87% |
| Volatility | 0.87% | 16.64% | 16.83% | 8.42% | 23.67% | 22.32% |
| Sharpe (8.27%) | 0.00 | -0.21 | -0.08 | -0.67 | 0.24 | -0.10 |
| MaxDD | 0.00% | -42.65% | -41.53% | -15.75% | -37.45% | -58.10% |
| Inflation CAGR | 9.38% | 9.38% | 9.38% | 9.38% | 9.38% | 9.38% |

Looking at the GTAA, the portfolio was invested approximately [70%] of the time.



|  |  |  |
| --- | --- | --- |
|  | Buy & Hold | GTAA |
| Return | 8.09% | 9.86% |
| Volatility | 10.71% | 8.19% |
| Sharpe | -1.35 | -1.55 |
| MaxDD | -19.61% | -9.56% |
| Inflation CAGR | 9.31% | 9.31% |

[recalc Sharpe ratio with new code]

It’s clear that even under an environment of rising rates the trend following strategy adds value. [Why? Go into detail about avoiding drawdowns… Diversification/driving benefits of commodities vs discussion in financialisation above]

# Practical and behavioural implications for Trend Following Investors

# Improving returns

There are a few ways which may improve returns that are worth investigating further.

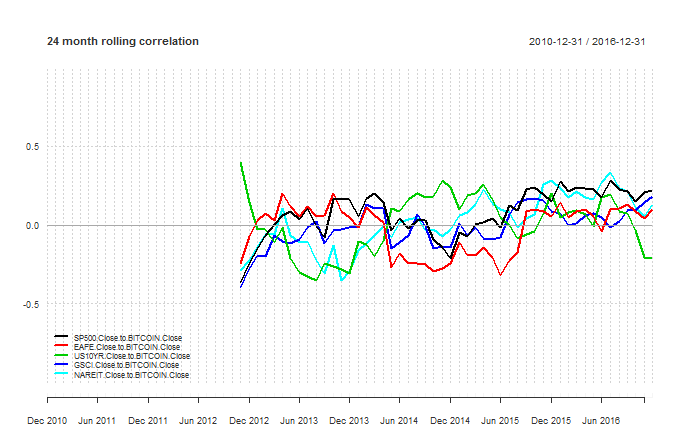
* Diversification of assets
* Avoiding whipsaws
  + Delaying entry
  + Trading bands
  + Filters
* SMAs slow to adapt? Exponential
* Diversification of strategies

## 

## Diversification of assets

Faber (2013) comments that his five asset class equal weighted asset allocation was chosen for simplicity and tests expanding the strategy to a 13 asset portfolio of different weightings. The addition increases the timing strategy’s absolute returns by 1.56% for similar volatility, improving the sharpe ratio from 0.73 to 0.94. Similar improvements to returns are seen in the buy and hold strategy with increased assets, highlighting again the benefits of diversification. It makes sense then to look at adding asset classes that are low correlated to the existing strategy.

One such asset class worth investigating is Bitcoin, a cryptocurrency introduced in 2008. Bitcoin falls within the third superclass of assets known as store of value assets which generally serve as a refuge during uncertainty (Greer 1997). Despite only having a short period of pricing history from late 2010, Bitcoin has so far demonstrated extremely low correlation to all other asset classes.



[look at extending to daily / 90d]

Still in its infancy Bitcoin is highly volatile and trades on multiple unregulated exchanges. As a result its less likely to suffer from the effects of financialisation witnessed in commodities and with the recent Bitcoin ETF approval rejected, there’s no obvious short term event in the near future likely to change this view. It appears that uncorrelated exposure Bitcoin seems an extremely attractive addition to the original asset allocation especially as it matures and its volatility reduces.

[insert equal weighted GTAA portfolio B&H, Timing vs GTAA with Bitcoin B&H and timing 2011-2016]

Ultimately the length of pricing history is short and the asset has yet to experience a market crisis. Without falling subject to the law of small numbers and gambler’s fallacy (Tversky and Kahneman, 1971), its unwise to make predictions of the diversifying value of adding Bitcoin to the asset allocation just yet, but for investors who can handle its volatility it’s definitely one asset class worth keeping an eye on in the future to improve returns.

Based on extensive research elsewhere, no further research was done investigating adding more assets as its generally accepted adding a limited number of additional uncorrelated assets to the asset allocation will improve returns.

## Avoiding Whipsaws

Trend following strategies are designed to identify trends and react by entering trades that will stay with the trend for as long as it lasts. The trading philosophy doesn’t attempt to predict the bottom or top of a market but rather react to a price move and capture as much of the remainder while it lasts. A drawback with trend following strategies is that performance generally suffers in consolidating, non trending or range bound markets. These sideways moving markets generate several false entry signals as the price whipsaws and quickly moves through the moving average in both directions, resulting in multiple buy and sell signals and trades for a small loss each time. Ultimately these periods are responsible for the low overall 30-40% win rate of trend following strategies

[insert chart of one asset when whipsawing with performance/P&L]

On average the size of the winners when the market is trending is much greater than the several small losses, resulting in the positive expectancy of these types of strategies. To avoid whipsaws, there are a couple of methods that can be used which will be applied to the GTAA:

* Delayed entry
* Bands
* Slope of moving average

Ultimately these delay entry into a trade and can miss short term whipsaws but at the expense of missing out of the first part of the move. However they help avoid costly whipsaws in prolonged sideways moving markets.

## Delayed entry

This method delays long entry for a set period after a long signal to confirm that the price is still above the moving average and has not fallen back below. It eliminates whipsaws at the expense of missing out of the first part of the move. The delay only applies to the entry of a long position, and if the price falls below the moving average, the position is closed out instantaneously.

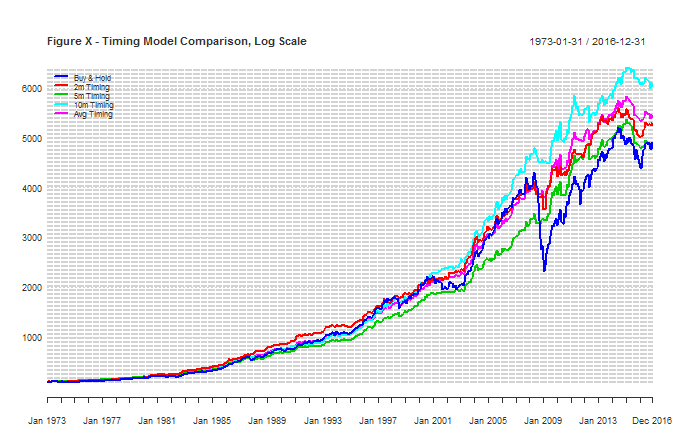
[calc insert data for delayed entry methods]

## Strategy Diversification

The value of diversification is widely known and previously acknowledged. For a buy and hold investment strategy, diversification is limited to the choice of assets invested. In an active approach to investing, diversification can be applied to all variables within a trading strategy including the type of indicator used as an entry or exit signal, the signal’s time period as well as strategy’s direction (long or short).

Peter Garnby (2016) demonstrates that weak individual trading strategies, which individually offer low risk adjusted returns, can be combined into a superior portfolio with much stronger risk adjusted returns. Over 500 trials he simulates blending 20 individual strategies each with individual sharpe ratios of 0.6 into portfolios that run for 10 years. Although absolute returns are not necessarily enhanced, he finds that portfolios of low correlated strategies return significantly improved risk adjusted performance with portfolio Sharpe Ratios of 3, a 370% improvement. The portfolio risk adjusted returns quickly decline as correlation increases, however the research shows the benefits of diversification can also be achieved by combining low correlated timing strategies.

Applying this knowledge to Faber’s timing strategy can be achieved in multiple ways. One of the simplest methods would be by diversifying the timing signal moving average period. Faber acknowledges that stability of using various parameters for the moving average period. Faber uses the 10m moving average and compares the returns to 3, 6, 9 and 12 month moving averages to find similar returns. Another two popular signals in the trend following community are the 50day and 100 day moving averages. Converted to monthly 2m and 5m, how does an equal weighted portfolio of the 3 different moving average timing strategies perform:



Buy & Hold 2m Timing 5m Timing 10m Timing Avg Timing

Return 9.29 9.49 9.27 9.84 9.57

Volatility 10.08 6.29 6.62 6.87 6.14

Sharpe 0.41 0.69 0.63 0.68 0.72

MaxDD -46.10 -13.29 -10.71 -9.56 -8.65

Calmar Ratio 0.20 0.71 0.87 1.03 1.11

Ulcer Index 7.95 2.39 2.66 2.36 2.11

Sortino Ratio 0.42 0.83 0.71 0.73 0.84

Inflation CAGR 4.04 4.04 4.04 4.04 4.04

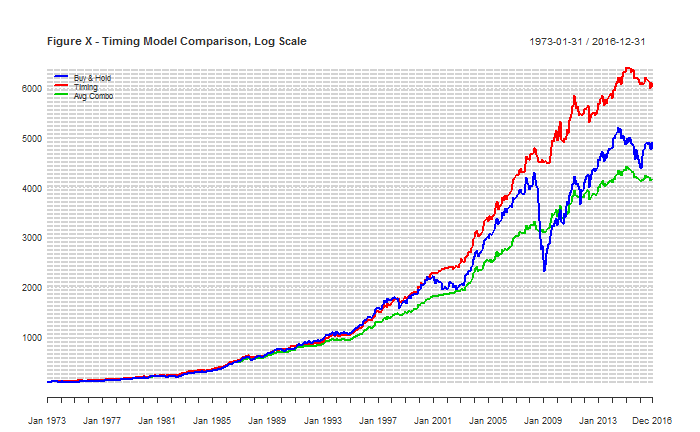
Similar to Faber’s findings, each timing signal returns individual performance with similar absolute returns, volatility and risk adjusted measures such as Sharpe Ratio. When combined into an equal weighted strategy, the average timing returns show similar absolute returns as expected from Garnby’s findings. However volatility and maxdd are the lowest and as a result risk adjusted measures such as Sharpe ratio, Sortino ratio, Calmar ratio and Ulcer index have all improved.

Diversification of strategies can also be applied to include the other improved strategy ideas. An equal weighted portfolio of strategies that includes the:

- 2m, 5m, 10m timing signals

- 2m, 5m, 10m, delayed timing signals

- trading bands

- [exponent moving averages?]

Buy & Hold Timing Avg Combo

Return 9.29 9.84 8.89

Volatility 10.08 6.87 5.67

Sharpe 0.41 0.68 0.67

MaxDD -46.10 -9.56 -6.75

Calmar Ratio 0.20 1.03 1.32

Ulcer Index 7.95 2.36 1.92

Sortino Ratio 0.42 0.73 0.83

Inflation CAGR 4.04 4.04 4.04

Although absolute returns are less but nearly a whole percentage point, lowering the volatility and max drawdown potentially allows the investor to take on more leverage to achieve enhanced total returns.

[if time] Additionally adding a swing trade/mean reverting signal improves the numbers to:

Note the above numbers exclude trading costs / taxes / etc talked about in practical considerations.

Lastly all of the above ignores trading fees… Downside is costs/taxes however with these assets trading costs are assumed to be minimal and worth the better returns. Taxes also are fine – fabers comments about winners being longer, etc.

# A Quantitative Approach to Tactical Asset Allocation in South Africa

South Africa has a very traditional investment industry that has lagged the world adopting recent investment trends such as indexation (Morningstar 2015). It is estimated that X% of funds invested are actively managed and of these funds a large majority are discretionary managed rather than quantitative. How will a quantitative strategy like Faber’s perform when applied to local assets and compare to the top ranking managers.

## Data

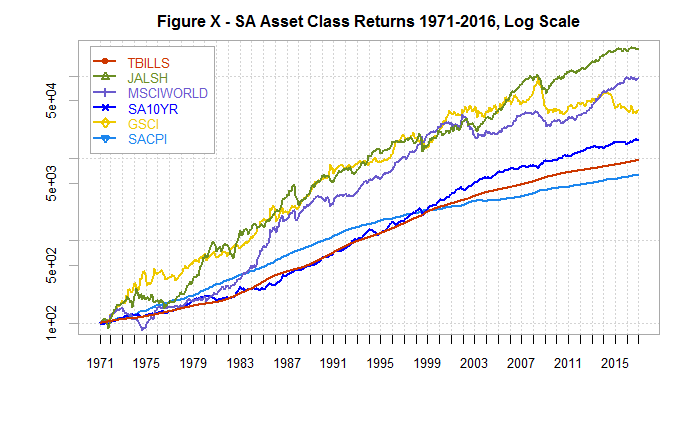
The biggest challenge to apply the strategy to South Africa is obtaining a long enough period of historical price data for each asset class in South Africa. Ibbotson et al (2016) view long periods of data as vital for uncovering “the basic the relationships between risk and return among the different asset classes”. With a long enough period, the data will capture major market events as well as periods under different regimes such as growth and decline or inflation and deflation. Although history is unlikely to repeat, infamous market crashes and financial crises in different asset classes around the world are common throughout history all the way back to the 1600s with the infamous tulip bubble crash. In one way or another, despite the common view that markets walk a random path, it shows that history tends to repeat itself and a long period of data may hold some level of predictive value in the future.

Unfortunately for South Africa, historical performance data for each asset class is difficult to find for long periods of history and near impossible for asset classes such as property. Domestic equity market data is available from the local Johannesburg Stock Exchange going back to 1960 however even they cannot guarantee that the data is completely accurate as some of it was captured prior to the current FTSE/JSE joint venture in 2002. Previous local research (Firer and McLeod, 1999) found that before 1960 data was never systematically collected and published. It was found during this study, that previous work collecting data (including Firer and McLeod) had been lost once the researcher had changed career paths or unfortunately passed away. Copies of data handed down researcher to researcher exist, however the validity of some of this data is questionable especially after finding inconsistencies when reviewing and comparing time periods where multiple data sets overlap.

To create long data sets of historical returns for South African asset classes, I have used the best quality most recent data spliced to the most reliable of the available older data. This is summarised by the following table.

|  |  |
| --- | --- |
|  | Source |
| Domestic Equities | 2002-2016: FTSE/JSE All Share Total Return Index |
| 1970-2002: JSE/Actuaries All Share Index with dividends allocated evenly over the year |
| Foreign Equities | 1971-2016: MSCI World Total Return Index in ZAR |
| Fixed Income | 2002-2016: JSE ALBI Total return index |
| 1971-2002: Total return index created using 10 yr Government Bond Yields for South Africa provided by IMF on FRED |
| Commodities | 1971-2016: S&P GSCI Total Return Index in ZAR |
| Property | 2002-2016: FTSE/JSE SA Listed Property Total Return Index |
| 1992-2002: Property sector total return data provided by local asset manager |
| Inflation | 1971-2016: South Africa CPI Index (Statistics South Africa) |
| Risk Free | 1971-2016: Risk free / Cash index created using Treasury Bill Yields for South Africa provided by IMF on FRED |

## Performance returns 1971-2016



TBILLS JALSH MSCIWORLD SA10YR GSCI

Return 10.53 18.48 15.87 12.00 13.60

Volatility 1.26 20.99 17.42 7.35 22.88

Sharpe (10.53%) 0.00 0.34 0.28 0.18 0.12

MaxDD 0.00 -42.45 -49.90 -18.63 -64.08

Inflation CAGR 9.48 9.48 9.48 9.48 9.48

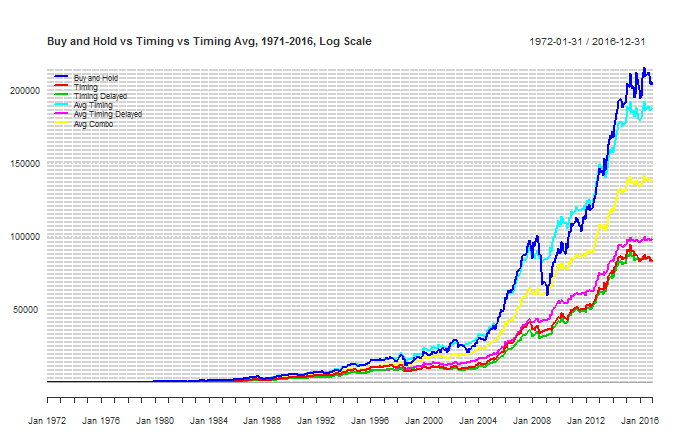
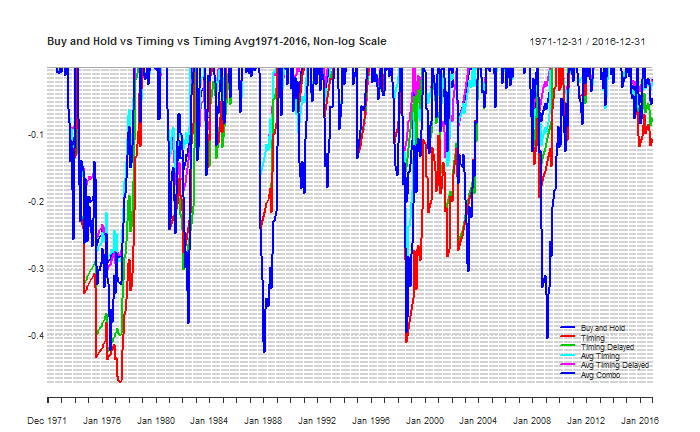
Over the period: [rewrite]

* Domestic equities have the best absolute returns of 18.48% followed by foreign equities with 15.87%
* Commodities still return 13.60% - shows the effect of the ZAR weakening boosting returns in local ZAR.
* Much higher inflation and risk free rate than the original US allocation

## Timing Signal

Let’s look at the asset returns individually and how the timing signal affect returns. Its interesting to note with South Africa assets that the timing model consistently resulted in better risk adjusted returns, usually by a reduction in volatility than better absolute returns. JALSH was an exception – it had a worse MaxDD and equal sharpe. [rewrite and mention this is where using multiple period moving averages or delayed entry would solve]

### JALSH

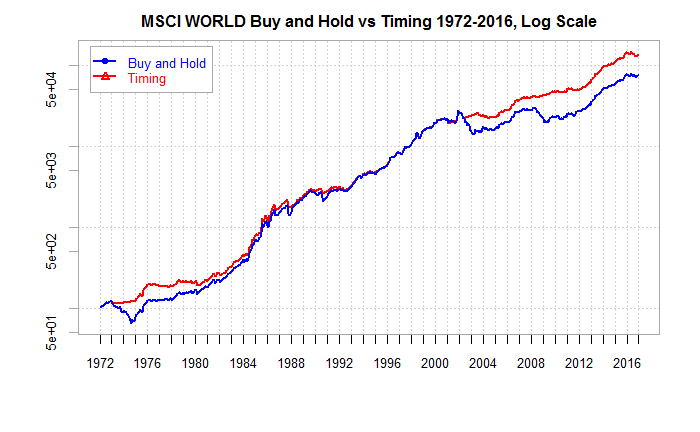
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Buy and Hold | Timing | Timing Delayed | Avg Timing | Avg Timing Delayed | Avg Combo |
| Return | 18.64% | 16.13% | 16.12% | 18.29% | 16.53% | 17.46% |
| Volatility | 20.99% | 17.26% | 15.96% | 14.90% | 12.69% | 13.50% |
| Sharpe | 0.68 | 0.67 | 0.73 | 0.94 | 0.96 | 0.97 |
| MaxDD | -42.45% | -47.02% | -42.34% | -29.30% | -30.20% | -29.31% |
| Calmar Ratio | 0.44 | 0.34 | 0.38 | 0.62 | 0.55 | 0.60 |
| Ulcer Index | 13.12% | 16.58% | 14.63% | 9.07% | 8.63% | 8.65% |
| Sortino Ratio | 0.44 | 0.45 | 0.50 | 0.65 | 0.70 | 0.70 |

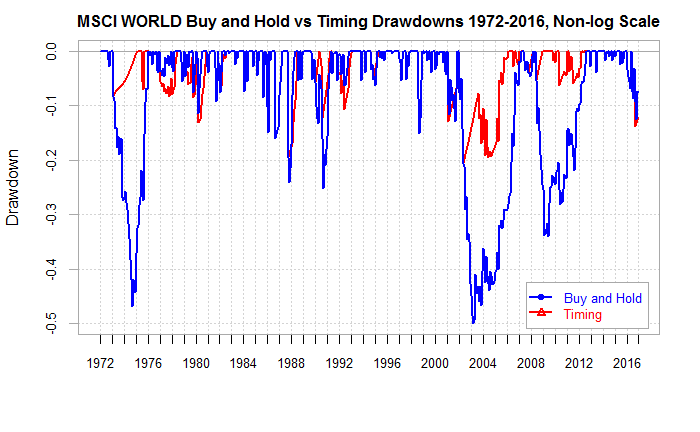
[add new format with extended methods, Need to add $100 becomes… Sharpe RF, fix scale, go through definitions of what measures were used and why]

Commentary:

* Interesting drawdown is the same – unusual for this strategy but have checked its real
* Timing model doesn’t add much value in this case
* There is always exceptions to any rule and it appears JALSH bucks the trend with the timing model not return significantly better risk adjusted returns. Analysing why – 1988
* Demonstrates power of compounding after an early loss
* Make this one pager..

### MSCI WORLD





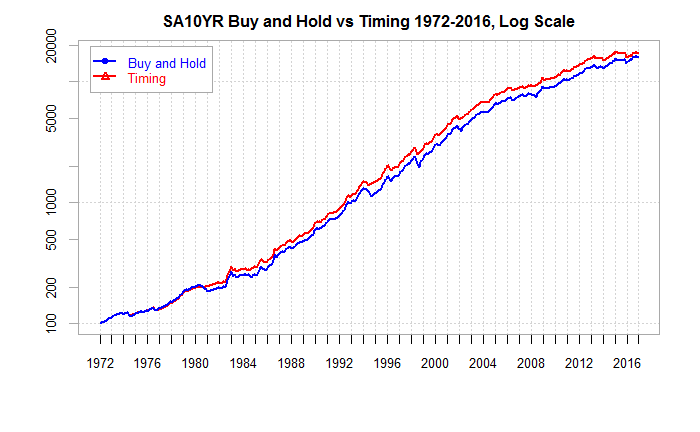
|  |  |  |
| --- | --- | --- |
|  | Buy and Hold | Timing |
| Return | 15.87% | 17.35% |
| Volatility | 17.42% | 15.09% |
| Sharpe | 0.69 | 0.90 |
| MaxDD | -49.90% | -20.54% |
| % Positive Months |  |  |

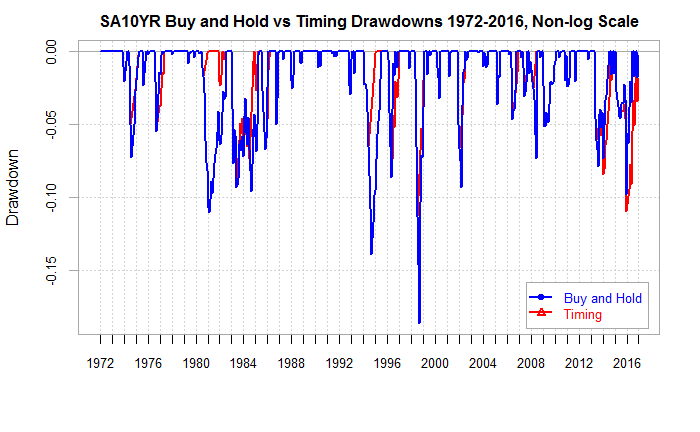
[update to include new strategies… Need to add $100 becomes… Sharpe RF, differences column, position chart]

Commentary:

* Much better results for the timing model in all performance measures

### SA10YR





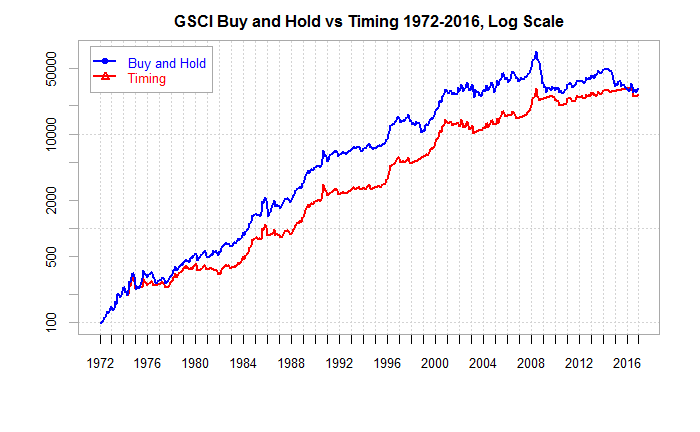
|  |  |  |
| --- | --- | --- |
|  | Buy and Hold | Timing |
| Return | 12.00% | 12.19% |
| Volatility | 7.35% | 6.62% |
| Sharpe | 1.05 | 1.21 |
| MaxDD | -18.63% | -11.35% |
| % Positive Months |  |  |

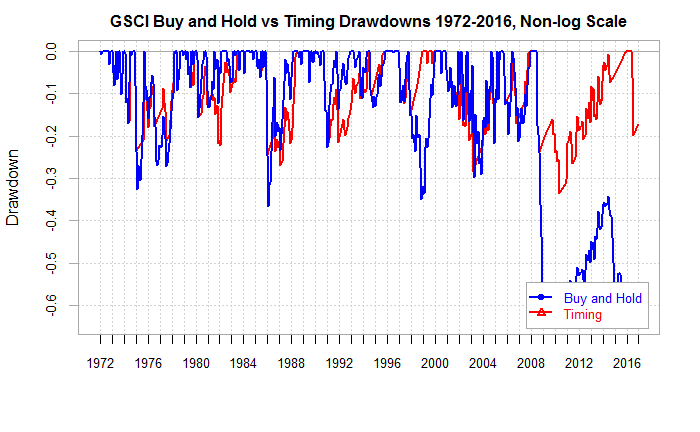
[Need to add $100 becomes… Sharpe RF, differences column]

Commentary:

* Much better results for the timing model in all performance measures

### GSCI





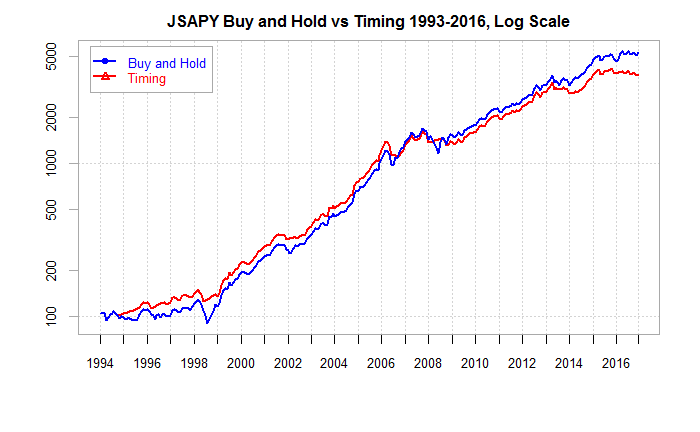
|  |  |  |
| --- | --- | --- |
|  | Buy and Hold | Timing |
| Return | 13.60% | 13.17% |
| Volatility | 22.88% | 19.00% |
| Sharpe | 0.44 | 0.50 |
| MaxDD | -64.08% | -33.50% |
| % Positive Months |  |  |

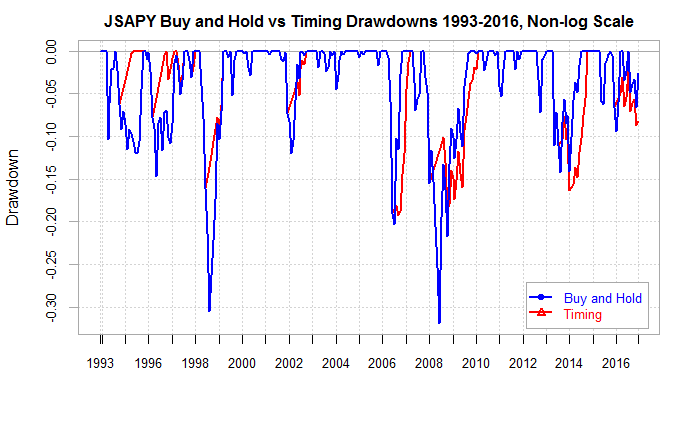
[Need to add $100 becomes… Sharpe RF, differences column]

Commentary:

* Most measures better.
* Interesting that the ZAR improves returns compared to USD GSCI

### JSAPY





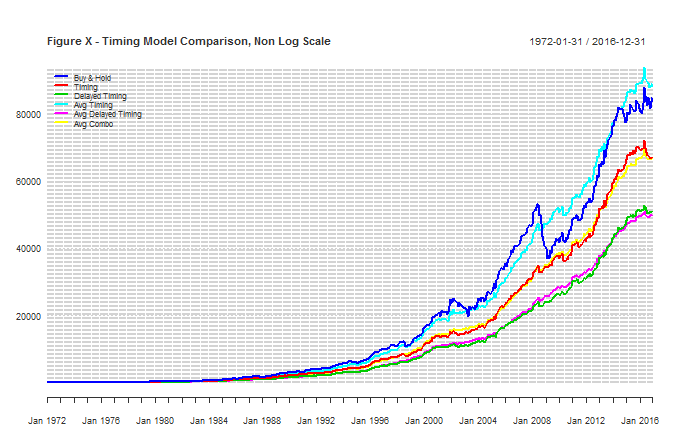
|  |  |  |
| --- | --- | --- |
|  | Buy and Hold | Timing |
| Return | 19.40% | 17.71% |
| Volatility | 15.85% | 13.26% |
| Sharpe | 1.15 | 1.26 |
| MaxDD | -31.87% | -19.25% |
| % Positive Months |  |  |

[Need to add $100 becomes… Sharpe RF, differences column]

Commentary:

* Again slightly less CAGR but less volatility and higher sharp / lower drawdown.

## Systematic Tactical Asset Allocation South Africa



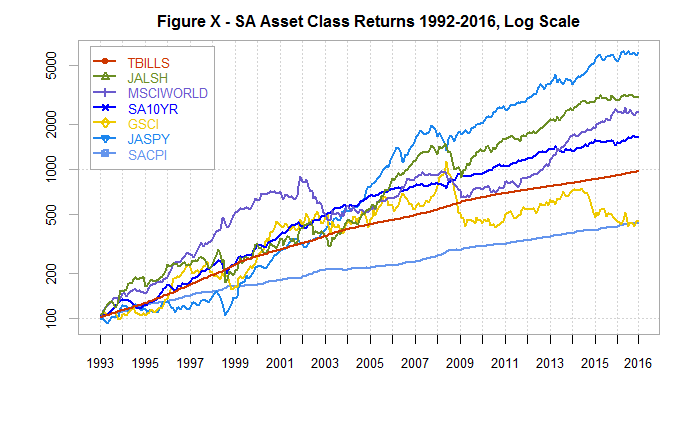
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Buy and Hold | Timing | Timing Delayed | Avg Timing | Avg Timing Delayed | Avg Combo |
| Return | 16.36% | 15.63% | 14.92% | 16.39% | 14.87% | 15.64% |
| Volatility | 10.95% | 8.76% | 7.96% | 7.87% | 6.50% | 7.07% |
| Sharpe | 0.49 | 0.53 | 0.50 | 0.68 | 0.61 | 0.66 |
| MaxDD | -30.61% | -11.59% | -11.59% | -7.29% | -7.07% | -7.18% |
| Inflation CAGR | 9.46% | 9.46% | 9.46% | 9.46% | 9.46% | 9.46% |
| Calmar Ratio | 0.51 | 0.59 | 1.32 | 0.78 | 1.66 | 1.15 |
| Ulcer Index | 6.35% | 2.60% | 2.58% | 1.74% | 1.40% | 1.50% |
| Sortino Ratio | 0.83 | 1.01 | 1.07 | 1.32 | 1.46 | 1.42 |

The absolute returns of the timing strategy are slightly worse however a larger drop in volatility results in a higher sharpe ratio. Importantly for investors, the biggest drawdown is 11.59%, approximately a third of the buy and hold.

Look at rolling returns / annual returns vs benchmark

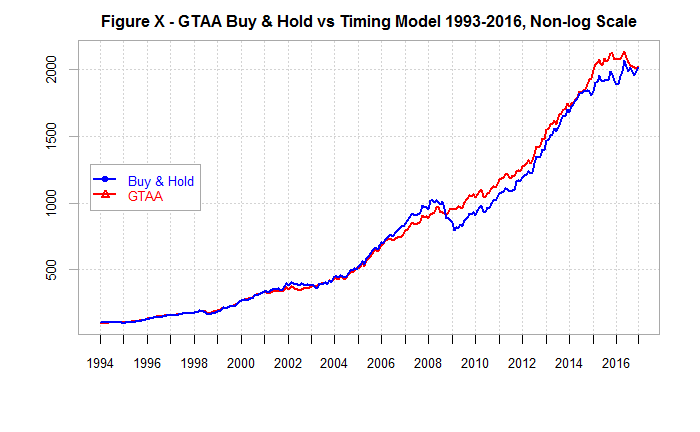
## Performance returns 1993-2016 including property

Now lets add property and compare since 1992



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure X - South African Asset Class Maximum Drawdowns 1992-2016** | | | | | | |
|  | TBILLS | JALSH | MSCIWORLD | SA10YR | GSCI | JASPY |
| Return | 9.93% | 15.29% | 14.18% | 12.41% | 6.51% | 18.64% |
| Volatility | 1.00% | 18.24% | 16.17% | 8.00% | 22.66% | 15.67% |
| Sharpe (9.93%) | 0.00 | 0.27 | 0.24 | 0.28 | -0.14 | 0.51 |
| MaxDD | 0.00% | -40.44% | -49.90% | -18.63% | -64.08% | -31.87% |
| Inflation CAGR | 6.33% | 6.33% | 6.33% | 6.33% | 6.33% | 6.33% |

Adding property will make a big difference – it’s the best performing asset since 1992. Also interesting to note over this period commodity returns are just slightly better than inflation which has lowered to 6.33%.



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Summary Annualised Returns for B&H vs Timing Model, 1994-2016** | | | | | | | |
|  | Buy and Hold | Timing | Timing Delayed | Avg Timing | Avg Timing Delayed | Avg Combo | |
| Return | 14.28% | 14.30% | 14.35% | 14.85% | 14.03% | 14.45% | |
| Volatility | 9.44% | 7.04% | 6.47% | 6.29% | 5.16% | 5.62% | |
| Sharpe | 0.43 | 0.58 | 0.64 | 0.73 | 0.74 | 0.75 | |
| MaxDD | -22.19% | -9.59% | -6.51% | -5.05% | -3.40% | -3.67% | |
| Inflation CAGR | 6.19% | 6.19% | 6.19% | 6.19% | 6.19% | 6.19% | |
| Calmar Ratio | 1.10 | 0.81 | 1.79 | 1.15 | 2.06 | 1.61 | |
| Ulcer Index | 4.66% | 1.95% | 1.42% | 1.24% | 0.79% | 0.96% | |
| Sortino Ratio | 0.84 | 1.27 | 1.60 | 1.55 | 2.06 | 1.84 | |

Including property, the timing strategy is slightly better/equal to the buy and hold. Again the timing strategy’s volatility is lower and max drawdown is still in the single figures.

Although performance metrics exhibit solid performance over a basket of US assets, when applied to South Africa its clear the timing strategy outperformance isn’t as strong. Why? Is it a case of overfitting in Faber’s paper, or a unique case where trend following rules don’t apply to a south Africa asset allocation?

Lastly as Faber has pointed out, diversification can also somewhat improve returns, again at a cost of increased taxes/trading fees.

numbers

* Diversifying with more asset classes:
  + We have only looked at asset classes in these example. Clare et all (2012 pg 8) research shows splitting an asset class into its components parts add value. Although perhaps too time consuming for retail investors, institutional investors could target better risk adjusted returns applying these strategies on individual assets within these broad asset classes.
  + Also add different asset classes – comment on how more and more is becoming available. Perhaps bitcoin as an example of an uncorrelated asset that could improve results.Diversifying using more moving average periods
* Using EMA
* Using vol filter
* Long and short (pg 158 faber ivy)
* Overlaying a mean reverting
* Pyramid in / out approach
* Signal has to be 1% above or below to change
* No bonds – already exposed to fixed income through treasuries – can remove and increase returns. However this will remove downside?
* High vol asset classes give better returns on a timing strategy (faber ivy 2009)

On analysis it appears the performance of the Systematic Tactical Asset Allocation with South Africa assets suffers due to domestic equities in the late 1970s. [Questionable data? – look to confirm]

Look at:

* adding more assets (can’t no data?) and   
  diversifying the moving average to longer and shorter signals
* look at exponential moving average

# Comparison to local SA funds

[change this to average timing] Retail funds in South Africa are known as Collective Investment Schemes (CISs) and are regulated under the Collective Investment Schemes Control Act 2002 (CISCA). Funds are then categorised according to classifications specified by the Association for Savings and Investment South Africa (ASISA), an industry body which assists the Financial Services Board with the regulation of the industry. ASISA uses a three tier classification system focusing on geographically where the fund will be invested (tier 1), what assets the fund invests in (tier 2) and then what the main focus of the fund will be (tier 3). One of the objectives of ASISA’s classification system is to facilitate the comparison of funds both across and within categories.

To compare the performance of the market timing strategy against comparative funds, the asset allocation has to be adjusted to fit within specific classification constraints. Two potential fund classifications that would only require minor reweighting to the equal weighted original allocation are Worldwide Multi Asset Flexible portfolios and South Africa Multi Asset High Equity portfolios.

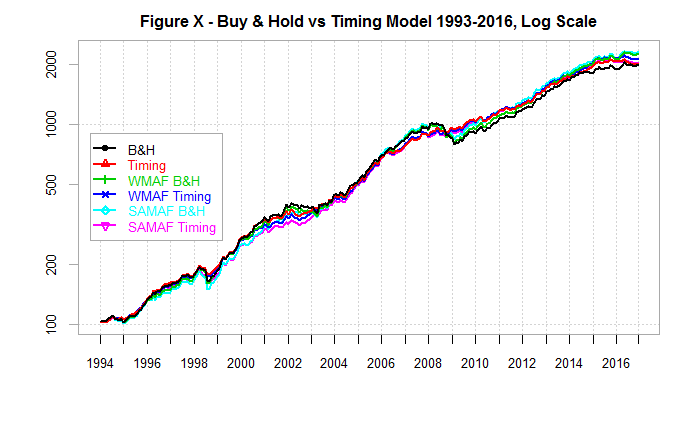
To fit within the Worldwide Mule Asset Flexible classification, the asset allocation has relative little constraints from ASISA. No minimum is set for domestic or foreign assets and they have complete flexibility in their asset allocation between and within asset class. Only CISCA regulations apply which in this case restricts commodity exposure to 10% [need to confirm this is the only constraint applicable here]. As such the following asset allocation has been selected:

* 22.5% Domestic Equity
* 22.5% Foreign Equity
* 22.5% Fixed Income
* 22.5% Property
* 10.0% Commodities

To fit within the South Africa Multi Asset Flexible classification, the fund must effectively invest at least 75% of their assets in South African investment markets considering a maximum of 25% of their assets can be assets outside of south Africa. [is there a commodity index or offshore equity index listed locally that counts as local?]. Combined with CISCA regulations, the following asset allocation has been selected:

* 25.0% Domestic Equity
* 15.0% Foreign Equity
* 25.0% Fixed Income
* 25.0% Property
* 10.0% Commodities

Ultimately the differences between each classification are minimal are seen in the following chart.



When comparing performance statistics, we see:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure X - South African Fund Classification Performance 1993-2016** | | | | | | |
|  | B&H | Timing | WMAF B&H | WMAF Timing | SAMAF B&H | SAMAF Timing |
| Return | 14.28% | 14.30% | 14.95% | 14.63% | 15.06% | 14.42% |
| Volatility | 9.44% | 7.04% | 9.22% | 7.00% | 9.22% | 7.13% |
| Sharpe (9.84%) | 0.43 | 0.58 | 0.51 | 0.63 | 0.52 | 0.59 |
| MaxDD | -22.19% | -9.59% | -18.75% | -11.52% | -19.22% | -13.62% |
| Inflation CAGR | 6.19% | 6.19% | 6.19% | 6.19% | 6.19% | 6.19% |

How do these compare to similar classification funds in South Africa? [get more info from peregrine/pres/s eed]

Morningstar is an investment research firm that provides performance reporting of ASISA funds in South Africa. Each month they release performance figures comparing funds of the same ASISA classification. Comparing each strategy to the peers we see mixed results with some periods of outperformance and some periods of underperformance.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 3m | 6m | 1yr | 3yr | 5yr | 7yr | 10yr |
| Peer Group Average | -1.41% | -1.56% | -3.75% | 7.31% | 13.95% | 12.02% | 9.74% |
| WMAF B&H | 3.93% | 0.82% | 5.80% | 8.29% | 13.42% | 13.07% | 10.59% |
| WMAF Timing | -0.41% | -4.36% | -1.25% | 5.92% | 11.42% | 10.66% | 10.63% |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 3m | 6m | 1yr | 3yr | 5yr | 7yr | 10yr |
| Peer Group Average | -1.27% | -0.40% | 1.72% | 5.50% | 10.82% | 10.28% | 8.87% |
| SAMAF B&H | 3.26% | 0.92% | 6.83% | 7.94% | 12.62% | 12.62% | 10.57% |
| SAMAF Timing | -1.27% | -3.62% | -0.33% | 5.39% | 10.49% | 10.20% | 10.30% |

# Conclusion

Write when finished

# Appendix 1 – Data validity check

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure 4 - Asset Class Maximum Drawdowns 1973-2012** | | | | | | |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | 5.42% | 9.77% | 9.19% | 8.12% | 8.34% | 9.64% |
| Volatility | 0.95% | 15.71% | 17.60% | 8.47% | 20.55% | 18.16% |
| Sharpe (??%) | 0.00 | 0.26 | 0.20 | 0.30 | 0.13 | 0.22 |
| MaxDD | 0.00% | -50.95% | -56.40% | -15.75% | -67.65% | -68.18% |
| Inflation CAGR | 4.33% | 4.33% | 4.33% | 4.33% | 4.33% | 4.33% |

Comparing to Fabers original numbers we see these small differences: (should this be in appendix with a comment saying comfortable obtained data represents the same asset classes?)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure 5 - Differences to Faber's Original Research 1973-2012** | | | | | | |
|  | TBILLS | SP500 | EAFE | US10YR | GSCI | NAREIT |
| Return | 0.01% | 0.07% | 0.02% | -0.06% | 0.02% | -0.01% |
| Volatility | 0.00% | 0.02% | -0.01% | 0.03% | 0.00% | 0.03% |
| Sharpe | 0.00 | -0.01 | -0.01 | -0.03 | -0.01 | -0.01 |
|  | 0.00% | 0.00% | 0.00% | 0.04% | 0.00% | -0.30% |
| Inflation CAGR | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% |

Differences here to the original paper are small:

* Differences in returns <0.07%
* Differences in volatility <0.03%

Suspect this is from small differences between data providers. Comfortable using for rest of research.

# Appendix 2 – Review of R

One of the goals of this masters was to learn a new programming language R. R is an open source language widely used by data scientists for analysis in a wide variety of fields. Initiated in 1997, R has grown in popularity along with an ever increasing number of packages available that extend the base R functions.

My experience using R over the last 9 months has been mixed. Despite being relatively fluent in other programming languages and generally very competent with computers, R proved to have a very steep learning curve. Supported of R say this is an unavoidable byproduct of the languages power and flexibility however it is also related to the minimal graphical user interface and requirement to enter everything via command line. Based around S, a language written in 1970, R can be clunky and difficult to use and is code based unless you install a third party GUI. Multiple hours were spent installing R, RStudio and learning the basics and understanding the general workflow. Installing packages especially on computers with strict proxies and firewalls also soaked up time.

R has many advantages; it’s free, powerful for data analysis, open source and supported online by a large active user base. Unfortunately, one of the drawbacks to this is that support can be slow and finding solutions or debugging code can be frustrating. Support was found from a variety of sources – online forums, mailing lists, IRC chats as simply searching the internet to find solutions on sites such as stackoverflow.

One of the biggest strengths of working with R was packages. Packages are user created bundles of code, that add specialist functions to the base R code. For example all performance metrics in the report was the result of one package, with many metrics requiring a simple line of code identifying returns to calculate CAGRs, Sharpe Ratios, and max drawdowns. A summary of the packages used can be found below.

One issue I found with using packages is that updates can occur and remove previous functionality. For example the package performanceanalytics, which provides several functions for analysing portfolio performance, updated it graphs to use xyz. This resulted in several charts no longer displaying as originally designed, with simple things such as date formats no longer working to more critical things such as being unable to display on a log y axis.

There are a variety of courses available online from coursera, datacamp as well as a book R4DS that I would recommend for anyone interested in exploring R further.

Packages used:

|  |  |
| --- | --- |
| PerformanceAnalytics | Collection of econometric functions for performance and risk analysis |
| Quantmod | Charting, downloading of data from FRED, yahoo finance. |
| Quantstrat | Functions for building trading strategies |
| Dplyr / Tidyverse |  |
| Rblpapi |  |
|  |  |
|  |  |

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[fill in once finished]

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