VOLATILITY AND THE ASSET ALLOCATION DECISION

by

JOÃO BRUNO MENESES SCHWALBACH
752540

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Supervisor: Mr. David McClelland

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ABSTRACT

This dissertation investigates the inclusion of volatility into the asset allocation decision, first as an asset class, and second as a tool for dynamic equity allocation. An examination on whether volatility exposure as an asset class has the necessary characteristics to form part of the broader investment universe is conducted. This is accomplished by comparing the risk-return characteristics of three naked option-selling strategies, a bull put spread strategy and a VIX futures strategy with the S&P 500 Index. Each volatility strategy is also included as part of a 30/30/40 volatility/equity/bond portfolio and compared to a traditional 60/40 equity/bond portfolio. Historically, the results indicate that all individual volatility strategies generated superior Sharpe ratios and exhibited less severe drawdowns than the S&P 500 Index, particularly during the 2008 Global Financial Crisis. Additionally, all volatility blended portfolios experienced better tail-risk profiles than the 60/40 equity/bond portfolio, with the naked option-selling strategies also generating similar returns as the 60/40 portfolio both over the full sample period as well during the period of recovery following the 2008 Global Financial Crisis. The results suggest that the returns associated with option-selling strategies are consistent, and have resulted in strong long-run risk-adjusted performance, qualifying short volatility exposure attained through option-selling strategies as an asset class. It however remains unclear whether the VIX futures strategy qualifies as an asset class given that it aims to exploit a market anomaly in the form of potentially non-priced volatility clustering in the S&P 500 Index. While the strategy generated considerable outperformance from 2004 to 2009, it underperformed from 2009 to 2016 suggesting that much of the non-priced volatility clustering has since been traded away. Drawing on the evidence of volatility clustering in equity markets, a managed volatility trading rule that regulates portfolio exposure between cash and equity based on how high the prevailing volatility level was relative to historical volatility levels is developed. Although transaction costs were not accounted for, the results indicated that the managed volatility trading rule has historically generated considerably superior Sharpe ratios than equity in developed and developing markets. In conclusion, volatility exposure attained through option-selling strategies has proven to be an attractive asset class, and historical evidence suggests that its inclusion into a traditional 60/40 equity/bond portfolio is likely to reduce the risk of future risk-adjusted underperformance relative to what had been achieved in the past. Additionally, the managed volatility trading rule remains an attractive alternative to investors who are precluded from investing in volatility as an asset class.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The strategic asset allocation decision is arguably the most important consideration faced by investors given that it explains around 90% of the variability of portfolio returns over time (Ibbotson & Kaplan, 2000). The decision of which asset classes to select, and the relative weighting assigned to each is thus an area that requires continuous improvement. Before evaluating individual assets according to their contribution to the overall portfolio risk and return, investors first need to define the universe of asset classes available for selection. Greer (1997) defines three broad categories of asset classes: capital assets, consumable/transformable assets, and store of value assets. Capital assets are those that offer an ongoing stream of cash flows and include equities, which offer dividends, and bonds, which offer interest payments. Consumable/transformable assets are used as part of a production process, such as commodities. Store of value assets are those that have a value but cannot be consumed and do not earn cash flows, such as currencies.

Once the universe of asset classes has been established, the next part of the strategic asset allocation decision is selecting and assigning a weight to assets. Equity and sovereign bonds (bonds) are generally accepted to be traditional asset classes, and are usually the principal building blocks of portfolios. Asness (1996) demonstrates that equity has historically achieved superior returns when compared to other assets classes, and suggests this causes investors to select it as the main return engine within portfolios. The author also illustrates that while bonds have experienced lower historical returns than equity, their historical standard deviation is considerably lower. As a result, Asness (1996) illustrates how superior risk-adjusted returns relative to a 100% equity portfolio could be earned with the implementation of a 60/40 equity/bond portfolio due to the diversification benefits provided by bonds.

It is well-established that other risky asset classes such real estate, gold and other commodities have improved the risk and return profile of the traditional 60/40 equity/bond portfolio. Hoesli, Lekander and Witkiewicz (2004) conclude that real estate is an effective diversifier to the traditional mix, and advocate for a nontrivial real estate allocation within portfolios. Baur and Lucey (2010) prove that gold is a ‘safe-haven’ asset that offers strongest performance when traditional portfolios need it the most: during equity market turmoil. Georgiev (2001) shows that an allocation to a basket of commodities has historically increased risk-adjusted returns, and have proven to be an effective hedge against inflation. These assets, as well as others, have historically been blended with the traditional mix of equity and bonds, and have been shown to offer diversification benefits.

More recently, Grant, Gregory and Lui (2007) present a case for short equity volatility exposure, captured systematically through selling options contracts on equity, as an asset class. The main finding of the authors' research is that the systematic sale of equity index volatility through the sale of volatility derivatives have offered significantly positive, passively generated returns over time. The authors also find that a strategy which involves the sale of equity volatility has historically outperformed equity during periods of market turmoil, resulting in superior Sharpe ratios being generated by volatility exposure when compared with equity. Further, when volatility exposure was added to a 60/40 equity/bond portfolio, the newly-created volatility-blended portfolio generated superior risk and return characteristics when compared to the traditional mix. The authors conclude that volatility meets their definition of an asset class. According to the definition of an asset class established by Greer (1997), volatility exposure attained through the systematic sale of options contracts is most likely to be classified as a capital asset. This is because option premiums, which qualify as cash flows, are systematically being earned.

The sale of put options is akin to attaining short volatility exposure, thus it follows that the purchase of put options is akin to attaining long volatility exposure. Israelov and Nielsen (2015) state that buying put option protection is a bet that realized volatility will exceed implied volatility over the time-horizon of the option. Implied volatility is the market's expectation of volatility in the underlying instrument over the life of an option and is determined by supply and demand dynamics, whereas realized volatility is the *ex-post* volatility experienced by the underlying instrument over the matching time-period. The researchers found that volatility risk premium (implied volatility minus realized volatility) was positive 88% of the time from 1990 to 2014, and concluded that market turmoil analogues to the October 1987 crash would have to occur at least once every 10-years for a long put options strategy on the S&P 500 Index to break even.

The fact the volatility risk premium (VRP) has been persistently positive on average is a clear sign that there is excessive demand for protection (resulting in the overpricing of protection), and this creates an opportunity for supplying protection in the form of systematically selling put option contracts. While this approach may initially appear to be risky, it has been shown by past research to generate steady and consistent returns. Further, it is entirely possible to hold an unleveraged position by simply holding a 100% cash collateralized portfolio along with the strategy. For example, if at-the-money (ATM) options are being sold systematically together with holding a fully-collateralized portfolio, the drawdown profile of the short volatility exposure strategy should be identical to that of the underlying except for the fact that option premiums are still being earned that offset downside losses.

VRP has also been found to be significantly positive by other researchers including Latane and Rendleman (1976), Jackwerth and Rubinstein (1996) and Jiang and Tian (2005). Past literature has offered explanations behind the tendency for VRP to be consistently positive over time. First, the demand for option protection generally exceeds the supply of option protection, particularly after the 2008 Global Financial Crisis (GFC). Second, given that option-selling is akin to selling insurance, investors require a premium that is positive over time and competitive with other assets of similar riskiness. Third, many investors are constrained against taking short positions and are thus restricted from participating. Consistent with the findings of Grant, Gregory and Lui (2007), Rennison and Pedersen (2012) also find that systematically attaining short volatility exposure through the sale of options has historically outperformed equity on a risk-adjusted basis.

Attaining short volatility exposure through option-selling strategies is neither the only way to attain volatility exposure, nor is the only way to generate returns from volatility exposure over time. The CBOE Volatility Index (VIX Index) aggregates 30-day implied volatility levels across varying degrees of moneyness into a single implied volatility level to represent the overall market consensus of volatility over the next 30 days. VIX Index derivatives such as VIX futures enable investors to gain exposure to changes in the VIX. Szado (2009) showed that long VIX futures provided highly attractive returns during adverse equity market conditions, offering strong tail-risk protection characteristics despite experiencing negative long-run returns. Simon and Campasano (2014) developed a VIX futures strategy, which found that taking short positions in VIX futures when the VIX futures curve is in contango (VIX spot price < VIX front-month future price), and taking long positions in VIX futures when the VIX futures curve is in backwardation (VIX spot price > VIX front-month future price) achieved substantial returns from 2006 to 2011.

The key difference between the VIX futures strategy and the option-selling strategies previously described is that the approach developed by Simon and Campasano (2014) is both long and short volatility depending on the shape of the VIX futures curve, whereas option-selling strategies are systematically short volatility. While a case can been made for short volatility exposure as an asset class, it is less clear whether dynamically switching between long and short volatility exposure can be classified as an asset class. While systematically selling options provide a reliable stream of cash flows in the form of option premiums, the VIX futures strategy exploits potentially non-priced volatility clustering. That is, the VIX futures strategy relies on the assumption that the VIX spot price will not change over time to the degree suggested by the VIX futures price, i.e. when the VIX spot price is lower (higher) than the VIX futures price, it is likely to remain lower (higher) than the VIX futures price all the way up to the expiration date. Thus investors can exploit this by buying (selling) the VIX future at a discount (premium) relative to the VIX spot, earning returns as the VIX future rolls down (up) the curve all the way up to convergence at the expiration date (Simon & Campasano, 2014).

Collie, Sylvanus and Thomas (2011) found historical evidence of volatility clustering in the S&P 500 Index, showing that levels of realized volatility tended to be persistent from period to period. In other words, the authors found that periods of high (low) realized volatility tended to be followed by periods of high (low) realized volatility. Additionally, Collie, Sylvanus and Thomas (2011) found that equity returns preceded by periods of high volatility were not significantly different from equity returns preceded by periods of low volatility.

Using these findings, Collie, Sylvanus and Thomas (2011) first defined the prevailing level of volatility as recent realized volatility given that realized volatility was found to be so persistent in the S&P 500 Index. Next, given that returns were not found to be significantly different depending on the volatility environment that preceded them, the authors developed a volatility-responsive trading rule that increased (decreased) equity exposure when the prevailing rate of volatility (recent realized volatility) was high (low) relative to historical standards. The researchers found that superior risk-adjusted performance was historically earned relative to the S&P 500 Index using a volatility-responsive trading rule. Specifically, the volatility-responsive trading rule was found to reduce equity drawdown risk considerably, while maintaining competitive absolute return levels relative to the S&P 500 Index.

1.2 PROBLEM STATEMENT

While traditional portfolios such as 60/40 equity/bond mix have performed well in the past, Summers (2016) suggests that it is unlikely that this performance will continue due to structurally weaker levels of global economic growth caused by secular stagnation. Summers (2016) identifies the global rise in the propensity to save as well as a global decline in the propensity to invest as drivers of secular stagnation. Specifically, the author attributes the expected structural decline in the global economy to the following: first, the rising levels of inequality has resulted in more wealth concentration among high net-worth individuals. Wealth concentration results in a lower spending propensities by the general public, which in turn drives higher levels of savings propensity. Second, the evidence suggests that there has been a rise in reserve accumulation by developing countries, who largely hold reserves in the form of highly liquid instruments such as US Treasury-bonds driving yields downward. Third, and perhaps most importantly, demographic issues such as lower birth rates and longer life expectancies have reduced the growth rate of the working population, resulting in less spending on consumer goods and more retirement saving. Summers (2016) suggests that there is a strong expectation that the US labour force will not grow over the next 20 years causing a vacuum in industries that service the labour force, such as equipment providers and the housing industry. Additionally, improvements in technology may substantially reduce the need for more physical investment.

While central banks have historically managed to bring spending forward thereby boosting demand and economic growth by reducing interest rates, such conventional expansionary monetary policy appears to be reaching its limits. This is especially true in the developed world, which currently has interest rates that are exceptionally low by historical standards. Additionally, the normalization of interest rates from historically low levels may contribute further to challenging conditions for traditional asset classes in the future.

Given that the popularity of the traditional 60/40 portfolio, the risk of underperformance relative to the past poses a significant problem for investors. In the 60/40 equity/bond mix, equity is primarily held due to its relatively high expected return and bonds serve to mitigate equity risk, particularly during adverse market conditions. In a world of lower expected growth levels and limited monetary policy amid exceptionally low interest rates by historical standards in the developed world, it is reasonable to consider that secular stagnation as proposed by Summers (2013) will lead to lower expected returns relative to the past. It then follows that the risk of such underperformance relative to the past, especially on a risk-adjusted basis, is a natural implication of the world view described by Summers (2013) given that that equity, which is the main driver of growth within traditional portfolios, is forecasted to underperform relative to historical standards.

Therefore, should investors wish to continue to generate comparative returns as had been achieved in the past using the same traditional asset classes, it stands to reason that the only way of doing so is by shifting more capital from bonds to equity given the need for higher expected returns. However, this approach has the unwanted side-effect of raising equity drawdown risk in the process. In order to reduce the probability of underperformance relative to benchmarks in the future, the addition of another return engine that can also offer further diversification to the traditional 60/40 equity/bond portfolio is needed.

1.3 RESEARCH QUESTION

The research question investigated in this dissertation is whether volatility, first, in the form of an asset class, and second, in the form of a risk management tool, can reduce the risk that a 60/40 equity/bond portfolio experiences inferior risk-adjusted performance in the future relative to what it had accomplished in the past. Specifically, in response to the problem statement described above, this dissertation advocates for the inclusion of volatility exposure into the asset management decision, first, as an asset class in the form of volatility exposure, and second, as a risk management tool, in the form of realized volatility as a forward signal for dynamic equity allocation.

The first part of this dissertation investigates whether volatility exposure can serve as an additional driver of performance within traditional portfolios to reduce the risk of underperformance on a risk-adjusted basis by complementing the role that equity serves in a 60/40 equity/bond portfolio. Some investors may have constraints that preclude them from attaining volatility exposure within their portfolios. As previously discussed, in order to reduce the risk of underperformance, these investors may have no choice but to shift some capital from bonds to equity, thereby increasing equity drawdown risk in the process. Thus, the second part of this dissertation investigates realized volatility as a risk management tool to reduce equity drawdown risk by regulating equity exposure, specifically for investors who may not be able to invest in volatility exposure as an asset class.

Regarding the investigation into volatility exposure as an asset class, this dissertation examines three approaches: first, strategies that are short near-the-money S&P 500 Index put options. Second, a bull put spread strategy which is simultaneously short at-the-money S&P 500 Index put options and long a 10% out-the-money S&P 500 Index put options with the same expiration date. Third, a VIX futures trading rule wherein trade direction is determined by whether the VIX futures curve is in contango or backwardation. Given the evidence for a considerable asymmetry of returns favouring the sellers of protection, this dissertation investigates three option-selling strategies which are each fully-collateralized with 3-month United States of America Treasury bills (US T-bills). They are: the CBOE PutWrite Index which replicates the sale of 30-day at-the-money (ATM) S&P 500 Index put options, a short ATM second-month S&P 500 Index put options strategy and a short 5% out-the-money (OTM) second-month S&P 500 Index put options strategy. A bull put spread strategy that is simultaneously short ATM and long 10% OTM second-month S&P 500 Index put options is also investigated.

Given that the S&P 500 Index has experienced strong growth with relatively low levels of volatility since the end of the period of investigation chosen by the authors, this dissertation investigates a similar rendition of the strategy, fully-collateralized with 3-month US T-bills, over a lengthened period from 2004 to 2016. The period from 2009 to 2016 is also isolated in order to determine whether the strategy persistently generated remarkably high returns during such a positive period of performance by the S&P 500 Index.

This dissertation evaluates the characteristics of each derivative strategy that provides volatility exposure according to a risk-return framework to determine whether volatility exposure qualifies as an asset. The annualized holding period return (HPR) of each strategy will be compared with that of the S&P 500 Index, and the risk of each approach will be proxied by volatility, drawdowns, Value-at-Risk (VaR), Conditional Value-at-Risk (CVaR) and worst 6-month HPR. Once strategies have been individually assessed and contrasted with equity, each will represent volatility in a 30/30/40 volatility/equity/bond strategy that will be compared with a traditional 60/40 portfolio to determine whether the inclusion of volatility into traditional portfolios would have improved risk-adjusted returns historically.

Regarding the investigation into realized volatility as a risk management tool, this dissertation validates the assumption that equity returns do not differ significantly depending on the volatility environment they were preceded by in developed and developing markets. A managed volatility trading rule that uses recent weighted realized volatility as signals to regulate portfolio exposure between equity and 3-month US T-bills in developed and developing markets is also investigated. The viability of the managed volatility trading rule will be compared with equity in each market based on historical annualized holding period return well as risk measures including volatility, drawdowns, VaR, CVaR and worst 6-month HPR.

1.4 CONTRIBUTIONS

In a world characterized by lower growth expectations and limited ability for central banks to effect expansionary monetary policy, it is prudent for diversification to be a staple for global investors. Past research has contributed to this end by investigating different strategies to capture volatility exposure as an additional asset class, which has been shown to improve diversification within portfolios. This dissertation aims to contribute to literature by comparing and contrasting several volatility exposure strategies on a level playing field. That is, this study takes several approaches that capture volatility exposure and uses each to replace half of the equity exposure in a traditional 60/40 equity/bond portfolio, such that the risk and return characteristics of each approach can be examined in an overall portfolio context.

Further, for investors who are precluded from attaining volatility exposure, this dissertation builds on past research which has used realized volatility on the S&P 500 Index as a risk management tool to successfully reduce S&P 500 Index drawdown risk while maintaining competitive levels of absolute return. This study also back tests the managed volatility trading rule on 3 other MSCI indexes in order to investigate its performance on global equity markets

1.5 LIMITATIONS

This dissertation limits the evaluation of volatility exposure as an asset class to equity index volatility on the S&P 500 Index. This is because the implied volatility data, used to price options, and volatility index futures prices that could be sourced, began too recently to justify adequate comparison with the US data. However data has been sourced to proxy for both developed and developing market equity, upon which the use of realized volatility as a signal to reduce equity drawdown risk can be explored. This dissertation ignores all taxation and transaction costs. Additionally, unless otherwise stated, closing prices were used in this study without considering bid-ask spreads. These omissions may have a bearing on how each strategy performed theoretically, compared with how they would have realistically performed with the inclusion of transaction costs and other leakages.

1.6 CONCLUSION AND STRUCTURE OF DISSERTATION

The addition of a new asset class into the existing universe of asset classes available to investors is always welcomed. This is especially the case given the predictions of secular stagnation theory, which suggests that future global growth levels ought to be lower than what had been experienced in the past. Thus, it is reasonable to suggest that the inclusion of an additional return engine into the universe of asset classes available to investors would be of great benefit.

Past research has found that volatility as an asset class has historically generated competitive absolute annualized HPRs similar to equity, with improved downside characteristics. This dissertation examines whether the inclusion of volatility as an asset class has historically improved the risk and return characteristics of a traditional 60/40 portfolio, to evaluate whether its inclusion will reduce the risk of future underperformance relative to what had been achieved in the past. Some investors may have constraints that disallow them from trading derivatives. Thus, this dissertation investigates the use of realized volatility as a risk management tool such that equity drawdown risk can be reduced in the event of higher equity allocations being necessary to reduce the risk of underperformance in absolute terms in future.

The balance of this dissertation is divided up as follows: Chapter 2 provides background information on the major topics under investigation. Chapter 3 elaborates on the data sourced for this study as well as the methodologies used in developing the various strategies that follow. Chapter 4 focuses on discussing the findings of the strategies investigated and compares these discoveries to past literature. Finally, Chapter 5 concludes the dissertation and suggests further areas of investigation.

1.7 LIST OF ABBREVIATIONS

The list of abbreviations used throughout this dissertation:

Table 1: List of abbreviations

Acronym	Definition
ATM	At-the-money
Cap	Market capitalization
CBOE	Chicago Board Options Exchange
CML	Capital Market Line
EAFE	Europe, Australasia and Far East
EM	Emerging Markets
EMH	Efficient Market Hypothesis
FM	Frontier Markets
FOMC	Federal Open Market Committee
GDP	Gross Domestic Product
GFC	Global Financial Crisis
HPR	Holding Period Return
ITM	In-the-money
MSCI	Morgan Stanley Capital International Europe
OTM	Out-the-money
QE	Quantitative Easing
R*	Natural rate of interest
S&P	Standard & Poors
T-Bill	Treasury bill
T-Bond	Treasury bond
US	United States of America
VIX	Chicago Board Options Exchange Volatility Index
VRP	Volatility Risk Premium

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 2 is focused on providing a holistic review of past literature relevant to this study. First, recent works on secular stagnation that provide the impetus for seeking to both explore other equity-like return streams as well as new risk management strategies that may implicitly reduce equity drawdown risk will be explored. Second, past research that investigated option-selling strategies will be investigated together with an alternative strategy to capture returns from volatility products in the form of a VIX futures strategy. Finally, past research on the use of volatility as a potential forward indicator that regulates equity exposure to reduce equity drawdowns will be examined.

2.2 SECULAR STAGNATION

Hansen (1939) first introduced the theory of secular stagnation which postulated that due to thinning investment opportunities as well as other economic issues experienced after the Great Recession, savings were expected to begin exceeding investment causing GDP to underperform potential GDP structurally. The author’s views did not pan out at the time with the US entering World War II in 1941, following which significant economic growth was experienced on the back of vast amounts of government investment. There has been a resurgence of the theory most notably by Summers (2013) and Krugman (2013) that argue that the theory put forth by Hansen (1939) may have been incorrect only in timing, and that the issues he raised may likely fit those currently being observed in the world economy.

Summers (2013) notes that current interest rates are low by historical standards in most developed nations. This observation also holds for expected future real interest rates when considering current 10-year interest rates and 10-year expected inflation rates in the industrial world as priced in by markets. The present expectation for extraordinarily low real interest rates to be far below what has been experienced in the past, is not a recent phenomenon. Many researchers including Laubach and Williams (2003) as well as Barsky, Justiniano and Melosi (2014) have found that real interest rates in the US have been downward sloping for a considerable amount of time. The implication of which is that there must exist a set of factors that are increasing the propensity to save and decreasing the propensity to invest, given that the real interest rate is the equilibration between savings and investments (Summers, 2016).

Summers (2016) suggests that some causes for the increasing propensity to save are first, rising inequality with more wealth concentration in high net-worth individuals resulting in lower spending propensities by the general public and a greater degree of savings propensity. Second, rising reserve accumulation in developing countries, who largely hold reserves in the form of highly liquid instruments such as US Treasury-bonds driving yields downward. Third, demographic issues such as longer life expectancies driving the need for increasing savings so as to have enough capital for retirement, and decreased spending while in retirement to ensure that savings stretch as far as possible combined with household deleveraging.

Regarding the tendency for the decrease in the propensity to invest, the author suggests that some drivers may include the expectation that the US labour force will not grow over the next 20 years causing a vacuum in industries that service the labour force, such as equipment providers and the housing industry. Additionally, improvements in technology may substantially reduce the need for more physical investment.

Summers (2016) notes that the less-than-impressive growth from 2003 leading up to the GFC was only achieved on the back of a vast erosion of credit standards and what is today considered to be a bubble in the housing market. The fact that such a stimulatory environment propelled merely ‘normal’ growth rates indicates that without such stimulus, the period may have resulted in sub-standard growth leading one to draw parallels to today's expectation of future growth.

Laubach and Williams (2003) define the natural rate of interest, often referred to as R*, as the real short-term interest rate that equates output with potential output, where potential output is the economy’s long-run growth rate which is consistent with stable inflation. R* is the unobservable equilibrating factor between savings and investment and is the real neutral interest rate in that it is neither stimulatory nor contractionary.

Stimulative monetary policy in the US has traditionally been achieved through a reduction in the federal funds rate. This easing acts to ‘pull-forward’ demand, encouraging consumers to purchase assets such as motor vehicles and property earlier than they otherwise would have given the cheaper cost of credit. This brings spending forward and thus acts to kick-start the economy and fills a temporary shortfall in demand. It follows then that having a clear understanding of what the prevailing R* is of considerable importance for monetary policy, because expansionary policy can only be effective if real rates are reduced below R*. Thus implying that if current R* is too low to begin with, conventional stimulatory monetary policy has a severely limited impact.

Since 1960, Summers (2016) found that the average amount of monetary easing during recessions has been a decrease of 5.1% in real terms per episode. Given how markets are currently pricing their expectations of future real interest rates, the author believes that the probability of the US being able to stimulate the economy during a recession to the degree that has been done in the past is highly unlikely. The author acknowledges that quantitative easing has been used in the past as an unconventional monetary policy tool, but while effective during its initial implementation buying into substantially illiquid fixed income markets and reducing large credit spreads, its effectiveness is largely seen to be diminishing. It therefore follows that the implication of secular stagnation is a permanent demand shortfall, where the 'pulling-forward' of spending is fast reaching the point of severely diminishing returns, resulting in the conclusion that standard monetary policy cannot be relied on the next time a recession comes.

What does this all mean for the rest of the world? The phenomenon of low real rates is not unique to the US, as Rachel and Smith (2015) find that global real rates have declined 4% from 1980 to 2015, and state that there exists no reason for global R* to recover over the next 15 years. If interest rates are truly going to be 'lower for longer', it follows that bond and equity values which are computed as the present value of future cash flows can only go up if either the discount rate decreases or expected cash flows increase. While the advent of globalization has had a major contribution to global economic growth, with open trade and the improved flow of capital and labour being some of its mechanisms, it has also brought with it the risk of rapid, and significant contagion effects. Should the 'new normal' of lower global growth rates manifest, contagion effects may be exacerbated as yield-seeking investors look to drive substantial amounts of capital to developing economies. While increased investment may lead to a beneficial outcome to developing nations in the short-run, should another global crisis surface, the 'flight to quality' and need for liquidity by the same international investors may lead to a simultaneous sell-off in developing markets leading to a convergence in the correlations of local asset classes.

Another consideration is the fact that the US Federal Reserve increased the federal funds rate by 0.25% in December 2015 for the first time since 2006 ending a 7-year period during which rates were near their lower bound of 0% to support the recovery post the GFC, with further rate hikes expected in the near-future (Cox, 2015). In the pursuit of achieving their policy objective of a 2% inflation target, the Federal Reserve were clear on the desire of 'normalizing' interest rates as long as the economy allowed for it. Further, negative interest rates in developed markets such as Germany and Switzerland have left the developed world with a relatively limited ability to reduce interest rates. Should a global program of 'normalizing' interest rates ensue, the rising rates are likely to have a negative impact on the returns on traditional asset classes such as equity and bonds. Volatility on the other hand is not directly influenced by interest rates, rather, is the result of supply and demand dynamics in derivative markets and may thus reduce interest rate sensitivity of portfolios.

Equity drawdowns will be experienced at the same time as drawdowns experienced in equity option-selling strategies given that such options will only pay out when equity experiences losses. However, given that premiums are consistently earned from consistently selling options, drawdowns are less severe, and recoveries are more rapid than equity (Rennison & Pederson, 2012). Should the world begin exhibiting tendencies that are described by secular stagnation theory, and equity begins generating disappointing long-run returns, option-selling strategies are still likely to contribute to portfolio growth given consistent premiums being received (Rennison & Pederson, 2012). Should the world turn out remarkably different to what is predicted by the theory, the benefits of the introduction of volatility as asset class into traditional portfolios should still hold in that it has generated returns which have been found to be significantly positive over the long-run, with less severe drawdowns than equity. Further, the impact that normalizing interest rates may have on equity prices, combined with the limited strength that monetary policy currently has if another large market crisis was to manifest puts forth the case for investors to implement robust risk management programs such as those presented in this dissertation.

2.3 THE ESTABLISHMENT OF VOLATILITY EXPOSURE AS AN ASSET CLASS

Greer (1997) defines three broad categories of asset classes: capital assets, consumable/transformable assets, and store of value assets. Capital assets are those that offer an ongoing stream of cash flows and include equity, which offer dividends, and bonds, which offer interest payments. The intrinsic value of a capital asset is normally the present value of its future cash flows, discounted at an appropriate discount rate. The price of a capital asset is driven by market supply and demand dynamics that guide its price to a level approximately equal to the consensus' view of its intrinsic value. Consumable/transformable such as commodities, and store of value assets such as currencies, do not generate cash flow, and thus their price is determined only by supply and demand dynamics.

There has been a definite rise in the popularity of exchange-traded volatility-related since the beginning of the 21st century (Whaley, 2013). The most pronounced increase in demand came after the 2008 GFC, when long volatility exposure proved to be a very effective counter-balance to the sharp fall in equity prices (Alexander, Kapraun & Korovilas, 2015). Lin and Lin (2016) agree with the assertion that long volatility exposure provides negative correlation with the underlying equity, suggesting that the rise in popularity of volatility-related products is mainly attributable to the value of hedging volatility risk by taking long positions in volatility derivatives such as VIX futures.

Grant, Gregory and Lui (2007) contend that volatility qualifies as an asset class that can be added to the investment universe available to investors. According to the authors, volatility exposure has historically offered significantly positive returns that have been generated without being attributable to the skill of the investor, but rather, captured passively using a systematic approach. Further, the authors found that even short volatility exposure has the tendency to outperform equity even in market crisis' suggesting that attractive absolute returns and diversification benefits offered by volatility exposure justify it meeting the definition of an asset class. Under the framework established by Greer (1997), given that option-selling results in cash flows being earned in the form of option premiums, short volatility exposure is similar to a capital asset.

Hafner and Wallmeier (2007) also advocate for volatility exposure as an asset class finding that a passive strategy involving systematically selling variance swaps has performed resoundingly well relative to traditional asset classes historically. Daigler and Rossi (2006) find that when combined with equity, long volatility exposure has historically been a highly effective diversifier. Rennison and Pederson (2012) strongly support volatility exposure as an asset class finding that the sale of options on various underlying instruments has demonstrated highly attractive risk and return characteristics over time with imperfectly correlation with traditional asset classes.

2.4 VOLATILITY RISK PREMIUM

2.4.1 Characteristics of the volatility risk premium

Christensen and Prabhala (1998) state that the volatility that is implied by an option premium is the market's estimate of the level of volatility over the remaining life of the contract. If one considers all variables in the formula used to calculate the price of an option as put by Black and Scholes (1973), if the current underlying stock price, strike price, time to expiry, risk-free interest rate and option premium is known, then the only unknown variable that is embedded in the calculation is implied volatility. Realized volatility is the *ex-post* calculation of volatility, calculated over the matching period using the actual results of the underlying instrument. The tendency for implied volatility to exceed realized volatility has long been established by researchers including Latane and Rendleman (1976), Jackwerth and Rubinstein (1996) and Jiang and Tian (2005) to name but a few. The positive spread between implied and realized volatility is known as the volatility risk premium (Israelov & Nielsen, 2015).

More recently, Israelov and Nielsen (2015) compared S&P 500 Index's 21-business-day annualized realized volatility with the VIX Index, which is the S&P 500 Index's volatility implied by option prices calculated using a range of options with varying degrees of moneyness but with a constant 30-day expiry (analogous to 21-business-days). Consistent with prior research, the authors find that on average, over a 24-and-a-half year period measured until mid-2014, a 3.40% volatility risk premium (VRP) is observed and that VRP had been positive 88% of the time. The authors also found that negative VRP returns came about when implied volatility was less than realized volatility. This mainly occurred during market downturns as losses which were not anticipated by options markets caused downward momentum in markets which then resulted in spiking volatility levels. The authors also noted that VRP had a quicker recovery time from drawdowns than equity as options markets were quick to price in higher volatility levels once a market crisis began unfolding requiring higher returns for selling options during a crisis. Thus in a relatively short period, implied volatility once again exceeded realized volatility and a recovery of VRP ensued.

Rennison and Pedersen (2012) investigated various markets including equity indices, commodity futures, currencies and swaptions and aimed to capture VRP in each market from 1994 to 2012. The study's findings serve to illustrate VRP's characteristics. First, the authors found that on average, each had a positive VRP corresponding to the value of about 10% of the average level of implied volatility. What is also interesting to note is that the magnitude of VRP varied across markets with commodity futures displaying the highest average implied volatility of 37.40% with a 4.40% VRP and currencies displaying the lowest average implied volatility of 10.30% with a 0.90% VRP. Sharpe ratios were all positive with the lowest being 0.70 for currencies and highest being 1.20 for commodity futures.

As volatility risk premium will be negative if realized volatility exceeds implied volatility, and given that negative VRP should occur as a result of a market crash that was not expected by market participants, Rennison and Pedersen (2012) found that VRP displays negative skewness over the short-run. Specifically, all strategies under investigation experiencing 3 to 4 standard deviation losses and 2 to 3 standard deviation gains over 1-month periods. When considering the longer-run, the authors found that VRP displays significant positive skew with with all strategies experiencing only 1 to 2 standard deviation losses but with 2 to 5 standard deviation gains over 12-month periods.

The authors also found that while VRP strategies may experience sudden sharp losses in the short run, they tend to recover very quickly consistent with past research. When considering the average length of drawdowns, VRP strategies experienced a relatively low 5-month period on average compared to over a 1-year period for US large market capitalization (large cap) equity. The reason cited by Rennison and Pedersen (2012) for this phenomenon is that implied volatility tends to overreact to market crisis' as the demand for hedging risk spikes and stays elevated for a considerable amount of time resulting in a relatively fast recovery for VRP. Should this hypothesis hold, it appears that volatility may exhibit a strong mean-reversion tendency. These results are also consistent with other empirical evidence that found that VRP experiences consistent small gains with short, large losses attributable to events that cause realized volatility to spike above implied volatility.

2.4.2 Explanations for the existence of the volatility risk premium

Researchers have offered explanations for the evidence that there exists a significantly positive volatility risk premium over time. The introduction of derivative markets have afforded investors the ability to externalize price risk in the short-run in the pursuit of capturing long-run risk premium in volatile assets such as equity. The ability to truncate at least some downside by the externalization of price risk, while usefulness, is also expensive.

Bollen and Whaley (2004) demonstrate that there exists a stark imbalance between supply and demand in the options market. The authors find that of all tradeable S&P 500 options in circulation, the majority of those actually traded are put options. Specifically, they find that the majority of this imbalance is caused by the demand brought about by put option buyers significantly exceeding the supply provided by put option writers.

Broker-dealers have been the main suppliers of put options, and Garleanu, Pedersen and Poteshman (2009) observed that these market makers, who are the intermediaries taking opposing positions to market participants, cannot perfectly hedge away exposures. This combined with the daily cost associated with hedging their own exposure mean that market makers, who are understandably risk-averse, require compensation for the risk of their unhedged inventory together with the cost of their hedged inventory which is reflected in option prices.

Given that the majority of demand for put options lie with option buyers, the authors also note that market makers will not simply supply an infinite amount of a particular option. Market makers are forced to charge higher prices for the same options to compensate them for growing risks and costs such as the degree to which imperfect hedges may harm them as well as hedging costs. The above is consistent with Black and Scholes (1973) who conceded that option holders would be expected to pay premiums higher than those computed by the Black-Scholes Pricing Model given the transaction costs associated with such purchases that are effectively borne by option holders.

Israelov and Nielsen (2015) back-tested a protective put strategy that involved being long the S&P 500 Index together with holding 5% out-the-money put options with monthly expiration dates. The researchers found that the strategy produced a lower risk-adjusted return as compared to holding only the S&P 500 Index and concluded that the high cost associated with holding put options as a strategy results in relative underperformance.

Gromb and Vayanos (2010) suggest that there are costs associated with arbitrage that prevent arbitrageurs from exploiting all mispricings including costs of short-selling, fundamental and non-fundamental risks, leverage and margin constraints, as well as constraints on equity capital. Given these limitations faced by professional arbitrageurs, there may exist an opportunity for investors with a long-term investment horizon who can withstand deep losses in the short-run in order capture the VRP over the long-run.

2.4.3 Capturing the volatility risk premium

There are a few ways to capture VRP, and while all involve the net sale of implied volatility, each may differ in terms of trading costs, risk, difficulty to implement and delta-hedging (which involves hedging against moves in the underlying markets such that the position is primarily exposed to changes in volatility).

- Options strategies

Option-selling strategies such as the sale of out-the-money put options are the simplest approach to capturing VRP. Option writers implicitly bet that the implied volatility used to price the premium received will exceed realized volatility and thus the quantity they must pay out on average over the long-run (Israelov & Nielsen, 2015). The maximum loss of writing a put option is the entire strike price minus the option premium received. Additionally, option-selling strategies are by definition correlated with the directional moves in underlying instruments which is the reason that some investors choose to delta-hedge. However, perfect delta-hedging can only be achieved temporarily given the speed of market movements, therefore even with high-frequency delta-hedging, some correlation with the underlying instrument is inevitable (Garleanu, Pedersen & Poteshman, 2009).

Other options strategies include selling straddles which involve selling both a call and a put on an underlying instrument with the same strike price and expiration date thereby receiving premiums for both (Moschini & Lapan, 1992). The maximum loss on the put will be the strike price minus the premium, however the maximum loss on the call is theoretically unlimited which however unlikely, is a drawback to this approach. A similar strategy is the short strangle which differs from the short straddle only in the put and call options are sold with different strike prices, that is, they are both sold slightly out-the-money but on the same underlying instrument and with the same expiration date (Schneeweis & Spurgin, 2001). The advantages and disadvantages of this approach are largely similar to the straddle.

A method investors can use to place an explicit floor on potential losses when realized volatility exceeds implied volatility is the bull put spread strategy which involves the simultaneous sale of a put option and the purchase of another put option with the same expiration date but lower strike price (Chaput & Ederington, 2005). In this approach, the premium received for selling a put option that is closer to the money should exceed the premium paid away for buying a put option further from the money. This results in the investor being a net seller of protection, but only captures part of the VRP as some has been sacrificed to place a limit on the maximum potential loss to the differential between the strike prices of the two options. This method of limiting maximum loss by using some premium to purchase protection further from the money than where the investor is selling protection can be applied to all option strategies that attempt to capture VRP.

- Variance swaps

Selling variance swaps allow investors to take a directional position in the volatility embedded in option prices without having to trade options and periodically delta-hedge. The payoff structure is directly linked to the spread between implied and realized volatilities, and because it is available on over-the-counter (OTC), it is reasonably easy to trade. As the name would suggest, the difference between implied and realized variance and not volatility on some underlying instrument will be settled at the expiration date.

2.4.4 The inclusion of volatility risk premium in a portfolio

The case built by Summers (2013) that the global economy is facing a long-run reduction in demand is a compelling reason for the inclusion of VRP which, in the long-run, should be more shielded from such environments given the consistent earning of option premiums. Thus, given that option-selling strategies have been found by Rennison and Pedersen (2012) to generate equity-like returns in the past, it follows that the replacement of some equity exposure with short volatility exposure would reduce the reliance placed on equity as the main driver of portfolio returns with the inclusion of another return engine. Equity volatility exposure as an asset class will by definition experience drawdowns when equity experiences drawdowns, however, given that premiums are received consistently, these portfolios with a combination of equity and volatility will experience drawdowns that are less severe and recoveries that are more rapid than portfolios with only equity exposure (Rennisson & Pedersen, 2012). In an attempt to limit the severity of drawdowns further, the feasibility of a bull put spread strategy that pays some premia away in order to limit downside while still being exposed to some upside is investigated.

Rennison and Pedersen (2012) evaluate VRP's portfolio contribution potential, comparing return, risk and correlation characteristics with other asset classes during four sub-periods: pre-crisis (1994-2007), the GFC (2007-2009), recovery (2009-2010) and sovereign crisis (2010-2012). The authors find that VRP experienced strong positive returns during the pre-crisis, recovery and sovereign crisis periods, and even though it suffered losses during the financial crisis period, it had significantly higher Sharpe ratios that were positive on average when compared to US large cap stocks which had a negative Sharpe ratio. This is in line with the evidence provided by the authors which showed that VRP experienced strong recoveries due to market overreaction which allowed for relatively short drawdown episodes.

Regarding correlation, the authors find commodity, currency and interest-rate VRP to have a relatively low positive correlation with US large stocks, emerging market equity, emerging market bonds, commodities and currency. The highest correlation was between commodity volatility and emerging markets at 34%. However, equity VRP had fairly stronger correlations with more traditional assets with a 50% correlation with US large cap stock and a 63% correlation with emerging market equity. Correlations across assets did increase as one would expect during the financial crisis period with correlations between equity VRP and US large stocks being 67% and equity VRP and emerging market equity being 71%.

While hedging the drawdown risk of VRP needs to be considered, the reliability of returns evidenced by Rennison and Pedersen (2012) perhaps make it like no other asset class. In terms of the sustainability of returns, Israelov and Nielsen (2015) investigated the VRP from 1990 to 2014, and found that the average positive spread between implied and realized volatility did not appear to have shrunk during the period. Even after the authors compared the VRP after bucketing implied volatilities as represented by the VIX Index into deciles, the lowest average VRP in decile 1 was 2.5% compared to the highest VRP in decile 9 of 4.7%.

2.4.5 VIX futures strategy

Capturing the VRP using options is not the only way of deriving a return stream from volatility. Simon and Campasano (2014) suggest that the rise in popularity of other volatility products such as VIX futures contracts is owed to their consistently negative correlation with equity returns. Szado (2009) showed that long VIX futures provided highly attractive returns during adverse equity market conditions, offering strong tail-risk protection characteristics despite experiencing negative long-run returns. Schwert (2011) found that negative stock returns are associated with elevated levels of volatility. Similarly, Israelov and Nielsen (2015) find that sharp and sudden losses in equity markets are normally associated with spikes in volatility, and these periods greatly benefit investors who are long volatility. During periods of market calm which represent the majority of trading days in the long-run, the authors suggest that investors who are short volatility benefit.

Long VIX exposure offers similar protection to sharp equity losses as the purchase of put options - both are a bet that realized volatility will exceed implied volatility that is priced in by options markets. Thus, in the same way as the purchase of put options has been found by Israelov and Nielsen (2015) to be a drag on returns in the long-run despite high degrees of outperformance during periods of market crisis, Szado (2009) finds the same to be true of long VIX exposure.

Simon and Campasano (2014) developed a trading strategy that tactically switches from long VIX futures contracts to short VIX futures contracts in an attempt to capture both the smaller but consistent returns associated with being short VIX futures contracts during calm market conditions for the majority of time, but also the larger return associated from being long VIX futures contracts during brief periods of market stress.

The researchers used the VIX futures basis which describes the difference between the price of VIX futures contract and the spot price of the VIX as their long or short signal. That is, at the beginning of each trading day, if the VIX futures curve was sufficiently upward sloping (in contango), VIX futures contracts were shorted. If the VIX futures curve was downward sloping (in backwardation), the researchers went long VIX futures. This strategy resulted in substantial and significantly positive returns even after accounting for transaction fees. However, a great deal of the performance was attributable to the extraordinary returns derived from being long VIX futures during the 2008 GFC considering that the period under investigation ended in 2011.

This approach differs from capturing VRP using options in that the VRP is derived from the tendency for implied volatility to exceed realized volatility as a result of excess demand for options contracts. The premise of the trading strategy devised by Simon and Campasano (2014) is based on the findings of Mixon (2007) and Nossman and Wilhemsson (2009) which found the forecast power of the VIX futures basis for changes in future VIX prices to be insignificant.

The implication of this lack of forecasting power found by Mixon (2007) and Nossman and Wilhemsson (2009) is that assuming the VIX futures curve is in contango, then because the VIX spot price does not tend to rise to the level of the futures price over the period, and given that the VIX futures price must converge to the VIX spot price upon settlement, the VIX futures price would have to fall to the level at which the VIX spot price is at. The researchers found that VIX futures basis has a significant forecast power of changes in VIX futures price changes, which presented a profitable trading opportunity for shorting VIX futures contracts when the VIX futures basis was in contango, and going long VIX futures contracts when the VIX futures basis was in backwardation.The key benefit offered by this approach is that while option-selling strategies are systematically short volatility, the VIX futures strategy is both short volatility and long volatility. This should in theory result in short volatility exposure most of the time according to the results of Simon and Campasano (2014), with occasional switches into long volatility exposure to profit from falls in equity associated with realized volatility exceeding implied volatility.

Using daily data from 2006 to 2011, Simon and Campasano (2014) found that the VIX futures curve with respect to the front-month contract was in contango 68.10% of the time and in backwardation 31.90% of the time. When the VIX price was less than 30% which represented 80.58% of the time during the period under investigation, the majority of the observations were found to be in contango. When the VIX price was between 30% and 40%, observations were evenly distributed, and when the VIX price was greater than 40% which only represented 9.24% of the time, the majority of observations were in backwardation. Periods of backwardation seemed to be clustered specifically during the GFC when markets experienced highly elevated VIX levels causing investors to perhaps price in some degree of mean-reversion with lower VIX futures prices relative to VIX spot prices.

The nature of the return stream derived from this approach is fairly clear: when the VIX futures basis was in contango, small and consistent daily returns were captured, and when the VIX futures basis was in backwardation, large gains were captured. This is similar to characteristics of VRP where small daily returns are captured on a daily basis as a result of being short implied volatility, the key difference is that when the VIX futures basis provides the signal, the VIX futures strategy attempts to profit from elevated levels of volatility by being long VIX futures as well.

2.5 REDUCING EQUITY DOWNSIDE RISK

The role of volatility in making asset allocation decisions from the position of an asset class that could replace or complement equity has so far been discussed. The next section outlines how volatility can be used to reduce equity drawdown risk without the use of derivatives (which may be restricted by some mandates) by regulating equity exposure with 3-month US T-bills.

Asness (1996) showed that investors have benefited historically by favouring an approach of allocating some percentage of their portfolios to ‘safe-assets’ such as Treasury-bonds (bonds) due to their diversification benefits. For example, in a traditional 60/40 equity/bond portfolio, the inclusion of bonds is primarily intended to act as an offsetting return stream in the event of a crisis in equity markets. Since the effective US federal funds rate peaked at 22% at the end of 1980, investors have enjoyed somewhat of a tailwind in markets with rates trending downwards to zero post-GFC. This downward trend in rates allowed bonds to be significant contributors to portfolio returns over the period, while still maintaining their characteristic of being the asset of choice during ‘flight to quality’ events. Around 30% of all bonds in the Barclays Global Aggregate Index currently trading with negative yields, including the 50-year Swiss government bond (Lewin, 2016). However, the contribution bonds will have in portfolios in the future is unclear. By purchasing a negative yielding bond, investors are locking in a guaranteed loss on their investment, despite this, investors still seek the protection that bonds provide in an equity crisis even though its effectiveness as part of a 60/40 portfolio during market crashes such as the GFC has been found wanting (Lee, 2011).

Rachel and Smith (2015) confirm that real interest rates around the world are currently starkly lower than they had been in the past. It is still possible for some equities to continue achieving returns similar to those enjoyed in the past due to higher cash flow expectations despite a lower growth environment. However, it is reasonable to suggest that the same simply cannot be said for the future long-run return contributions for bonds given such extraordinarily low interest rates in developed markets, and limited ability to decrease rates further.

Beber, Brandt and Kavajecz (2009) find that in times of market stress, investors move capital from more risky assets to bonds due to a demand for liquidity. As the purpose of including developed market sovereign bonds in portfolios is first and foremost its historically proven attractiveness particularly in times of economic crisis, it stands to reason that if equity drawdown risk can be reduced without coming at the expense of significant drags on return, the reliance placed on bond exposure which is likely to underperform may be tapered. Thus, if the theory of secular stagnation holds, and long-run developed market sovereign bond returns turn out to be zero or perhaps even negative, then it follows that reducing equity drawdown risk implies less reliance on bond exposures.

Reducing equity drawdown risk is not an easy task. The introduction of derivative markets has allowed investors to hedge exposures by purchasing instruments such as options contracts to place an explicit limit on the losses that could potentially be incurred. Such protection has been restrictively expensive (Israelov & Nielsen, 2015).

An even simpler approach to reducing equity drawdown risk is to hold less equity. However, the aim of reducing equity drawdown risk should not be to eliminate volatility in its entirety, as investors enjoy upside volatility and wish to be compensated for accepting downside volatility in the long-run (Ang, Chen & Xing, 2006). Instead, the aim should be to explore strategies to systematically reduce exposure to the catastrophic impact brought about by tail-events that not only negatively impact portfolio returns, but also pose significant business risk to asset management firms who may experience a drain of assets under management caused by client withdrawals in often the most inopportune of times.

The efficient market hypothesis (EMH) suggests that higher levels of risk would need to be accepted if higher levels of expected returns were desired. The implication of accepting more risk in pursuit of higher returns is increased exposure to risky assets that have historically experienced some periods of underperformance, and occasionally suffered severe drawdowns brought about by ‘black swan’ events (Taleb, Goldstein, & Spitznagel, 2009). ‘Black swan’ events are low probability events that generally have a high impact on the left tail of return distributions, and are impossible to predict (Taleb, Goldstein, & Spitznagel, 2009).

World markets are more connected than ever, with ever-greater interdependence largely brought about by globalization. Countries around the world have largely embraced the open economy model, significantly improving global economic conditions (Feachem, 2001). A cost of this success is the contagion between markets. It is entirely possible that a seemingly isolated crisis in one country affects other countries in significant ways. An example of this is the GFC which initially affected the real estate market in the US, but in a rapidly began affecting the entire economy and soon became a global crisis with many countries still recovering from it (Aloui, Aïssa & Nguyen, 2011). These ‘butterfly effects’ are part of the reason that led Taleb, Goldstein and Spitznagel (2009) to favour preparation over prediction. That is, instead of allocating resources to predicting such events, which by their very nature are impossible to predict, rather allocate resources to limit their impact when they inevitably occur.

All investors should consider the need to reduce both the frequency and magnitude of tail-events particularly with regard to equity in order to improve long-run performance, and there exists various approaches that have been documented to meet this need each with their own benefits and pitfalls. Various methods will be investigated below using a framework developed by Chee (2015) who classified tail-risk management strategies into those that provide explicit downside protection by eliminating the left tail of the distribution of outcomes, and those that attempt to redesign the distributions of outcomes. An approach or combination of approaches that maximize equity drawdown protection while minimizing the reduction of expected return is preferred *ceterus parabis* given that the probability of strong long-run performance is increased.

2.5.1 Explicit downside hedges

Explicit downside hedges such as purchasing put options or VIX futures allow investors to truncate downside risk. While the cost of these strategies often disallows them to become a permanent feature of portfolios, they do not affect the strategic asset allocation decision, that is, do not alter the shape of potential return distributions by changing the target weightings assigned to each asset within a portfolio. The reason for this is that these derivatives are overlays onto existing positions, rather than new allocations that require portfolio adjustments. Instead, they are used to eliminate the risk of suffering losses beyond a certain level while still accepting the uncertainty brought about by the investors choice of asset allocation.

- Purchasing put options

A protective put is made up of a long position in an underlying instrument together with a long position in a put contract on the underlying instrument (Santa-Clara & Saretto, 2009). This provides the option holder with an exact level of downside protection in exchange for a premium, as the investor has the option to sell the underlying instrument should its price fall below the strike price and thus only participate in a certain amount of the downside (Geske & Johnson, 1984).

Figlewski, Chidambaran and Kaplan (1993) investigate the performance of various protective put strategies which involve holding a long position in the underlying stock together with the purchase of put option protection. The authors found that the strategy did not perform as well as expected historically suggesting that when markets are forecasted to earn relatively low returns, it may be more beneficial to simply sell the underlying stock and hold cash as opposed to buy put protection on it. The expensiveness of put options has also been established by Evans, Geczy, Musto and Reed (2009), Israelov and Klein (2015) and Ge (2016).

Arnott (1998) suggests that the use of put options as instruments used for portfolio insurance have issues that require consideration. First, the author found that the expensiveness of put options may alter the level of moneyness that investor can realistically insure at. Second, in the case of long-term investors, the arbitrary time-horizons at which put options expire are not aligned with the investment time-horizon. Third, given that premium needs to be paid to attain put option protection, less weighting can be given to other assets within the investor's portfolio.

Israelov and Nielsen (2015) evaluated a protective put strategy on the S&P 500 Index that involved the purchase of 5% out-the-money put options on a monthly basis. While the strategy proved successful during the sudden shocks in return, improving downside beta and portfolio volatility as compared to the volatility of the index, it achieved approximately half of the excess return attained by the index. Furthermore, while the index experienced a Sharpe ratio of 0.37, the strategy was only able to achieve a Sharpe ratio of 0.12. Not only was the excess return significantly lower, but the strategy proved to be considerably less efficient than simply holding the index, implying that the cost of holding the put options clearly went unrewarded.

- Purchasing VIX futures

VIX futures are exchange-traded contracts based on the future level of the VIX Index (Zhang & Zhu, 2006). In terms of the relationship between the spot price (VIX Index) and the futures price (VIX futures), literature has some mixed results. Simon and Campasano (2014) found that the VIX futures basis has a poor forecasting power on future VIX Index changes. However, Shu and Zhang (2012) find that VIX futures prices tend to lead the VIX Index implying that VIX futures market may have some price-discovery function.

The phenomenon of falling stock prices being associated with rising levels of realized volatility was discussed in Black (1976), that found a negative correlation between stock returns and their volatility level particularly during periods of market stress. Modigliani and Miller (1958) stated that securities issued by the firm in order to raise capital (debt or equity) are merely different ways of dividing the ownership of the firm. Based on this principle, Black and Scholes (1973) linked market volatility to the underlying capital structure of firms, as holders of bonds issued by firms have a claim on the firm's value equal to the face value of their bonds, a decrease in the market value of a firm influences the degree of leverage on its capital structure, with this increased leverage resulting in rising implied as well as realized volatility. This phenomenon has since been referred to as the "leverage effect", and presents a case where being long volatility (expecting realized volatility to exceed implied volatility) may offer protection during a crisis.

Today, VIX futures contracts exist which can be used to provide investors with such directional exposure to volatility. Long VIX futures exposure offer a positive payoff profile when there is a rise in volatility usually caused by falls in equity prices. This negative correlation with equity returns was found to be historically reliable by Simon and Campasano (2014). Szado (2009) compared the use of long put options on the S&P 500 Index to long VIX exposure and concluded that holding the long VIX exposure could have provided improved protection as compared to put options during the GFC. Consistent with the findings of long put options, the author notes that long VIX exposure has historically resulted in negative returns. This is not surprising given the evidence already presented that showed that providers of protection require a premium to insure purchasers of protection.

2.5.2 Approaches that re-shape the distribution of outcomes

The following approaches attempt to reduce uncertainty by condensing the left side of the return distribution thereby implicitly reducing both the frequency and magnitude of drawdowns. Whilst the cost of implementing such approaches are substantially lower than explicit downside hedges like option-buying strategies; investors achieve the change in distribution only by manipulating strategic asset allocation, which may, in the long-run affect how investors perform relative to their mandates.

- Diversification

Markowitz (1952) is considered to be the father of Modern Portfolio Theory (MPT) and provided a mean-variance framework which is still widely used by investment professionals to describe the risk and return profile of any portfolio. Markowitz (1952) separates the process of portfolio selection into 2 stages, the first being the use of experience and observation to postulate the future performance of assets, the second takes those assumptions and uses them for portfolio selection. The first-order moment under consideration for a portfolio is expected return which describes the expected percentage increase in the value of an asset from one period to the next. The second-order moment under the framework is standard deviation which is the proxy for describing the risk profile of an investment.

Standard deviation is a measure of the variability of the distribution of returns around its mean. Under normal circumstances, researchers analyze only a sample of returns as opposed to the entire population. Thus, sample statistics which are considered to be unbiased estimators of the true population are calculated.

Markowitz (1952) assumes that investors are risk-averse, that is, investors prefer less risk to greater risk *ceteris paribus*, and thus desire the lowest risk possible for a given level of expected return, and inversely the highest expected return possible for a given level of risk. Efficient portfolios, therefore, are those who have the highest possible expected return per unit of standard deviation, or alternatively, the lowest possible standard deviation per unit of expected return. The author links all possible combinations of these efficient portfolios on a mean-variance framework, with the resulting curve known as the efficient frontier.

Building on the framework established by Markowitz (1952), Tobin (1958) established the separation theorem adding US Treasury Bills (T-bills) as a proxy for cash to the mean-variance framework. Tobin (1958) established a premise that T-bills are a risk-free asset and thus plot on the mean-variance framework directly on the expected return axis. By drawing a straight-line tangent to the most northwesterly point of the efficient frontier from the risk-free rate on the expected return axis, the Capital Market Line (CML) was created.

The implication of the CML is that only a single optimal portfolio exists, as opposed to the many efficient portfolios on the efficient frontier. Thus, if investors are unable to accept the risk implied by the position of the tangent portfolio, an allocation to the riskless asset could be mixed with the tangent portfolio such that risk can be reduced while still maintaining the highest possible expected return. Similarly, if a higher level of risk is desired, instead of being long cash (lending) together with some exposure to the tangent portfolio, investors can be short cash (borrow) together with some exposure to the tangent portfolio such that the highest possible expected return is achieved per unit of risk.

There exists a trade-off between risk and expected return where an increase in expected return can generally only come about by accepting higher levels of standard deviation as the inherent cost. The high degree of volatility brought about by holding only a single security in a portfolio however, is not necessarily rewarded with a high expected return. Sharpe (1964) suggests that a portfolio's risk can be divided into unsystematic and systematic risk. Unsystematic risk cannot be reduced, however, systematic risk can be diversified away. Specifically, the author explained that diversification allows investors to eliminate the idiosyncratic risk of each individual security, thereby reducing overall portfolio risk without necessarily reducing expected return. Risk-adjusted returns can therefore be improved at a zero explicit cost by diversifying within asset classes only if expected returns are not perfectly correlated.

The risk reduction benefits of diversification can best be explained with an example of a 2 stock portfolio. Assuming that a portfolio consists only of a single stock ABC, then the volatility of the portfolio is simply equal to that of ABC. If the investor adds stock XYZ to ABC and places an even amount of cash in each assuming the standard deviations of ABC and XYZ are 20% and 10% respectively, with covariance equal to 0.017, then the portfolio volatility is equal to 14.49%. Based on this simple example, it is clear that assets should not be chosen only on the merit of their own risk and return characteristics, but also on how the asset move behave in conjunction to others within a portfolio.

Diversification benefits are felt even more when investors additionally diversify across asset classes. To illustrate this, if instead of stock XYZ, bond AAA was added to ABC with equal allocations, and bond AAA had a standard deviation of 7% with the covariance between the two being -0.0042, then the portfolio volatility would reduce to 9.55%. Diversifying geographies over and above diversifying within and across asset class would further benefit risk reduction given the addition of even more imperfectly correlated return streams, however, it is important to note that correlations are not fixed and may change unfavourably during a crisis for example, where correlations may converge due to a sell-off across all asset classes when liquidity is needed, rendering diversification ineffective.

The benefits of diversification arise as the idiosyncratic risk of any single asset as a proportion of total risk decreases as the number of imperfectly correlated assets are added to a portfolio, until the portfolio risk as a whole consists almost entirely of systematic risk which is undiversifiable. The universe of investable asset classes is limited, and the introduction of an additional imperfectly correlated return stream in the form of volatility risk premium has been shown by many authors such as Rennison and Pedersen (2012) and Grant, Gregory and Lui (2007) to be beneficial to investors' portfolios in the long-run.

It has been observed that the benefits of diversification seem to break down when the correlations of asset classes converge during tail-events (Baur & Lucey, 2010). The reasons for sell-offs in even 'safe' assets during tail-events are many, but not all investors who participate in sell-offs are doing so out of choice. Some investors may hold geared long positions, which may need to have maintenance margins topped up during a tail-event forcing these investors to liquidate even 'safe' assets such as bonds. Fund managers may experience 'bank runs', and may be compelled by mandate to hold a certain strategic asset allocation and will need to sell-off exposures across the board to maintain their target asset allocation. Thus, while diversification is still a wise and effective approach to managing the frequency of drawdowns, it may not be as effective in reducing the magnitude of drawdowns when correlations converge (Baur & Lucey, 2009). What follows is a brief summary of various asset classes that have historically been viewed as diversifiers.

- Sovereign bonds

Sovereign bonds are debt securities issued by sovereign nations that carry a credit rating which is a function of the country's default risk (Kliger & Sarig, 2000). Sovereign nations have the ability to issue bonds denominated in their own currency as well as that of a physical currency such as the US Dollar which may be more attractive to international investors not looking to be exposed to currency risk (Burnside, Eichenbaum & Rebelo, 2006). The credit rating on the debt denominated in the country's local currency is often greater than its Dollar-denominated debt given the state's ability to print more local currency in order to service debt repayments, as well as its capacity to collect taxes in its own currency to service debt (Burnside, Eichenbaum & Rebelo, 2006). The same cannot be said about its Dollar-denominated debt which is more volatile as its value is dependent on the appetite of foreign investors.

Bonds offer returns in the form of income from periodic coupon payments, as well as capital growth which generally arises as a result of falls in interest rates. The issue investors face is that at the time of writing, around 30% of all bonds in the Barclays Global Aggregate Index have negative yields, up from 8% at the end of March 2015. This phenomenon is not unique to short-term debt, as Swiss government bond yields all the way up to 50-year maturities are trading in negative territory (Lewin, 2016). Purchasing a bond with a negative yield and holding it to maturity will result in a loss on the investment, and if the tendency for an expanding universe of negative yielding bonds persists, their inclusion into future portfolios may be on account of their diversification benefits during a crisis alone.

Chan, Treepongkaruna, Brooks and Gray (2011) found that US T-bond prices tend to have counter-cyclical price movements, rising during regimes of economic recession, falling during regimes of economic expansion. When looking at periods that the researchers deemed to be 'crisis regimes', associated with high levels of volatility and sharply negative equity returns, strong evidence pointed toward a 'flight to quality', wherein investors divested from risky assets in favour of US T-bonds in search of liquidity (Vayanos, 2004). 'Flight to quality' also refers to the fact that US T-bonds are backed by the full faith and credit of the US government, and are generally viewed as safe assets due to a low probability of default risk given the sovereign's ability to both collect taxes and print more of its currency in order to fulfil its debt obligations. These findings are in line with those of Shiller and Beltratti (1992) who found that equities and bonds have historically exhibited negative co-movement.

The US Federal Open Market Committee (FOMC) raised the target funds rate by 0.25% in December 2015 for the first time since 2006, with further rate hikes expected by the market (Cox, 2015). This combined with the growing negative yield environment offered by other developed market bonds may result in a negative long-run trendline contribution to balanced portfolios, however excluding bonds altogether may come with significant consequences as it is still reasonable to expect a 'flight to quality' during tail-events, and may still offer positive returns if interest rates become even more negative.

Svensson (2015) states that the US Federal Reserve has targeted approximately 2% inflation since the beginning of 2012. If achieved, would benefit the US government as the higher the level of inflation, the more debt servicing that needs to be committed gets wiped away (Krause & Moyen, 2016). Therefore, the higher inflation is relative to prevailing yields, the more beneficial from the point of view of the borrower. Should real yields turn negative in the US in the same way as they have in many other developed nations, a case can still be made for the inclusion of bonds in balanced portfolios over and above their counter-balancing effect during an equity crisis provided bond exposure is attained with gearing using a futures contract for example. In this case, investors are short T-bills and long the T-bond position, and if it is assumed that the cost of gearing is 0.50% and the yield on a US 30-year T-bill is 2.50%, then the yield differential is locked in what is known as positive carry (Acharya & Steffen, 2015). While positive carry has been enjoyed in the past, it is not a given and may be eroded with a flattening of the yield curve or a significant enough price movement.

Should secular stagnation theory as posited by Summers (2013) hold, it is assumed that an economy needs a low R* in order to operate normally, with a relatively flat yield curve implied by the stagnation being secular. In this case, if inflation is near its target level, investors who hold geared bond positions may suffer even more than regular bond investors in that not only would they experience low or even negative real yields, but low or even negative carry depending on their cost of gearing, amplifying portfolio detraction. As pointed out by Summers (2013), it is reasonable to expect interest rates to be forcefully kept low on account of sheer demand for safe assets globally, particularly by central banks. The need for additional risk management tools to complement bonds is thus not only justified but imperative to long-run performance.

- Gold

Gold has historically been considered a 'safe-haven' asset class favoured by investors during times of severe economic uncertainty. A 'safe haven' asset may be defined as one who is uncorrelated or negatively correlated with another asset during market downturns (Baur & Lucey, 2010). According to the authors, 'safe haven' assets are differentiated from hedges in that hedges display negative or no correlation with another asset on average whereas ‘safe haven’ assets simply display positive but imperfect correlation with another asset on average.

In their study, Baur and Lucey (2010) found that gold is indeed a ‘safe haven’ asset and perform best when equity holders need them the most: during market turmoil. The authors suggested that a reason for the popularity of gold during periods of market stress is that it has long been considered a store of value, a characteristic that may also explain why the metal is also seen as an inflation hedge. Gold has also been used a medium of exchange for significantly longer than fiat money and, unlike fiat money, it is finite and adding to its supply requires considerably more effort than a printing press.

Ciner (2001) suggests that the demand for gold stems both from central banks who seek to maintain a consistent level of the precious metal as a part of their foreign exchange reserves, as well as its use in jewelry which is manufactured in the private sector. While the benefits of holding gold during a downturn appear to be consistent, it is important to note that gold does not have a cash flow stream. Instead, gains and losses are capital of nature and therefore may not offer steady returns over time.

- Commodities

Commodity returns come in the form of capital growth as opposed to a stream of cash flows and are thus not directly influenced by a rise in interest rates in the same direct way that bonds are, but rather by changes in supply and demand. A basket of commodities across energy, grains, industrial metals, precious metals, soft metals and livestock offer investors the diversification benefits of an imperfectly correlated return stream, and has been shown to increase portfolio risk-adjusted returns (Georgiev, 2001). Further advantages of holding commodities including being a hedge against inflationary episodes as well as having a positive roll yield during periods of high spot price volatility if exposure is attained through the use of futures contracts (Georgiev, 2001).

Should secular stagnation theory hold and lower global economic growth rates become the norm, it is reasonable to expect that lower commodity prices be the norm as well. The supply of commodities is relatively sticky as supply has historically taken a long time to match demand (Canuto, 2014). Additionally, other reasons that explain why the supply of commodities is sticky include significant initial capital outlays required, high storage costs and production quotas. Thus, it follows that the price fluctuations in the short-run are widely influenced by demand. Therefore, with lower economic growth driving the demand for infrastructure, raw materials and energy down, lower commodity prices may be the result. From an asset allocation point of view, commodities may not offer the diversification benefits needed during protracted periods of low growth and thus their pro-cyclical nature may actually detract from returns.

- Property

Property returns come in the form of both income stemming from rental income as well as capital gains from the appreciation of property values. Not only does this asset class offer diversification benefits as shown by Stevenson (2000), but has historically been a partial hedge against inflation given that many rental contracts have clauses that link periodic rent increases to inflation (Linnack and Ward, 1988). Property tends to exhibit similar behavior to equities during periods of market stress, generally experiencing negative returns (Chan, Treepongkaruna, Brooks, & Gray, 2011). When combined in a traditional 60/40 equity/bond portfolio, Hoesli, Lekander and Witkiewicz (2004) show that real estate has historically contributed to absolute return levels as well as offering downside diversification to the traditional mix.

- Managed volatility trading rule

Spikes in volatility are generally associated with low stock returns. Schwert (2011) investigated the realized volatility of stock returns during the most prolific crisis' since the 20th century including the Great Depression, the Flash Crash of 1987 and the GFC and found that high levels of volatility are a common thread throughout these and other periods of crisis. Chan, Treepongkaruna, Brooks and Gray (2011) similarly find that crisis regimes are characterized by high levels of volatility and severe drawdowns in equity returns.

Equity correlations and equity volatility tend to move together, and thus low volatility periods tend to allow for the benefits of diversification to be enjoyed, while periods of high volatility may see the convergence of correlations and the weakening of diversification effects (Andersen, Bollerslev, Diebold, & Ebens, 2001). Engle (2001) found that market volatility is not static, but rather changes over time in a manner that is not indicative of randomness. Hill (2011) concurs with the non-random nature of changes in volatility finding a relatively higher level of positive autocorrelation in the volatility of the S&P 500 Index than S&P 500 Index returns, suggesting that longer term risk is often preceded by short-term rises in volatility.

Investors accept risk in the expectation that they will be compensated for doing so. However the premise behind a managed volatility approach is that this expectation is not necessarily met. Collie, Sylvanus and Thomas (2011) also found that changes in equity volatility are more persistent than changes in returns and have some explanatory power on subsequent realized volatility.

The persistence and explanatory power of recent realized volatility may assist investors understanding the prevailing level of volatility, and could act as proxy. If the prevailing rate is currently at a high level, then it stands to reason that investors should reduce equity exposure, and if the prevailing level of volatility is low then investors should increase equity exposure if the above findings hold. The managed volatility approach postulates that by changing the shape of the portfolio distribution to fully participate in equity markets when markets are relatively calm, and to reduce participation when markets are in turmoil will result in more stable portfolio performance brought about by less portfolio volatility.

To test this hypothesis, Collie, Sylvanus and Thomas (2011) devised a simple trading rule that used recent realized volatility as the proxy for the prevailing level of volatility and set three volatility regimes: equity was given a maximum allocation during low volatility regimes, with allocations reduced during medium volatility regimes and reduced further during high volatility regimes. Not only did the trading rule result in less portfolio volatility when compared to the index, but actually delivered a higher annualized return after accounting for transaction costs. In terms of tail-risk, the trading rule appeared to reduce the depth of the most severe drawdowns, as well as reduce the time until recovery, all the while having a similar effective exposure to equity as the buy-and-hold portfolio.

While the findings of Collie, Sylvanus and Thomas (2011) seem impressive, it is prudent to assume that not every kind of tail-event is represented in past data. Thus an event that results in a sudden market crash without being preceded by high levels of volatility will render the trading rule ineffective. In this event, diversifying specifically with sovereign bonds may offer imperfect correlation with falling equity prices and justify their inclusion into portfolios with short-run outperformance being experienced when needed most.

2.5.3 Measures of tail-risk

Drawdowns are a simple and visually effective means to illustrate the magnitude of a decline in the value of a portfolio from its highest point. While drawdowns may be a useful proxy for risk in that they provide information of the severity of tail-events in the past, it is helpful to compare the distributional properties of strategies with one another. The most commonly used proxy for risk is volatility which is a measure of the variability of the distribution of returns around its mean, however past research has been highly critical of volatility as a proxy for risk.

Value-at-Risk (VaR) is a risk measure that quantifies potential financial losses given the probability of such potential losses occurring and a specific time-frame within which they could occur, and Sarykalin, Serraino and Uryasev (2008) found VaR to be superior to volatility. Rockafellar and Uryasev (2002) were, however, critical of VaR given that it relies on returns being normally distributed, making the measure unreliable when returns exhibit some other distribution and sub-optimal as it does not indicate the actual extent of losses that might be incurred beyond the threshold amount. The researchers suggested that the use of VaR creates a bias toward optimism instead of the conservatism given that VaR serves simply to provide the lowest bound for losses in the tail of the loss distribution.

The authors suggested that the use of Conditional-Value-at-Risk (CVaR) to measure financial risk is a more appropriate alternative to the use of VaR. CVaR is an extension of VaR and attempts to place a value of the expected loss an investor can expect if a tail-event was to occur, as it measures the probability of a specific loss exceeding the VaR at a defined confidence level.

2.6 CONCLUSION

The theory of secular stagnation predicts that lower growth rates will be achieved in the future relative to what had been achieved in the past. The path to normalizing interest rates from historically low levels adds to the already challenging economic environment faced by traditional assets such as bonds and equity. Past research has indicated that volatility exposure has improved the risk-adjusted performance of traditional portfolios, and has also generated competitive absolute returns when compared to equity. The addition of an additional absolute return engine into traditional portfolios is not guaranteed to resolve the challenge posed by secular stagnation. However, the diversification benefits derived from the addition of volatility as an asset class has been shown by past research not only to benefit downside risk, but also absolute return. Past research has been reviewed to cater for investors who are precluded from attaining volatility exposure, and who may need to increase equity exposure to reduce the risk of underperformance from an absolute return point of view. Specifically, literature has indicated that similar absolute returns as passively holding the S&P 500 Index can be generated with a volatility-responsive trading rule that regulates equity exposure according to the prevailing level of volatility.

CHAPTER THREE

DATA & METHODOLOGY

3.1 INTRODUCTION

Chapter 3 initially describes each data set used in this study and offers justification as to their inclusion. Then, the methodology used in this dissertation is described in two sections: first, the methodology used to explore volatility exposure as an asset class, and second, as a signal to reduce equity drawdown risk. First, in terms of volatility exposure as an asset class, three approaches will be investigated: option-selling strategies that are short volatility in a systematic fashion, a bull put spread strategy that is net-short volatility and has an explicit floor on losses, and a long and short VIX futures trading rule. Being systematically short volatility using option-selling strategies is investigated due to the tendency for implied volatility (being sold) to exceed realized volatility resulting in a positive aggregate net premium on average over time. The VIX futures trading rule differs from this approach in that it relies on the empirically bad forecasting power of the VIX futures basis to predict changes in the spot VIX that in turn present profitable trading opportunities. This strategy also differs from option-selling strategies in that it has dynamic allocations and is therefore more sensitive to measurement error. Second, in terms of the potential use of volatility as a forward indicator, a trading strategy that uses the prevailing level of volatility (as described by recent realized volatility) as a signal to regulate equity exposure will be explored.

3.2 DATA

3.2.1 Data used to explore volatility as an asset class

Table 2 below summarizes the data used for the investigation on volatility as an asset class, both independently, and as part of 30/30/40 volatility/equity/bond portfolio. Historical closing implied volatility data for at-the money (ATM), 5% and 10% out-the-money (OTM) S&P 500 Index put options are used to compute historical option premiums used in the option-selling strategies as well as the bull put spread strategy investigated. The VIX futures strategy was developed using the VIX Index, VIX futures and E-mini S&P 500 Index futures prices. The iShares 20+ Year T-bond ETF was used as a US T-bond proxy in the 30/30/40 volatility/equity/bond portfolios back tested in this dissertation.

Closing prices were sourced from Bloomberg for each data set on a daily basis. The earliest data that could be sourced for historical S&P 500 Index implied volatilities started on the 21st of November 2005, thus the CBOE S&P 500 PutWrite Index was also examined from the same date up to the 30th of June 2016. Our VIX futures price data began on the 26th of March 2004, thus closing VIX Index and E-mini S&P 500 Index futures prices were sourced from the same date up to the 30th of June 2016.

Table 2: Summary of data used for exploring volatility as an asset class

Data Set	Periodicity	Start Date	End Date	Source
VIX Index	Daily	2004/03/26	2016/06/30	Bloomberg
S&P 500 Index Put Option Implied Volatilities	Daily	2005/11/21	2016/06/30	Bloomberg
CBOE S&P 500 PutWrite Index	Daily	2005/11/21	2006/06/30	Bloomberg
VIX Futures Prices	Daily	2004/03/26	2016/06/30	Bloomberg
E-mini S&P 500 Futures Prices	Daily	2004/03/26	2016/06/30	Bloomberg
iShares 20+ Year Treasury Bond ETF	Daily	2005/11/21	2016/06/30	Bloomberg

The VIX Index proxies the implied volatility priced in by the market over a range of options on the underlying instrument over a 30-day period across varying degrees of moneyness. This makes equity volatility indices such as the VIX Index starkly different to standard equity indices as preceding observations are not reference points for subsequent observations, but are rather observed independently. In other words, while a growth of 1% on equity results in the index increasing from a base of 100 to 101 points, changes in market expectations of future volatility as proxied by the VIX

Index are not represented by increasing or decreasing an index value from the base of the previous period. That is, the expected future volatility of the S&P 500 Index as priced by options markets which may be 40 VIX points one day and 20 VIX points the next. The VIX Index is not a tradable instrument, however exposure can be attained through the use of derivative instruments such as options and futures contracts. As a proxy for US equity implied volatility, VIX Index data is used. Other market equity volatility data was excluded from this study as the starting dates of these indices were too recent to justify fair comparison with US data.

While the VIX Index is useful in that it condenses various implied volatilities into a single number, option strategies that are short near-the-money options are investigated, with the same maturity as the VIX. Historical daily data on the end of day implied volatility levels of ATM, 5% OTM and 10% OTM S&P 500 Index put options are used. Daily implied volatility levels at each degree of moneyness listed above are used to compute the daily value of option premiums using the Black-Scholes options pricing model. The CBOE PutWrite Index is designed to track the performance of a fully collateralized portfolio that writes ATM put options on the S&P 500 Index with a 30-day maturity level and will be useful to compare the relative performances of the option-selling strategies investigated in this dissertation.

VIX futures contracts are standardized futures contracts on the 30-day implied volatility of the S&P 500 Index at the expiration date. For example, the price used to purchase a December VIX futures contract describes the 30-day implied volatility of the S&P 500 Index on the day that the December contract expires. Front-month VIX futures are those that have an expiration date closest to the current date. Second-month VIX futures are those that have an expiration second closest to the current date. VIX futures contracts expire 30-days before S&P 500 options contracts expire, which is on the third Friday of every month. Should either the third Friday of the month when S&P 500 options expire or the 30th day preceding this date (usually a Wednesday) when VIX futures contracts expire be a holiday, then VIX futures contracts will expire one day earlier than they otherwise would.

The iShares 20+ Year T-bond ETF which seeks to track the performance of an index composed of US T-bonds with maturities greater than 20-years was used as a proxy for US T-bonds. Given that the performance of volatility in the long-run is investigated, it is deemed appropriate to use long-dated bonds as part of the 30/30/40 volatility/equity/bond portfolio mix evaluated in this dissertation.

3.2.2 Data used to explore volatility as a signal to reduce equity drawdown risk

Table 3 provides a summary of the equity index and US T-bill data used in this dissertation. S&P 500 Index data is used as a proxy for the US equity market. The MSCI EAFE (Europe, Australasia and the Far East) Index is used to represent the developed world excluding the US and Canada. Developing markets are separated into the more advanced emerging markets and less advanced frontier markets as categorized by the MSCI EM Index and the MSCI Frontier Index respectively. Data for each index is sourced from their respective inception dates aside from the S&P 500 Index for matching purposes. Given that each equity index data set is based on closing USD prices, 3-month US T-Bill yields are used as a proxy for cash to calculate excess returns which are in turn used to compute Sharpe ratios, as well as a part of the return earned on fully collateralized portfolios.

Table 3: Summary of equity and fixed income data

Index	Periodicity	Start Date	End Date	Source
S&P 500 Index	Daily	1972/01/03	2016/06/30	Bloomberg
MSCI EAFE Index	Daily	1972/01/03	2016/06/30	Bloomberg
MSCI EM Index	Daily	1988/01/01	2016/06/30	Bloomberg
MSCI FM Index	Daily	2002/06/03	2016/06/30	Bloomberg
3-Month US T-Bills	Daily	1972/01/03	2016/06/30	Bloomberg

3.3 METHODOLOGY

3.3.1 Volatility strategies

- Option-selling strategies

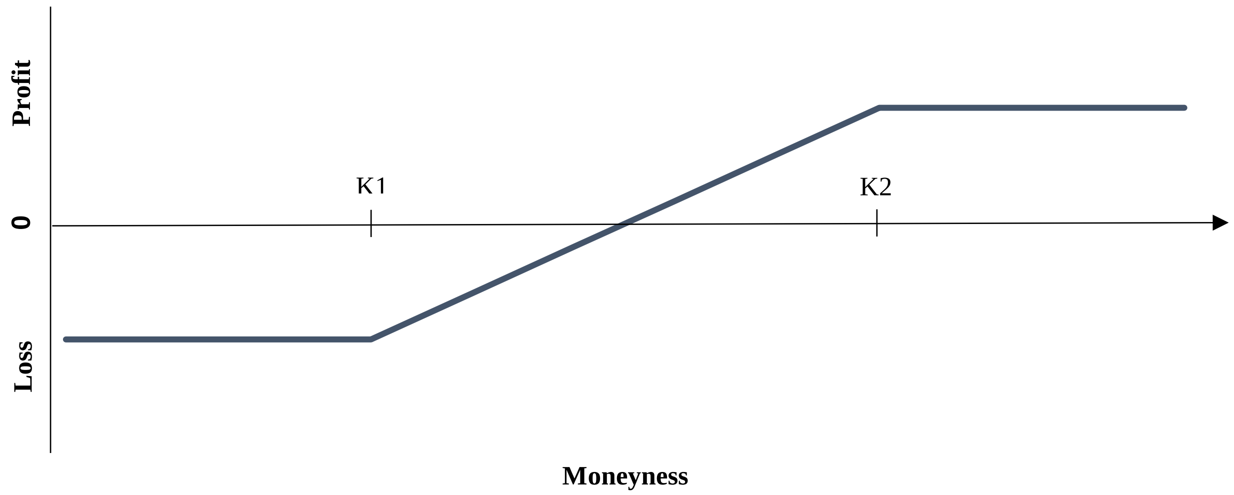
The CBOE S&P 500 PutWrite Index is a proxy for a strategy that involves the sale of 1-month ATM S&P 500 Index put options that are fully collateralized with cash reserves earning money market rates. While using the index as a proxy for VRP may be simple, it is limited as it does not accommodate more conservative investors who would prefer to sell options that are further OTM (the sale of a 5% OTM option would exempt the option writer from loss up to the 5% level for example).

Simply modelling the CBOE S&P 500 PutWrite Index would also not allow the flexibility afforded by bull put spread strategies that explicitly cut tail-risk at predetermined levels.

Four approaches to capture VRP will be investigated in this study and compared with the S&P 500 Index. First, the CBOE S&P 500 PutWrite Index. Second, a strategy that simulates the sale of ATM S&P 500 Index put options. Third, a strategy that simulates the sale of 5% OTM S&P 500 put options. Fourth, a bull put spread strategy that simulates the simultaneous sale of ATM S&P 500 Index put options and purchase of 10% OTM S&P 500 Index put options.

Bull put strategies are constructed by going short a put option and simultaneously going long another put option with a lower degree of moneyness with the same expiration date creating a payoff profile illustrated by figure 1 below. In figure 1, the strategy will simultaneously sell an S&P 500 Index option with strike price K2 and buy an S&P 500 Index option with the same expiration date with strike price K1 with a lower degree of moneyness thereby placing a floor on the maximum potential loss should a tail-event occur. The maximum profit of the strategy is the premium received for selling a put with strike price K2 minus the premium paid for buying a put with strike price K1. Given that that long position is at a lower level of moneyness than the short position, the trade remains a net short position, and thus a net profit appears to be the logical result over time as VRP is still captured.

Figure 1: Bull put spread payoff profile



The CBOE S&P 500 PutWrite Index sells new front-month ATM S&P 500 Index options on expiration date (after allowing the portfolio's old options to expire) where the expiration date on S&P 500 Index options are generally the third Friday of each month provided it does not fall on a US public holiday (in which case the expiration date is moved one day back). The S&P 500 Index put options that are simulated in each of the strategies under investigation differ from this approach as no option is allowed to expire. That is, at the end of each month, second-month S&P 500 Index put options contracts that generally have 6 to 7-weeks to expiry are sold. At the end of the following month, when these contracts have approximately 2 to 3-weeks to expiry, the options are closed and the new batch of second-month contracts are sold with the process continuing in the same fashion. For example, second-month options that would expire during April of 2016 would have been sold on the 29th of February 2016 when they had 46-days to expiry (analogous to the aforementioned 6 to 7-week period). This position would then be closed on the 31st of March 2016 with 15 days left until expiration (similar to the aforementioned 2 to 3-week period) after which new second month options that would expire during May 2016 would be sold and so forth.

The reason for this approach is so that the portfolio could be rebalanced at the end of each month i.e. the new options that are written are scaled to the level at which the portfolio was at the end of the month. Additionally, investors who write longer maturity options accept more risk than investors who write shorter maturity options all else equal given the greater time value associated with the longer maturity option. This higher risk should, in turn, raise expected returns slightly which is why second-month options with 6 or 7 weeks to maturity are sold and closed out with 2 to 3-weeks to maturity as opposed to front month options as per the CBOE S&P 500 PutWrite Index.

At the end of each month, the premiums earned by writing S&P 500 index put options (as well as premiums paid simultaneously in the case of the bull put spread strategy) will be calculated according to the option pricing model originally established by Black and Scholes (1973) given by the below equations.

$$\mathrm{P} = N(-d_2)Ke^{-rt} - \mathrm{SN}(-d_1) \quad \textbf{(1)}$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r\,\frac{s^2}{2}\right)t}{s \times \sqrt{t}} - N(d_2)Ke^{-rt} \quad \textbf{(2)}$$

$$d_2 = d_1 - s \times \sqrt{t} \quad \textbf{(3)}$$

Where P is equal to the price of the put premium, S is equal to the current price of the S&P 500 Index, t is equal to time to exercise date, K is equal to strike price of the option, r is equal to the risk-free rate (assumed to be the 3-month US T-bill rate), N is equal to a cumulative normal distribution and s is current implied volatility.

The calculated premiums should accurately simulate actual premiums given that *ex-post* implied volatility data was used for each relevant degree of moneyness with all other variables used in the options pricing model also known. During each day of the month, the value of open option positions is computed using the above equations so as to simulate a daily mark-to-market. All volatility strategies are assumed to be 100% collateralized. Thus, the return on cash as approximated by 3-month US T-bill rates are also added to the portfolio, and an index starting at 100 for each strategy is created to ensure comparability.

To measure the performance of each strategy, annualized holding period returns are calculated according to equation 4 below where P_t is the level of the index at the end of the period and P_o is the level of the index at the beginning of the period. Drawdowns across the period were also calculated for each strategy with the formula given as equation 5 below where the drawdown denoted D(T) is equal to the minimum value between zero or the drawdown given by the current observation X(t) minus the historical peak of the time series denoted as X(T), where time T is the total time period from time t_0 up to time t.

$$\text{Annualized Holding Period Return} = (1 + \frac{P_T}{P_0})^{\frac{365.25}{T - t_0}} - 1 \quad \textbf{(4)}$$

$$D(T) = min\{0, X(t) - \max X(T)\} \quad \textbf{(5)}$$

In order to calculate and compare tail-risk measures of each strategy, equation 6 below describes the equation used to calculate VaR and equations 7 and 8 are the formulas used to calculate CVaR on a daily basis, where X is equal to a random variable with the cumulative distribution function FX(z)=P{X≤z} and a is equal to the chosen confidence level.

$$VaR(X) = min\{z|FX(z) \geq a\} \quad \textbf{(6)}$$

$$CVaR_a(X) = \int_{-\infty}^{\infty} zdF_X^a(z) \quad \textbf{(7)}$$

$$where\ F_X^a(z) = 0\ when\ z < VaR_a(X)\ or\ \frac{Fx(z) - a}{1 - a}\ when\ z \geq VaR_a(X) \quad \textbf{(8)}$$

- VIX Futures Strategy

The VIX futures strategy involves going short VIX futures if the current VIX futures basis is in contango and going long VIX futures if the VIX futures basis is in backwardation, delta-hedging positions on a monthly basis using E-mini S&P 500 Index futures. At the end of each trading day, the VIX futures basis is calculated as per equation 9 as the difference between a rolling 30-day VIX implied futures closing price (calculated as a weighted average of the front and second-month contracts) and the closing price of the VIX.

$$Basis_t = \left(P_{FM} \times \frac{T_F - t}{30} + P_{SM} \times \frac{30 - (T_F - t)}{30}\right) - P_{VIX} \quad \textbf{(9)}$$

Where P_{FM} is the closing price of the front month VIX future, T_F-t is the days that the front month contract has until expiry, P_{SM} is the closing price of the second-month VIX future, and P_{VIX} is the closing price of the VIX. If the basis is positive, the futures curve is said to be in contango and thus a short signal is indicated for the following morning’s trade. If the basis is negative, the VIX futures curve is said to be in backwardation and thus a long signal is indicated for the following morning’s trade. Table 4 illustrates an example of this below. Given that the closing price of the VIX on the 28th of June 2016 was 18.75, and that closing price of the 30-day implied VIX future was 19.01, the basis would be 0.26 which would mean that the futures curve was in contango indicating a short instruction at the beginning of the next day.

Table 4: Basis calculation on 2016/06/28

Instrument	P_{Close}	T_F-t	Weight	$P_{Weighted}$	P_{VIX}	Basis
VIX FM Future	18.88	22	$\frac{22}{30}$	13.845	-	-
VIX SM Future	19.38	22	$\frac{8}{30}$	5.168	-	-
Total	**-**	**-**	**-**	**19.01**	**18.75**	**0.26**

Continuing with the established example, the US dollar (USD) profit/loss calculated at the end of the following day is calculated as the difference between the notional value of the closing front month VIX future and the notional value of the same opening front month VIX future. As the VIX futures curve is said to be in contango in the above example, the USD profit/loss for the day is simply multiplied by -1 as a short position would have been taken at the beginning of the day.

In order to limit the impact that changes in the S&P 500 Index futures had on VIX futures, daily delta hedging is modeled. At the end of each day, the USD profit/loss on a single E-mini S&P 500 future is calculated as the difference between the notional values of the closing and opening front month E-mini S&P 500 futures and similarly multiplying the answer by -1 if the VIX futures curve had been in contango at the close of the day before. Consider table 5 which illustrates how these calculations were done on the day following the short instruction established at the close of the 28th of June 2016. The VIX future closed at a lower price, thus because a short position would have been taken at the beginning of the trading day given the instruction calculated in table 4, a gain of $1525 is earned for the day. Similarly, although the E-mini S&P 500 future ended the day at a higher price, because a short trade would have been entered at the beginning of the day, a loss is incurred of $1925 resulting in a net loss of $400 for the day.

Table 5: Daily profit/loss on single futures contracts example on 2016/06/29

Instrument	Contract Unit	P_{Open}	P_{Close}	N_{Open}	N_{Close}	Daily Profit/Loss
VIX FM Future	1000	19	17.475	$19000	$17475	$1525
E-Mini S&P 500 FM Future	50	2028.25	2066.75	$101413	$103338	-$1925

To prevent frivolous trading, VIX futures are held either to expiry or until the VIX futures curve changes from its current state, i.e. if for 10 consecutive days the VIX futures curve is said to be in contango, and at the end of the 10^{th} day it is said to have changed into backwardation, the short positions in both the VIX futures and E-Mini S&P 500 futures would close and new long positions would open at the beginning of the 11^{th} day. If the VIX futures curve does not change states, positions are maintained, and thus daily USD profit/loss will simply be calculated as the difference between the closing notional values of the previous day and the closing notional values of the present day for both VIX and E-mini S&P 500 front month futures (multiplied by -1 if in contango state).

In order to adequately delta hedge positions, a ratio of the number of VIX futures contracts to E-mini S&P 500 futures contracts is estimated given large differences in national values. This hedge ratio is calculated at the end of each month according to equation 10 below.

$$HR_t = \frac{100{,}000}{N_{S\&P}} \qquad \textbf{(10)}$$

Where HR_t is equal to the hedge ratio calculated at the end of the month, $N_{S\&P}$ is equal to the notional value of an E-mini S&P 500 front-month futures contract at the end of the month. The reasoning behind this estimation is a theoretical upper bound for the VIX of 100 is assumed (this is not so in reality as the VIX is not constrained by an upper bound, but a theoretical one is set for modelling purposes that cannot be dismissed as impossible given the fact that 80.86 is the all-time highest close for the VIX which occurred on 20 November 2008). Thus, the notional value of what is deemed to be the theoretical upper bound of the VIX is 100,000 (100 VIX points multiplied by 1000 contract units), divided by the current notional value of the E-mini S&P 500 future would result in the number of E-mini S&P 500 futures contracts to hold for every VIX futures contracts held.

For example, on 30 June 2016, the E-mini S&P 500 front month future's notional value was $104,513, using equation 2, the hedge ratio would be equal to 0.96. Assuming that the VIX futures curve was in contango at the end of 30 June 2016, this would imply shorting 0.96 E-mini S&P 500 front month futures and shorting 1 VIX front month future at the beginning of 1 July 2016 and maintain the same ratio for the entire month regardless of the direction of trades. For simplicity, it is assumed that E-mini S&P 500 front month futures can be traded in decimals.

Total USD profit/loss for each day is then calculated by multiplying the number of contracts held by the USD profit/loss on a single contract for both VIX and E-mini S&P 500 front month futures. The total daily USD profit/loss together with the daily return on cash (given that index is assumed to be 100% collateralized) as represented by the 3-month US T-bill is then converted into an index. The risk and returns characteristics of the index is then compared with equity using equations 4 to 8 together with other statistical measures.

3.3.2 Managed volatility trading rule

- The relationship between volatility and subsequent return

Similar to past research, before a managed volatility trading rule can be developed, it must firstly be determined whether investors are efficiently rewarded for participating in markets with heightened volatility. Volatility is defined as standard deviation which is a measure of the variability of the distribution of returns around its mean, and is calculated daily using equation 11 (assuming a 252-day US trading year).

$$s = \sqrt{\frac{\sum_{t=1}^{T}(R_{\mathrm{t}} - \bar{R})}{n-1}} \tag{11}$$

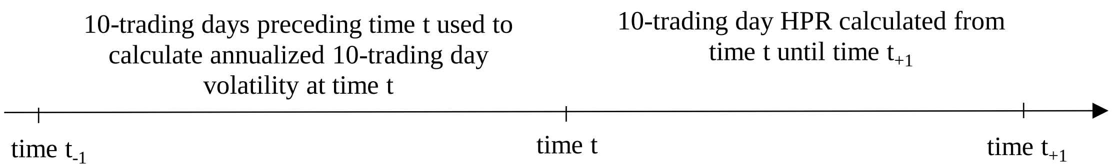
Correlation is a standardized measure of co-movement and is calculated as the covariance between 2 assets divided by the product of each assets' standard deviation as shown in equation 12 below. The correlation coefficient is bounded between -1 and +1, a -1 coefficient implies a perfectly negative correlation, +1 implies perfectly positive correlation and a correlation of zero implies the absence of any linear relationship.

$$\rho_{1,2} = \frac{Cov_{1,2}}{s_1 s_2} \tag{12}$$

The association between negative returns and highly volatile periods are established by Israelov and Nielsen (2015), however, should the returns after such periods not sufficiently compensate investors for their acceptance of such risk, it stands to reason that risk-averse investors should opt for less risky assets until volatility has subsided. Past research has confirmed that investors experienced disappointing returns following volatile periods when recorded over longer periods (monthly and quarterly). In order to investigate whether the above holds true in the short-run also, the data for each market is divided into periods of 10-trading days (analogous to a 2-week period), after which annualized standard deviations are calculated for each such period, then the return for the 10-trading days following each respective period is recorded.

For example, figure 2 below shows how the standard deviation at time t is calculated for the 10-trading days that preceded time t, following which the HPR for the 10-trading days following time t is recorded as the matching return. Each 10-trading day period is then organized into ascending order according to their volatility, and then categorized into deciles (given as *y*) according to equation 13 below.

Figure 2: Determining the relationship between volatility and subsequent returns



$$\mathrm{L}_y = (n+1)\frac{y}{100} \tag{13}$$

Where L_y is equal to the position of the desired decile and n is equal to the number of observations. For example, if only 99 periods are investigated (n), the upper bound of the first decile (L_{10}) would simply be the 10th lowest standard deviation given that n=99 and y=10. An investigation into subsequent returns is then conducted with average HPRs at time t_{+1} calculated for each decile as well as for each data set as a whole. In order to better understand the distribution of returns per decile both the 5th and 95th percentiles of each individual return decile is also calculated, for example, the 5th percentile (L_5) would be the 5th lowest HPR assuming that 100 HPRs were organized in ascending order.

It stands to reason that investors should be rewarded for accepting higher risk. Thus one would expect HPRs in deciles categorized by high volatility to be significantly higher than the average HPR across all deciles. Should this not necessarily be the case, however, it follows that higher risk-adjusted returns could be achieved by only participating in markets during periods of low volatility. In order to determine whether mean returns across each decile ($\bar{R}_d$) differed significantly from the mean return across all deciles ($\bar{R}$), a 2-tail paired t-test was performed with an alpha of 0.05 according to equation 14 below was conducted across the markets under investigation.

$$\begin{aligned} \mathrm{H}_0&: \bar{R}_d = \bar{R} \\ \mathrm{H}_a&: \bar{R}_d \neq \bar{R} \end{aligned} \tag{14}$$

- Managed volatility trading rule

Under the premise that investors are not adequately rewarded for participating in volatile markets, a trading rule similar to that developed by Collie, Sylvanus and Thomas (2011) is investigated in order to test the efficacy of moderating equity exposure depending on the prevailing volatility level. Collie, Sylvanus and Thomas (2011) found volatility to be persistent, thus recent weighted volatility is used to represent the prevailing level of volatility, such that new information weighs more heavily than old information. The reason for this approach is that Engle and Patton (2001) found that volatility is somewhat mean reverting and thus not random, so if each day was weighted equally, realized volatility would lag the true unobserved prevailing level of volatility. For example, should markets be at the end of a crisis and calmer conditions prevail, standard volatility may still be elevated whereas weighted volatility which weights recent information more than old information would indicate lower levels of volatility more congruent with prevailing conditions.

Mina and Xiao (2001) note that the optimal decay factor to estimate daily volatility is 0.94. In order to calculate the weighted standard deviation, equation 15 is used where w_i is the weight given to the *ith* observation, N' is equal to the total number of non-zero weights and $\bar{R}_w$ is the weighted mean return. For example, the weight assigned to the return at time t is 1, the weight assigned to the return at time t_{-1} is 0.94, and the weight assigned to the return at time t_{-2} is 0.8836 (0.94 times 0.94) and so on.

$$S_w = \sqrt{\frac{\sum_{i=1}^{N} w_i (R_i - \bar{R}_w)^2}{\frac{(N' - 1) \sum_{i=1}^{N} w_i}{N'}}} \quad \textbf{(15)}$$

The time-frame chosen to capture daily weighted volatility is 42-trading days (akin to 2-calendar months). The reason that a longer period was preferred to a shorter period such as the 10-trading day period to determine the relationship between volatility and subsequent return is that it is reasonable to suspect that slightly older data may still provide some valuable information given substantial past research on the persistence of volatility. In some cases, older information may still have a bearing on recent information and thus a time-frame of 42-trading days attempts to capture some remnants of older information which may also assist in reducing the impact of potential noise in new data. Under this convention, figure 3 below illustrates how using a 0.94 decay factor will result in the most recent 10-trading days being given a combined weight of 49.85%, with the most recent 21-trading days having a combined weight of 78.57%, leaving just a 21.43% weighting for the oldest 21-trading days.

Figure 3: Illustrating how the decay factor weighs past information

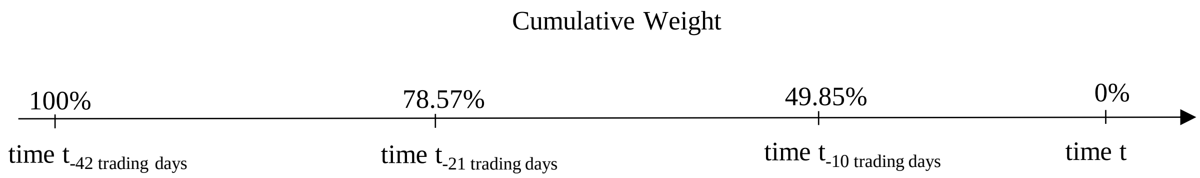
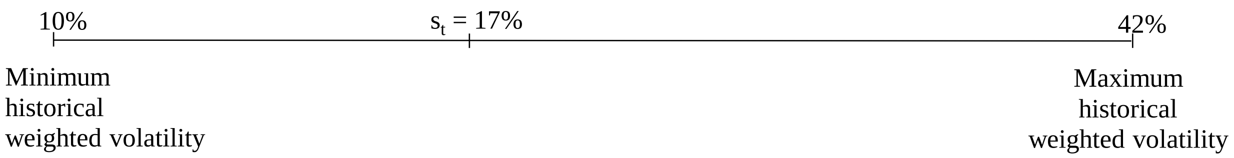


Figure 4 below illustrates how at the end of every trading day, the 42-trading day weighted volatility (s_t) is compared with the distribution of all available preceding history's daily 42-trading day weighted volatility's. In the example, assuming that time t has an s_t of 17%, where s_t is equal to the standard deviation at time t, this s_t is classified under the 4th decile of the historical distribution, and it is according to the decile classification that equity exposure is assigned to capture next day equity returns.

Figure 4: Classification of s_t relative to historical distribution



After s_t has been assigned into a decile relative to the historical distribution, table 6 describes how the equity cash asset allocation decision was taken on a daily basis. The low volatility threshold is set at the 6th decile of historical volatility, with any 42-trading day weighted volatility (daily volatility) categorized as equal to or less than the level of volatility that corresponds to the 6th decile of historical volatility being assigned a 100% equity allocation and a 0% cash allocation.

Table 6: Summary of daily equity allocation according to level of volatility

Daily Weighted Volatility vs Historical Volatility	Equity	Cash	Portfolio
$s_t \leq 6^{th}$ Decile	100%	0%	100%
6^{th} Decile $< s_t \leq 7^{th}$ Decile	67%	33%	100%
7^{th} Decile $< s_t \leq 8^{th}$ Decile	33%	67%	100%
$s_t > 8^{th}$ Decile	0%	100%	100%

The high volatility threshold is set at the 8th decile such that when daily volatility was higher than the 8th decile of historical volatility, a 0% equity allocation and 100% cash allocation was assigned. When daily volatility was between the 6th and 7th decile of historical volatility, a 67% allocation was given to equity and 33% allocation given to cash, and finally, when daily volatility was between the 7th and

8th decile of historical volatility, a 33% allocation was given to equity and a 67% allocation was given to cash.

Defining daily equity-cash allocation by the prevailing level of volatility relative to its historical distribution as opposed to defining it according to how the prevailing level of volatility compares to some absolute level of volatility gives flexibility to the trading rule. As the same rule is tested across various markets, it is reasonable to suggest the long-run average volatility of developing markets is greater than developed markets, thus making the use of the same absolute level of volatility upon which daily volatility is compared to as had been done in past studies problematic.

Additionally, it is reasonable and prudent to accept that not all types or severities of tail-events are represented in historical data, thus although the strategy is susceptible to tail-events of greater severity than what had been experienced in the past, it is preferred to the use of any rolling period which may have zero representation of tail-events at all.

The use of all available historical data also allows the trading rule to be fluid in nature as the 6th decile which defines the low-volatility threshold can change dramatically with the inclusion of severe tail-events such as the GFC. The drawback of this approach is that new information has a smaller and smaller impact on the time series as time goes on. That is, a shock towards the end of the series will have less impact on how asset allocation decisions are subsequently made than a shock towards the beginning of the series.

The trading rule may present other challenges to investors with fixed strategic asset allocation targets. As the rule regulates exposure between equity and cash, the overall effective equity exposure investors may expect over time can be computed per equation 16 below. For example, if the trading rule suggested equity allocations of 67% and 33% over 2-trading days, the effective equity exposure would be 50%.

$$Effective\ Exposure = \frac{Sum\ of\ Daily\ Equity\ Exposures}{n} \qquad \textbf{(16)}$$

3.4 CONCLUSION

While derivatives are used in this dissertation to attain volatility exposure, each strategy investigated assumes that portfolios were 100% collateralized. This means that all possible losses could readily be paid out. In the case of ATM option-selling strategies, 100% collateralization creates an effective apples-to-apples comparison with equity as drawdown profiles are identical with the exception that the drawdowns of short ATM option-strategies still earn premium while experiencing drawdowns. By applying systematic, rules-based methodologies, the strategies used in this dissertation to capture volatility exposure will result in a better understanding of the risk and return characteristics of volatility exposure. The same rules-based approach is applied to the managed volatility trading rule in that the same formula is applied across markets that intend to cover the entire globe.

CHAPTER FOUR

FINDINGS

4.1 INTRODUCTION

Chapter 4 discusses the findings of the trading rules developed to capture returns from volatility products as well as to reduce equity drawdown risk by using volatility as a signal to regulate equity exposure. Each strategy is summarized according to its cumulative return, risk (using annualized volatility, 95% and 99% daily Value-at-Risk and Conditional Value-at-Risk) as well as other summary statistics over the period and compared with an equity over a matching period.

4.2 VOLATILITY RISK PREMIUM STRATEGIES

4.2.1 Vanilla options strategies

- The volatility risk premium

Figure 5 below illustrates implied volatility as proxied by the VIX Index vs. *ex-post* realized volatility on the S&P 500 Index as well as the volatility risk premium (implied volatility minus realized volatility). Consistent with the findings of Israelov and Nielsen (2015), the results indicate that the volatility risk premium (VRP) was positive 88.94% of the trading days between 3 January 1990 and 30 June 2016. Over this period, the average of the VIX Index was 19.79% compared with average realized volatility of 15.58% resulting in the average VRP of 4.21%. It is evident that option-buyers would have paid a considerable amount away over time for protection given so few instances when VRP was negative. Negative VRP episodes were caused by sharp and unexpected falls in the S&P 500 Index, and not necessarily during equity bear markets. For example, during the US recessionary episode from Q3 2001 to Q4 2002, the VRP was positive 82.82% of the time. In terms of the 2008 GFC, the period from Q3 2008 to Q4 2009 suggests that the VRP was positive 70.92% of the time with the average VRP over this period being 1.72%. This suggests a strong tendency for the VRP to rapidly adjust to major shocks as option-sellers rapidly demand higher premiums to provide insurance in highly volatile markets.

Figure 5: Volatility risk premium

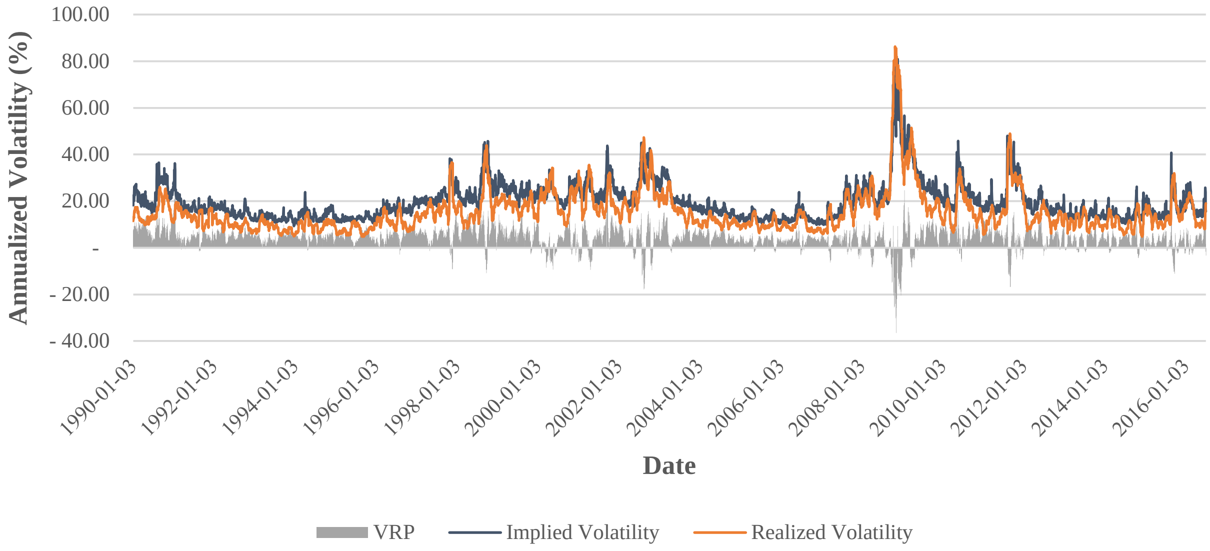


Figure 6 below exhibits the average VIX level per decile where decile 1 (10) contained the lowest (highest) historical VIX price levels. The mean VIX level in decile 1 was 11.47% compared with 37.06% for decile 10. The VIX level was greater than 30% only 8.70% of the time indicating that generally, relatively low levels of volatility were anticipated by options markets over the period examined.

Figure 6: Mean VIX Index level per VIX decile

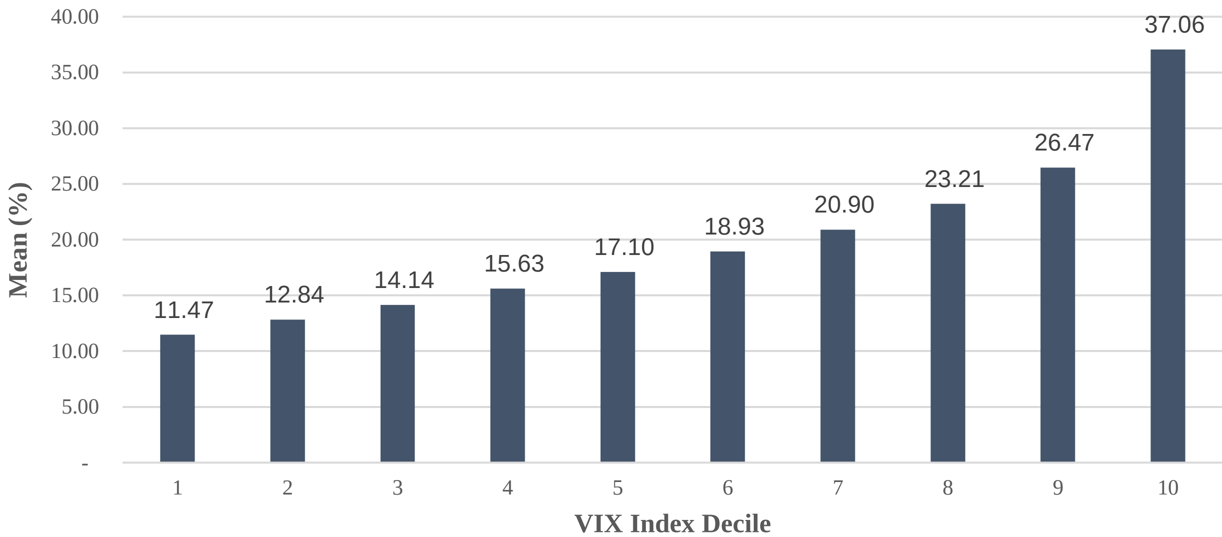
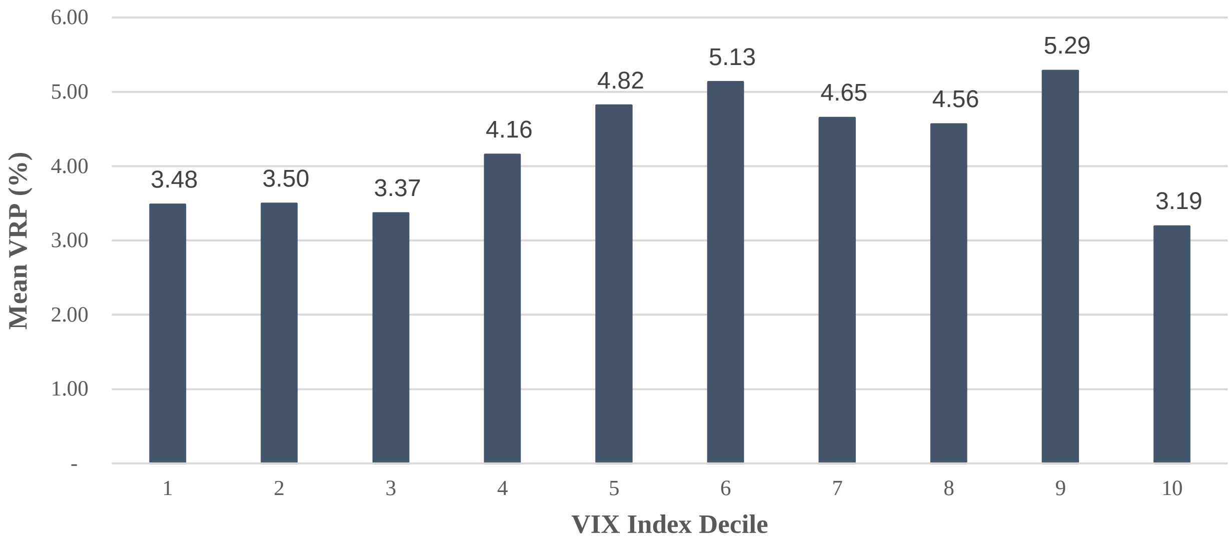


Figure 7 illustrates the mean VRP per VIX decile across the period. It is evident that VRP was positive on average across each decile, consistent with the findings of Israelov and Nielsen (2015). The fact that VRP was not much different in decile 1 from the other deciles, despite the low VIX level resulting in low options prices in absolute terms, indicates that options were still expensive as long volatility exposure would have still had negative returns. Decile 10 generated the lowest VRP of 3.19% and the highest VRP of 5.29% was generated by decile 9.

Figure 7: Mean volatility risk premium per VIX decile



- CBOE S&P 500 PutWrite Index vs. short ATM S&P 500 Index options

Figure 8 below compares the cumulative returns of a short ATM S&P 500 Index put option strategy (short ATM options strategy) to the CBOE S&P 500 PutWrite Index. Figure 9 illustrates the drawdowns over the period for both strategies. Both strategies involve the sale of ATM S&P 500 Index put options, but the former writes second-month contracts at the end of every month, and the latter sells front month ATM S&P 500 Index options on each expiration date. The annualized HPR for the short ATM options strategy was 6.77% which was slightly higher than the 6.61% achieved by the PutWrite Index. Given that the short ATM options strategy writes options with slightly longer maturity than the PutWrite Index does, one would expect a slight outperformance over time accompanied by slightly higher risk. Table 7 confirms that this was indeed the case with the annualized volatility experienced by the short ATM options strategy being 15.07% which was slightly greater than the 14.27% attained by the PutWrite Index. Ultimately, Sharpe ratios were similar with the short ATM options strategy achieving 0.40 compared with 0.41 obtained by the PutWrite Index.

Figure 8: CBOE S&P 500 PutWrite Index vs short ATM S&P 500 Index options cumulative returns

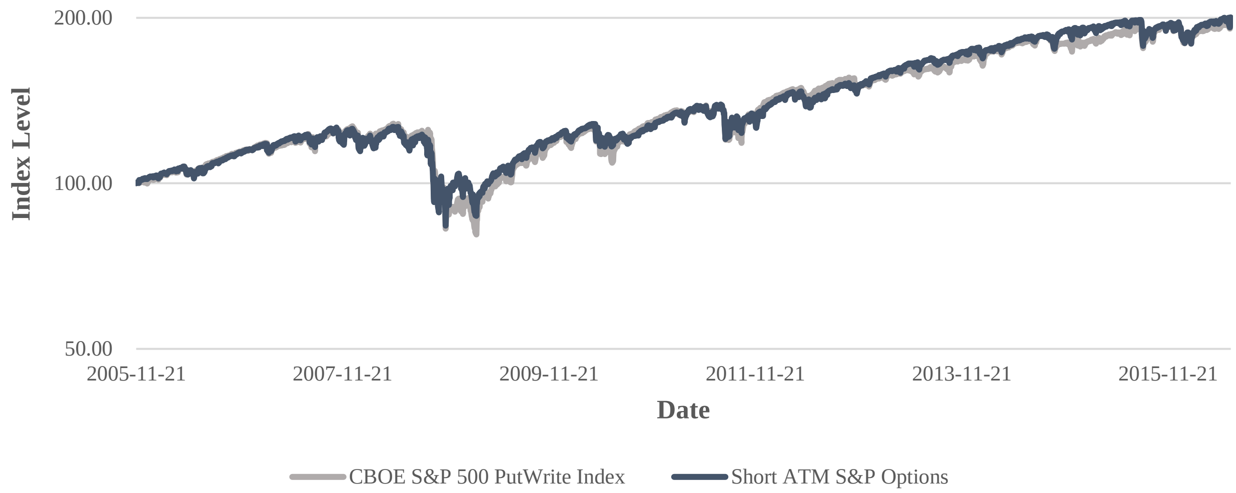


Figure 9: CBOE S&P 500 PutWrite Index vs short ATM S&P 500 Index options drawdowns

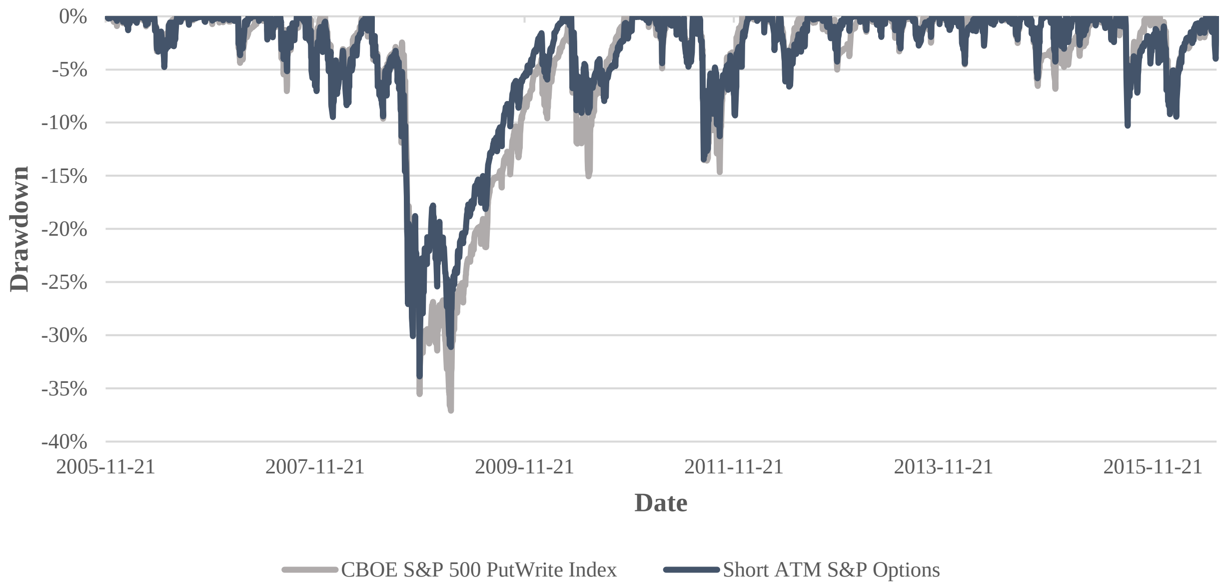


Table 8 indicates that the daily returns of the two strategies had a considerably high correlation of 0.93 over the period which one would expect given the similarity of the approaches. The tail-risk statistics across both strategies are also fairly similar. The 95% daily CVaR statistics were -2.44% and -2.36% for the short ATM options strategy and PutWrite Index respectively, and -4.55% and -4.52% for the 99% daily CVaR statistic respectively. The maximum drawdown suffered by the short ATM options strategy was -33.87% and -37.09% for the PutWrite Index, and the minimum daily return -7.81% for the short ATM options strategy was also similar to the -9.37% suffered by the PutWrite Index. The worst 6-month HPR experienced by the option-selling strategy was -29.29% compared with -31.47% by the PutWrite Index, and the best 6-month HPR was 19.22% and 24.48% for the option-selling strategy and PutWrite Index respectively.

In terms of the distributional properties of each approach, skewness was 0.01 for the short ATM options strategy and -0.18 for the PutWrite Index. Excess kurtosis for both strategies were high with the short ATM options strategy and PutWrite Index experiencing an excess kurtosis of 20.39 and 27.13 respectively. Overall, the remarkable similarity of the two strategies as evidenced by a high correlation of daily returns and similar risk profile validates the methodology used to compute both the daily value of option premiums as well as the translation of those premiums into an index.

- S&P 500 Index vs. CBOE S&P 500 PutWrite Index vs Short ATM S&P 500 Index options

Figure 10 below illustrates the cumulative return of the S&P 500 Index, CBOE S&P 500 PutWrite Index and the short ATM S&P 500 Index put options strategy from the 21 November 2005 until 30 June 2016. From an absolute return vantage point, the annualized return of 4.97% obtained by the S&P 500 Index was inferior to the annualized returns experienced by the PutWrite Index and the short ATM options strategy. Figure 11 illustrates that the VRP strategies also enjoyed considerably shallower drawdowns through the period which is evidenced by an annualized volatility of 20.46% experienced by the S&P 500 Index compared with 15.00% and 14.27% suffered by the short ATM options strategy and PutWrite Index respectively.

Figure 10: S&P 500 Index vs. CBOE PutWrite Index vs. Short ATM S&P 500 Index options cumulative returns

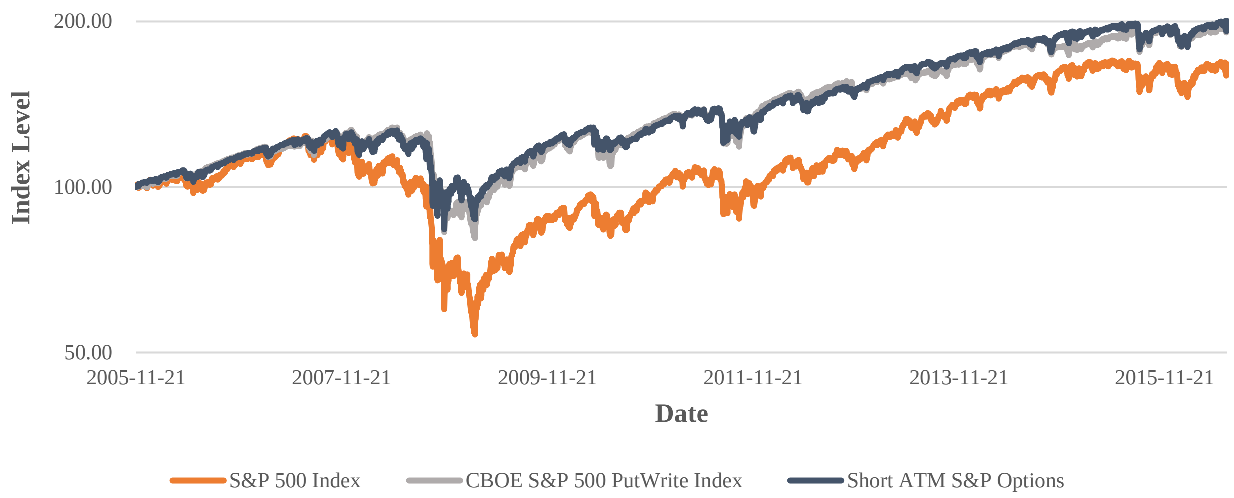
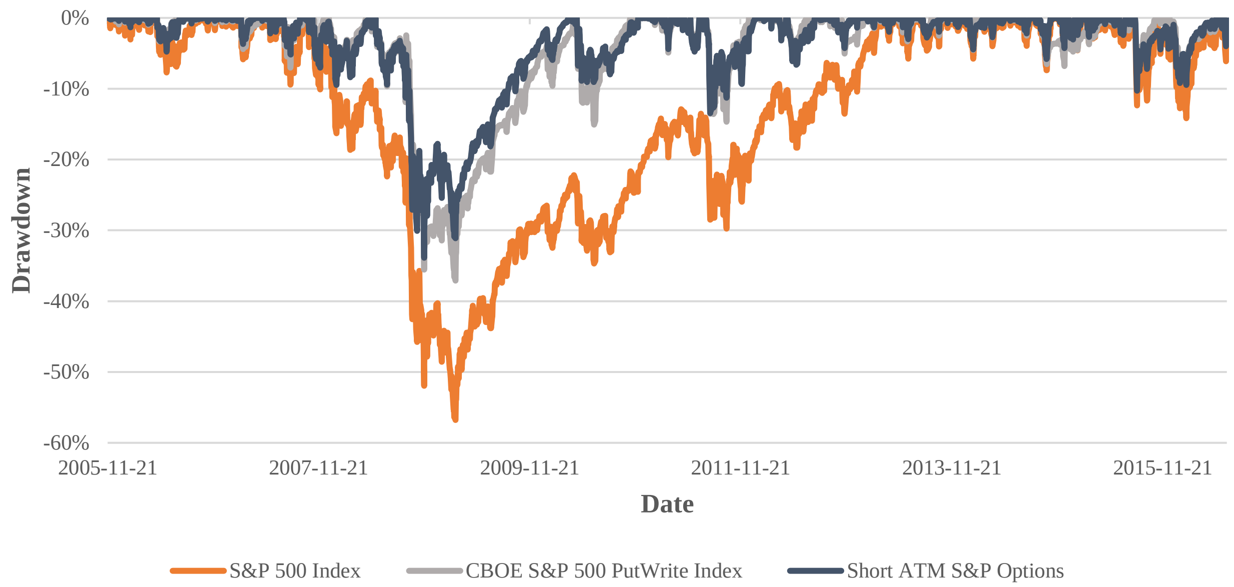


Figure 11: S&P 500 Index vs. CBOE PutWrite Index vs. Short ATM S&P 500 Index options drawdowns



Past research has indicated that option-selling strategies tend to have faster recoveries from deep drawdowns than equity due to the mean-reverting tendencies of volatility. That is, when implied volatility spikes above realized volatility as a result of sharp losses in equity, past research has suggested that options markets tend to rapidly price in mean-reversion. This, in turn, causes implied volatility to fall lower than realized volatility faster than equity tends to recover.

It is important to note that the GFC largely impacted the period under review. Thus one cannot infer that option-selling strategies will always outperform equity on an absolute basis. It is evident that equity achieved stronger returns during the recovery phase following the GFC, which suggests that equity may outperform option-selling strategies during periods of low volatility, but option-selling strategies may have shallower drawdowns and quicker recoveries than equity during market crisis'.

The Sharpe ratio of 0.21 obtained by the S&P 500 Index was less impressive than the 0.40 and 0.41 Sharpe ratios achieved by the short ATM options strategy and PutWrite Index respectively. Regarding tail-risk measures, the 95% daily CVaR for the S&P 500 Index was -3.20% which was inferior to the –2.44% and -2.36% obtained by the short ATM options strategy and PutWrite Index respectively. Similarly, the 99% daily CVaR of -5.55% was more severe than the -4.55% and -4.52% experienced by the short ATM options strategy and PutWrite Index respectively. The best 6-month HPR was 30.86% for the S&P 500 Index, which was greater than both the option-selling strategy and PutWrite Index which generated 19.22% and 24.48% respectively. The worst 6-month HPR experienced by the S&P 500 Index of -39.78% was however more severe than the -29.29% and -31.47% suffered by the option-selling strategy and PutWrite Index respectively.

The daily returns of the S&P 500 Index had a similar negative skew as the PutWrite Index. The VRP strategies and the S&P 500 Index had positive excess kurtosis indicating that each had leptokurtic distributions characterized by fat tails and sharp peaks. The excess kurtosis for the short ATM options strategy was 20.39 and 27.13 for the PutWrite Index which were higher than the 10.58 experienced by the S&P 500 Index indicating that the distribution of the daily VRP strategy returns had relatively sharper peaks with relatively fatter tails than equity over the period. The maximum drawdown of the short ATM options strategy was -33.87% compared with -37.09% and -56.78% for the PutWrite Index and S&P 500 Index respectively. This finding was in line with the relative inferiority of the S&P 500 Index on tail-risk measures when compared with option-selling strategies.

Table 8 indicates that the S&P 500 Index had a correlation of 0.95 with the short ATM options strategy and 0.90 with the PutWrite Index over the period. Thus, option-selling strategies may be an additional asset class worth considering given that it has offered imperfectly-correlated equity-like returns, with a more attractive risk profile. Additionally, volatility as an asset class may be more robust than equity to the rising levels of interest that may come about as interest rates are normalized. This assertion cannot be reliably tested given that implied volatility data used to price put options on a daily basis was only available from 2005 and thus did not contain a long enough period during which the US Federal Reserve engaged in a program of increasing interest rates over a fairly long period.

- S&P 500 Index vs. various VRP strategies

Given that both the PutWrite Index as well as the short ATM options strategy were competitive on a risk-return basis with equity over the period, two additional short implied-volatility strategies will be investigated. First, a short 5% OTM S&P 500 Index options strategy (short 5% OTM options strategy) that should be of a lower risk profile than the strategies that are short ATM options given that losses are only suffered when the spot price is less than 5% below the strike price as opposed 0%. Second, a bull put spread options strategy which is short ATM S&P 500 Index options and long 10% OTM S&P 500 Index options (bull put spread strategy) with the same expiry dates. The purpose of the simultaneous long/short position is so that a floor is placed on the maximum loss that can be experienced if implied volatility rises sufficiently over realized volatility.

Figure 12 below illustrates the cumulative return of the strategies from 21 November 2005 to 30 June 2016, and figure 13 shows the drawdowns for all strategies over the same period. The 5% OTM options strategy appeared to enjoy the greatest performance of all approaches with an annualized HPR of 7.43% while the bull put spread strategy obtained the worst performance on an absolute basis of 2.37%. The short ATM options strategy obtained an annualized HPR of 6.77% which implied that the purchasing of 10% OTM options cost the bull put spread strategy 4.40% per annum. This finding is in line with the results of Israelov and Nielsen (2015) who found the purchase of put options to be restrictively expensive. This finding would also negate the feasibility of bull put spread strategies with long positions closer to the money given the higher drag on returns associated with options purchased closer to the money if investors were interested in absolute return targets. Therefore, the sale of naked near-the-money options (where the risk preference premium lies) appears to be the more efficient than the bull put spread strategy.

Figure 12: Cumulative return per option-selling strategy

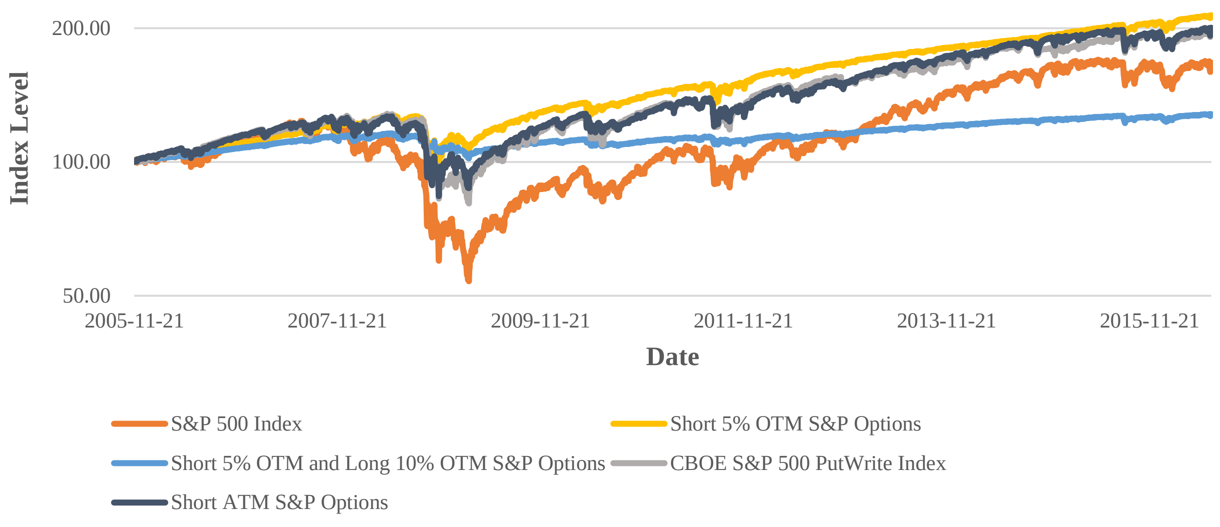


Figure 13: Drawdowns per option-selling strategy

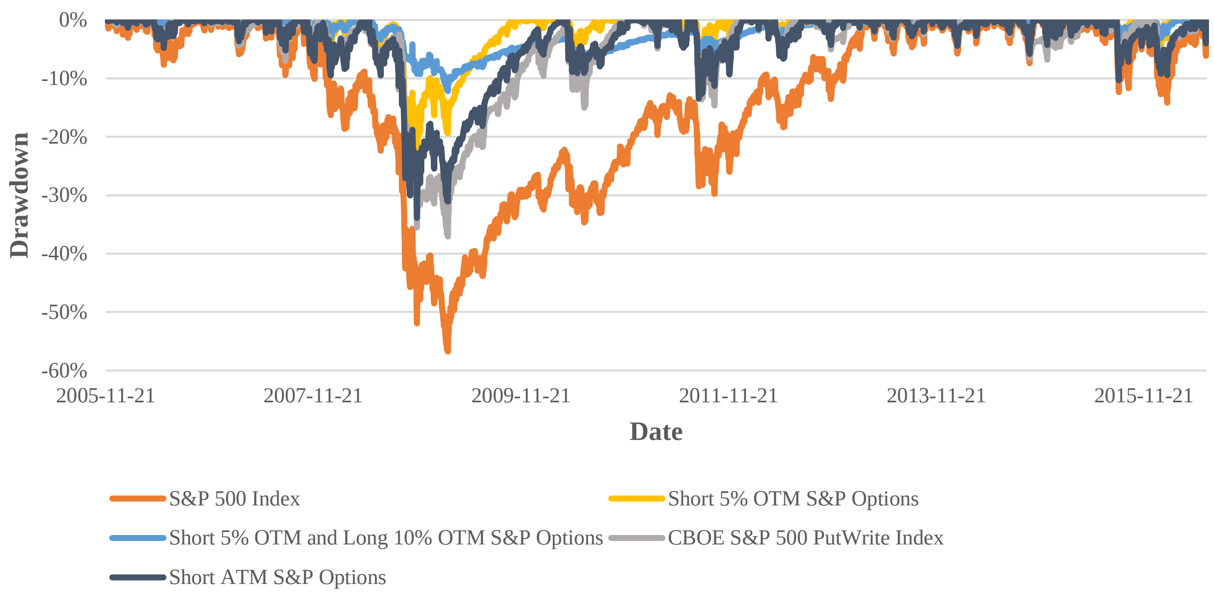


Table 7: S&P 500 Index vs. CBOE S&P 500 PutWrite Index summary statistics

	Short ATM S&P Options	Short 5% OTM S&P Options	Short 5% OTM and Long 10% OTM S&P Options	CBOE S&P 500 PutWrite Index	S&P 500 Index
Annualized HPR	6.77%	7.43%	2.37%	6.61%	4.97%
Annualized Volatility	15.07%	11.60%	4.08%	14.27%	20.46%
Sharpe Ratio	0.40	0.57	0.40	0.41	0.21
VaR (95%)	-1.37%	-0.69%	-0.36%	-1.25%	-1.98%
CVaR (95%)	-2.44%	-1.75%	-0.68%	-2.36%	-3.20%
VaR (99%)	-3.17%	-2.39%	-0.89%	-2.99%	-3.94%
CVaR (99%)	-4.55%	-4.08%	-1.34%	-4.52%	-5.55%
Maximum Drawdown	-33.87%	-26.91%	-12.14%	-37.09%	-56.78%
Skewness	0.01	0.65	-0.79	-0.18	-0.09
Excess Kurtosis	20.39	51.20	18.83	27.13	10.58
Minimum Daily HPR	-7.81%	-7.63%	-2.55%	-9.37%	-9.03%
Maximum Daily HPR	10.39%	10.32%	2.50%	11.58%	11.58%

Figure 14: Best and worst 6-month HPR per option-selling strategy

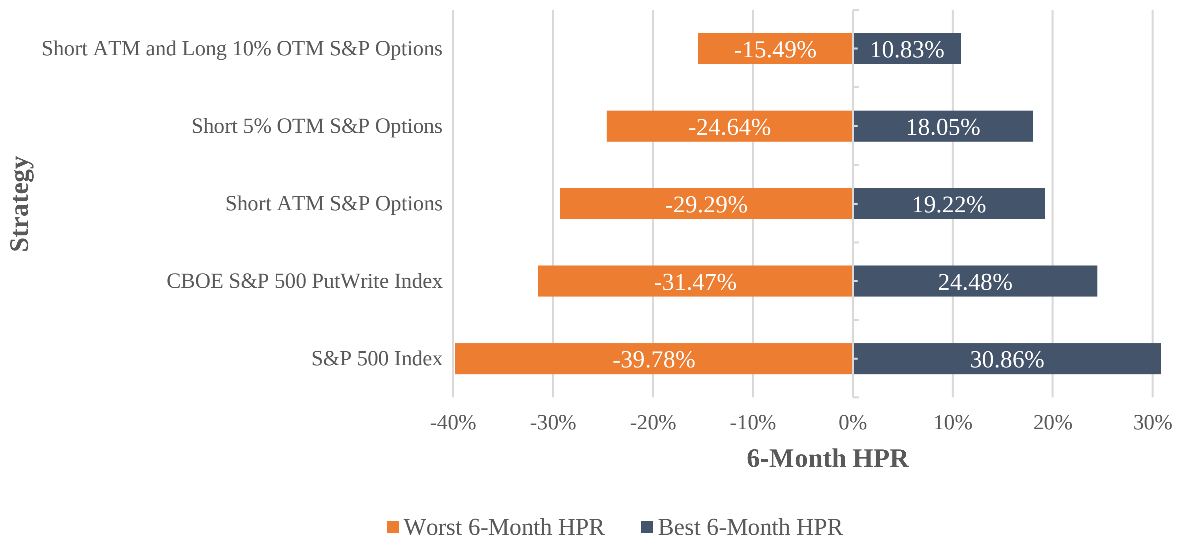


Table 7 shows that the lower return obtained by the bull put spread strategy was accompanied by a relatively low annualized volatility of 4.08% compared with the 11.60% experienced by the short 5% OTM options strategy which was lower still than the 15.07% experienced by the ATM options strategy. The short 5% OTM options strategy enjoyed the highest Sharpe ratio of 0.57 followed closely by 0.41 attained by the PutWrite Index and 0.40 experienced by both the short ATM options strategy and bull put strategy respectively.

All tail-risk measures indicated that the bull put spread strategy was considerably less risky than the other strategies with a 95% CVaR of -0.68% and 99% CVaR of -1.34% followed by the short 5% OTM options strategy which experienced -1.75% and -4.08% respectively. Table 7 shows that the maximum drawdown of -12.14% obtained by the bull put spread strategy was considerably less than the other strategies with equity experiencing the deepest maximum drawdown of -56.78%. The short 5% OTM options strategy exhibited a positive skewness of 0.65 and the bull put spread strategy exhibited negative skewness of -0.79. The excess kurtosis of the short 5% OTM options strategy was 51.20 over the period compared with a relatively lower positive excess kurtosis of 18.83 for the bull put spread strategy.

The short 5% OTM options strategy appeared to have more favourable risk-return characteristics than the short ATM options strategy achieving slightly higher return as well as a more attractive risk profile. Since the end of the GFC, it is evident from figure 12 that the short ATM strategy was experiencing higher daily returns than the short 5% OTM strategy which one would expect during periods of relatively low volatility as the greater risk accepted by the short ATM option strategy is expected to be rewarded.

Table 8 indicates that the daily returns of the short 5% OTM options strategy had a correlation of 0.78 with the bull put strategy; 0.88 with the PutWrite Index; 0.86 with the S&P 500 Index and 0.95 with the short ATM options strategy. The bull put strategy had a correlation of 0.86 with the short ATM options strategy, 0.77 with the PutWrite Index and 0.83 with the S&P 500 Index.

Table 8: Correlations between strategies over the full period

	Short ATM S&P Options	**Short 5% OTM S&P Options**	**Short 5% OTM and Long 10% OTM S&P Options**	**CBOE S&P 500 PutWrite Index**	**S&P 500 Index**
Short ATM S&P Options	1.00				
Short 5% OTM S&P Options	0.95	1.00			
Short 5% OTM and Long 10% OTM S&P Options	0.86	0.78	1.00		
CBOE S&P 500 PutWrite Index	0.93	0.88	0.77	1.00	
S&P 500 Index	0.95	0.86	0.83	0.90	1.00

In summary, our findings were consistent with those of Rennison and Pedersen (2012), in that the return characteristics of the VRP strategies aside from the bull put spread strategy appeared to be comparable to the S&P 500 Index on average across the period but were superior to equity during the GFC. The drawdowns experienced by all the VRP strategies were more favourable than the S&P 500 Index, and all VRP strategies enjoyed a faster recovery post-GFC than the S&P 500 Index. Moreover, the tail-risk statistics experienced by the option-selling strategies were historically superior to those of the S&P 500 Index. All VRP strategies obtained higher Sharpe ratios than the S&P 500 Index which indicates that investors should consider the introduction of volatility as an asset class into their portfolios. Additionally, the option-selling strategies simulated in this dissertation were modelled in portfolios that were 100% collateralized. That is, the exposure attained through the sale of options was matched one-for-one with cash, such that cash was held for all possible losses. Thus, barring any constraints, investors could utilize leverage (by reducing collateralization) to increase expected returns. Thus, should investors seek higher returns over time from more conservative options strategies such as bull put spread strategies, the reduction of the level of collateralization could raise expected returns.

4.2.2 VIX futures strategy

- Findings for the full sample period

An investigation into the performance of the S&P 500 Index and a VIX futures strategy inspired by Simon and Campasano (2014) was conducted from the 31st of March 2004 until the 30th of June 2016. Daily trade directions of VIX futures (long or short) were inferred from the state of the VIX futures curve as at market close the day before. If the VIX futures basis was in contango, a short position on VIX futures was taken at the beginning of the following day. If the VIX futures curve as in backwardation, a long position was taken.

Positions were delta hedged on a monthly basis in an attempt to minimize the risk associated with adverse price movements in the underlying instrument. Tables 9 to 11 below disect the statistics used in this study. Table 9 describes the levels of the VIX Index, front-month VIX futures prices and basis, second-month VIX futures prices and basis as well as the E-mini S&P 500 futures prices. The VIX Index averaged 19.38% over the period with the VIX front-month and second-month futures averaging slightly higher at 19.88% and 20.65% respectively. The maximum of the VIX Index over the period was 90.86% which was higher than the 67.95% and 59.77% for the VIX front-month and second-month futures respectively. Similar to the findings of Simon and Campasano (2014), the range exhibited by the VIX futures prices was smaller than the VIX Index which implies that the VIX futures were at lower prices to the VIX when the VIX was at relatively high levels and higher prices to the VIX when the VIX was at relatively lower levels. This finding appears to demonstrate that options markets price in a degree of mean-reversion in volatility levels. The average of the basis of the front-month and second-month futures was 0.50% and 1.28% respectively. This indicates that contango episodes were more prevalent than backwardation episodes as both front and second-month averages were positive.

Table 9: Summary statistics of the VIX Index and VIX futures levels

Levels	VIX Index	Front-Month	Second-Month	Front-Month Basis	Second-Month Basis	E-mini S&P 500
Mean	19.38%	19.88%	20.65%	0.50%	1.28%	1 422.34
Maximum	80.86%	67.95%	59.77%	4.98%	7.13%	2128.00
Minimum	9.89%	10.25%	11.72%	-23.31%	-35.57%	676.00
Top Decile	29.52%	29.10%	30.17%	2.06%	3.93%	2018.75
Bottom Decile	12.06%	12.77%	13.85%	-0.70%	-1.23%	1072.8
Skewness	2.53	2.21	1.81	-4.61	-4.41	0.58
Excess Kurtosis	8.47	6.11	4.10	38.71	32.38	-0.59

Table 10 below describes the first-order differences in the VIX Index, first-month and second-month VIX futures as well as E-mini S&P 500 Index futures. It is evident that the volatility of VIX Index changes is greater than that of both the front-month and second-month futures with standard deviations of 29.06%, 20.43% and 14.57% respectively. This illustrates the the VIX futures curve fluctuates considerably over time despite it being upward sloping on average. The volatility on the E-mini S&P 500 futures was lower than that of the VIX Index and front-month VIX futures, while its largest positive and negative daily changes were similar to those of the VIX Index and futures.

Table 10: Summary statistics of first-order differences in the VIX Index and VIX futures

Levels	VIX Index	Front-Month	Second-Month	Front-Month Basis	Second-Month Basis	E-mini S&P 500
Mean	0.01%	0.01%	0.01%	0.00%	0.00%	0.03%
Standard Deviation	29.06%	20.43%	14.57%	17.24%	20.21%	19.65%
Maximum	16.74%	19.75%	19.85%	8.89%	15.37%	14.11%
Minimum	-17.36%	-10.94%	-7.30%	-21.01%	-20.63%	-9.88%
Top Decile	1.60%	1.20%	0.90%	0.81%	1.01%	1.17%
Bottom Decile	-1.53%	-1.05%	-0.82%	-0.78%	-0.96%	-1.24%
Skewness	0.89	1.64	3.69	-2.51	-1.05	0.16
Excess Kurtosis	19.46	25.67	75.79	60.06	43.99	15.48

Table 11 below provides more information on the periods of contango and backwardation per VIX Index level. At the lower end of the spectrum, it is evident that 67.91% of all historical VIX Index levels were below 20% and 22.53% of all VIX levels were between 20% and 30%. At the higher end of the spectrum, 5.06% of all observations were between 30% and 40%, 2.69% were between 40% and 50%, and only 1.81% were greater than 50%.

Table 11: Summary statistics periods of contango and backwardation per VIX Index level

Front Month	Obs	VIX Average	Basis of VIX	Obs & % of time in Contango		Obs & % of time in Backwardation	
All Observations	3 085	19.38%	0.50%	2 330	75.53%	746	24.18%
VIX<=20	2 095	14.71%	0.82%	1 739	83.01%	351	16.75%
20<VIX<=30	695	23.83%	0.53%	468	67.34%	223	32.09%
30<VIX<=40	156	33.92%	-0.77%	78	50%	78	50%
40<VIX<=50	83	44.21%	-1.08%	41	49.40%	42	50.60%
VIX>50	56	61.45%	-6.05%	4	7.14%	52	92.86%

Table 11 also indicates that the front-month VIX futures curve was in contango 75.53% and in backwardation for 24.18% of the days in the sample period. Periods of contango were generally associated with periods of low volatility as the front-month VIX futures curve was in contango 83.01% of the time when the VIX was less than 20% and 67.34% of the time when the VIX was between 20% and 30%. Periods of backwardation were generally associated with periods of high volatility as the front-month VIX futures curve was in backwardation 92.86% of the time when the VIX was greater than 50%.

Figure 15 illustrates this finding by shading the areas beneath the levels of the VIX Index and front-month VIX futures prices during episodes of backwardation. The relatively high degree of volatility in VIX futures basis is evident in figure 15 given that periods of backwardation were relatively dispersed over the sample period. A cluster of backwardation episodes occurred during the 2008 GFC, during which investors began pricing in futures prices that were less than spot prices in an expectation for future VIX levels to fall back to historical norms.

Figure 15: Periods of contango and backwardation per VIX Index level

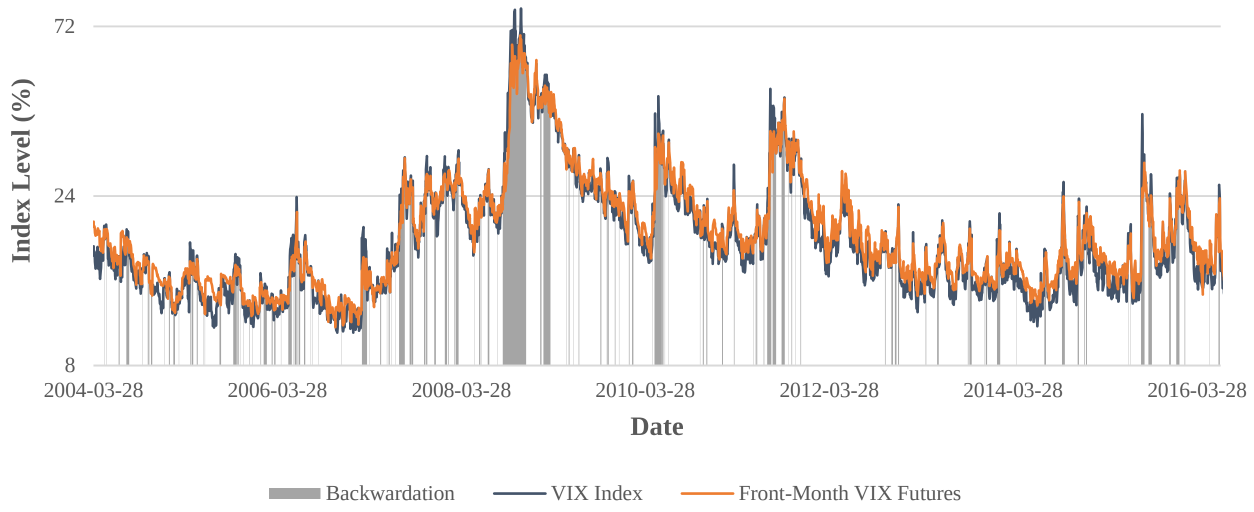


Figure 16 below illustrates the cumulative return of the S&P 500 Index (equity) vs. the Combined VIX Strategy over the period, with figure 17 showing the drawdowns of both strategies over the period. It is evident that until the GFC, the combined VIX strategy outperformed equity. Given that the market was relatively calm for the vast majority of the time before the GFC evidenced by steadily rising equity levels, VIX futures curves were generally in contango.

Figure 16: S&P 500 Index vs. combined VIX futures strategy cumulative returns

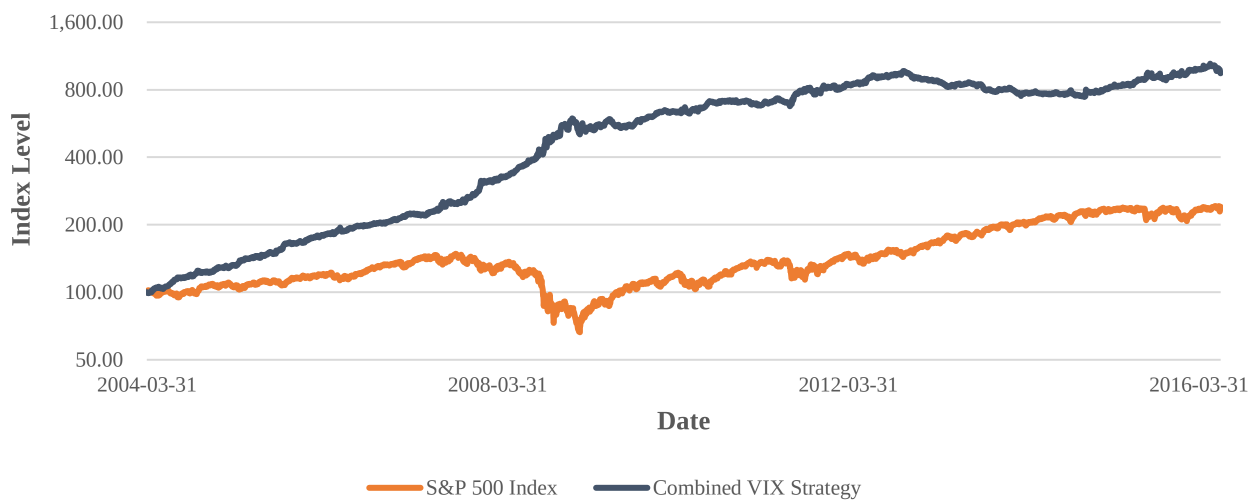


Figure 17: S&P 500 Index vs. combined VIX futures strategy drawdowns

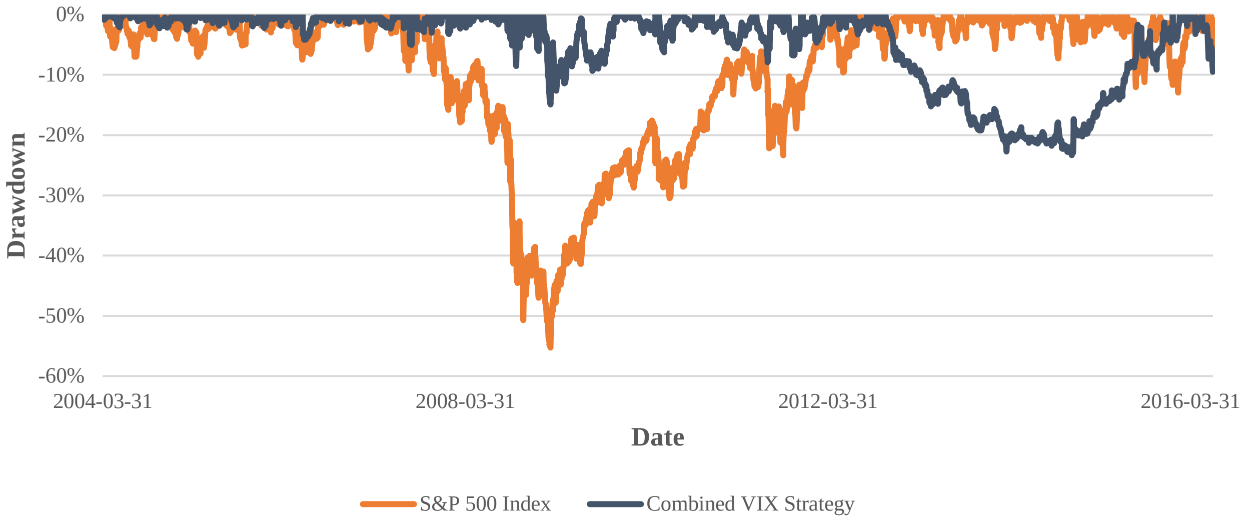


Table 12: S&P 500 Index vs. combined VIX futures strategy summary statistics

	Combined VIX Strategy	S&P 500 Index
Annualized HPR	19.82%	7.42%
Annualized Volatility	18.15%	19.44%
Sharpe Ratio	1.04	0.34
VaR (95%)	-1.65%	-1.81%
CVaR (95%)	-2.80%	-3.00%
VaR (99%)	-3.56%	-3.66%
CVaR (99%)	-4.83%	-5.28%
Maximum Drawdown	-23.34%	-55.25%
Skewness	-0.05	-0.09
Excess Kurtosis	9.00	11.47
Maximum Daily HPR	7.72%	11.58%
Minimum Daily HPR	-8.24%	-9.03%

The strategy truly set itself apart from equity during the GFC where the state of VIX futures curves changed into backwardation thus triggering long positions in both VIX futures and equity futures. During the GFC, while a long VIX futures strategy without delta hedging experienced a sharp and substantial rise, the combined strategy experienced a somewhat less sharp but still impressive gain. This makes sense as E-mini S&P 500 futures contracts were purchased during a period of rapidly falling prices due to monthly delta-hedging.

The gains experienced when the VIX futures basis was in contango mirrored the gains on short VRP strategies examined in the previous section as they were small in nature but frequently occurred with reasonably small drawdowns. The large gains experienced by the strategy which may explain a great deal of its outperformance were experienced during times when the VIX futures curve was in backwardation. While many of the largest single day losses were also experienced when the VIX curve was in backwardation, the win/loss ratio (the number of profitable trades divided by the total trades made) for these trades was higher than trades conducted when the VIX futures curve was in contango.

Over the entire period, the VIX curve switched states 287 times implying that trading would have occurred approximately once every 10-trading days (analogous to a 2-week period). According to table 12, the cumulative return of the combined VIX strategy was an impressive 19.82% over the period under consideration compared with just 7.42% achieved by the S&P 500 Index. This finding is similar to that of Simon and Campasano (2014), and it is clearly evident that the success of the trading strategy over the period resulted from opportunely timing switching between long and short positions, particularly during the GFC. The maximum 6-month HPR for the VIX futures strategy was 56.65% compared with 31.00% for the S&P 500 Index. The lowest 6-month HPR for the VIX futures strategy was -9.06% compared with -39.78% for the S&P 500 Index.

In terms of risk measures, the volatility experienced by the combined VIX strategy was only 11.86% compared to 19.44% experienced by equity, resulting in a considerably superior Sharpe ratio in favour of the combined VIX strategy. Tail-risk measures also confirmed the efficiency of the combined VIX strategy with a daily 95% VaR and daily 95% CVaR of -0.94% and -1.62% respectively compared with -1.81% and -3.00% for equity respectively.

Skewness for the strategy was -0.05 compared with -0.09, and both the strategy and equity experienced positive excess kurtosis of 9.00 and 11.47 respectively. The highest single day return for the strategy was 7.72% vs 11.58% for equity and the sharpest single-day drop for the strategy was -8.24% compared with a similar -9.03% for equity.

It is important to note that the strategy began experiencing a steady drawdown from the end of 2012 until almost the end of the period under investigation. Similar drawdowns were experienced by the options selling strategies examined in the previous section. Equity appeared to have achieved formidable returns over this period, and while the overall strategy seems to mirror past findings fairly well, it is worthwhile isolating for the period after the GFC seeing as the GFC itself contributed so dramatically to the trendline of the strategy.

- Findings for the sub-sample period from 2009 to 2016

Figure 18 below describes the cumulative return of the strategy as well as equity from 2 January 2009 to 30 June 2016. The S&P 500 Index experienced a sharp initial drawdown in the first quarter of 2009, but generated strong returns up to the end of the period. While the strategy kept pace with equity for the first few years, it appeared to underperform equity from the end of 2012. From the fourth quarter of 2012 to the second quarter of 2016, the strategy suffered a lengthy drawdown best illustrated in figure 19.

Figure 18: S&P 500 Index vs. combined VIX futures strategy post-GFC cumulative returns

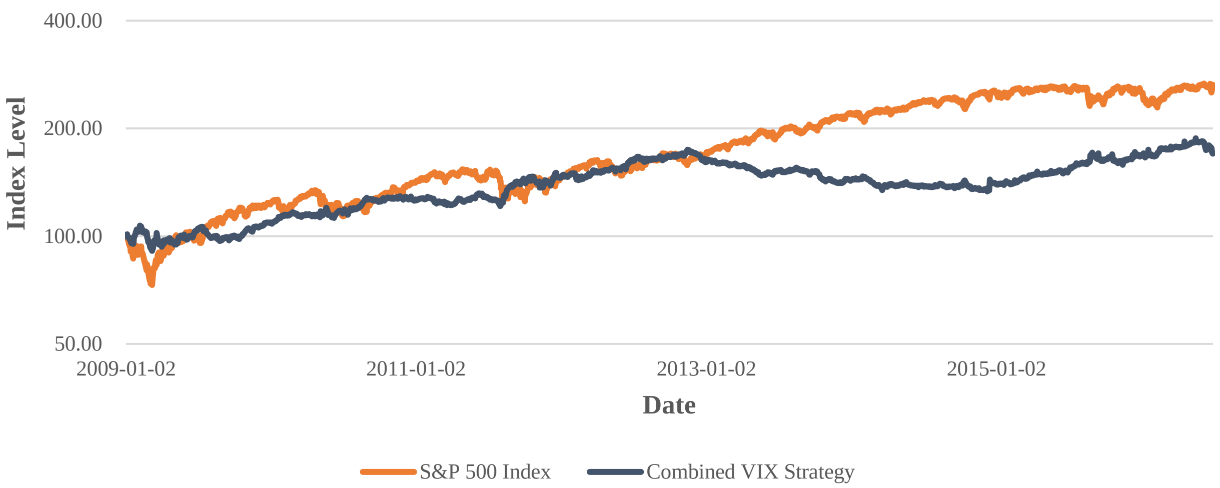
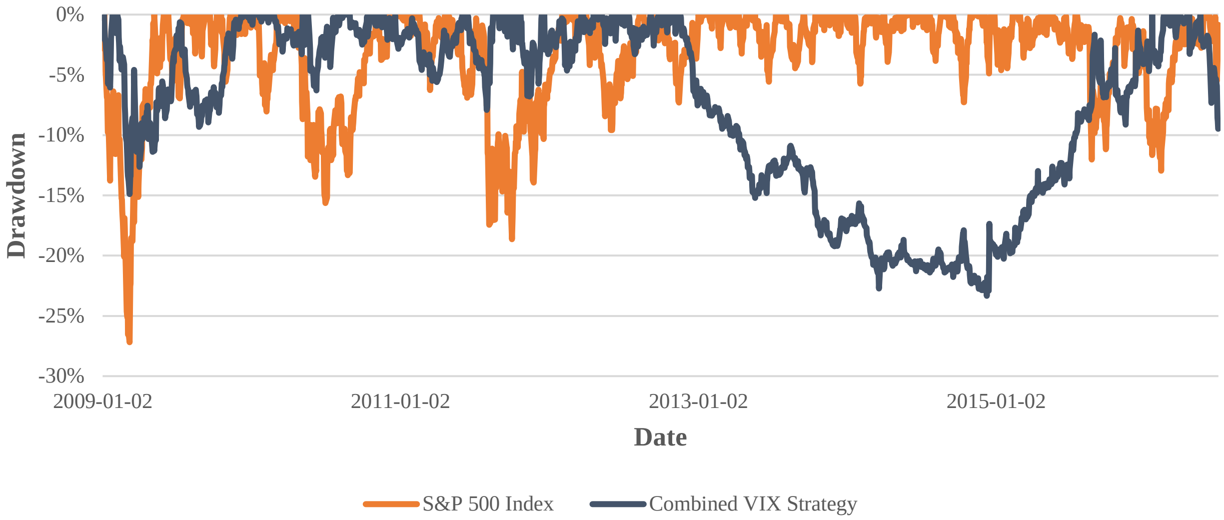


Figure 19: S&P 500 Index vs. combined VIX futures strategy post-GFC drawdowns



VIX levels across this drawdown period appeared to be low relative to historical levels, and the VIX futures curve was in contango over 85.01% of the time. Over the full sample period, the VIX futures curve was in contango an average of 75.53% of the time, thus the relatively low levels of volatility contributed to more periods of contango after the fourth quarter of 2012. The win/loss ratio when the VIX curve was in contango, i.e. the number of days in which profit was earned compared with the number of days in which losses were suffered was 41.09% for the period after the fourth quarter of 2012. This culminated in underperformance greater than what was experienced during the GFC while equity was experiencing a recovery.

Table 13 asserts that the annualized HPR for the strategy for the period following the GFC was 7.34% compared with 13.88% for equity. The strategy still maintained approximately the same volatility during this period as it had across the entire period resulting in a slightly smaller Sharpe ratio of 0.64 compared with 0.69 achieved by equity. The maximum 6-month HPR for the VIX futures strategy was 19.76% compared with 31.00% for the S&P 500 Index. The lowest 6-month HPR for the VIX futures strategy was -9.06% compared with -17.71% for the S&P 500 Index.

Skewness for the strategy was 0.21 compared with -0.17 for equity which differed from the statistics drawn from the full sample period. Both the strategy and equity experienced positive excess kurtosis of similar magnitude (5.23 and 4.35 respectively). The highest single day return for the strategy was 4.47% vs 7.10% for equity and the sharpest single-day drop for the strategy was -4.31% compared with a similar -6.65% for equity.

While the strategy experienced a prolonged drawdown episode which reached its lowest point at -23.34%, it only had one other drawdown greater than 10% across the period. Equity, on the other hand, experienced 6 separate sharp drawdown episodes of 10% or more, with the deepest drawdown being -27.19% resulting in mixed results in terms of tail-risk measures. While equity had less attractive VaR's, the strategy had less attractive CVaR's at both a 5% and 1% level of significance.

Table 13: S&P 500 Index vs. combined VIX futures strategy post-GFC summary statistics

	Combined VIX Strategy	**S&P 500 Index**
Annualized HPR	7.34%	13.88%
Annualized Volatility	11.33%	17.83%
Sharpe Ratio	0.64	0.69
VAR (95%)	-1.25%	-2.32%
CVaR (95%)	-3.38%	-1.96%
VAR (99%)	-2.62%	-4.66%
CVaR (99%)	-5.49%	-3.22%
Maximum Drawdown	-23.34%	-27.19%
Skewness	0.21	-0.17
Excess Kurtosis	5.23	4.35
Minimum Daily HPR	-4.31%	-6.65%
Maximum Daily HPR	4.47%	7.10%

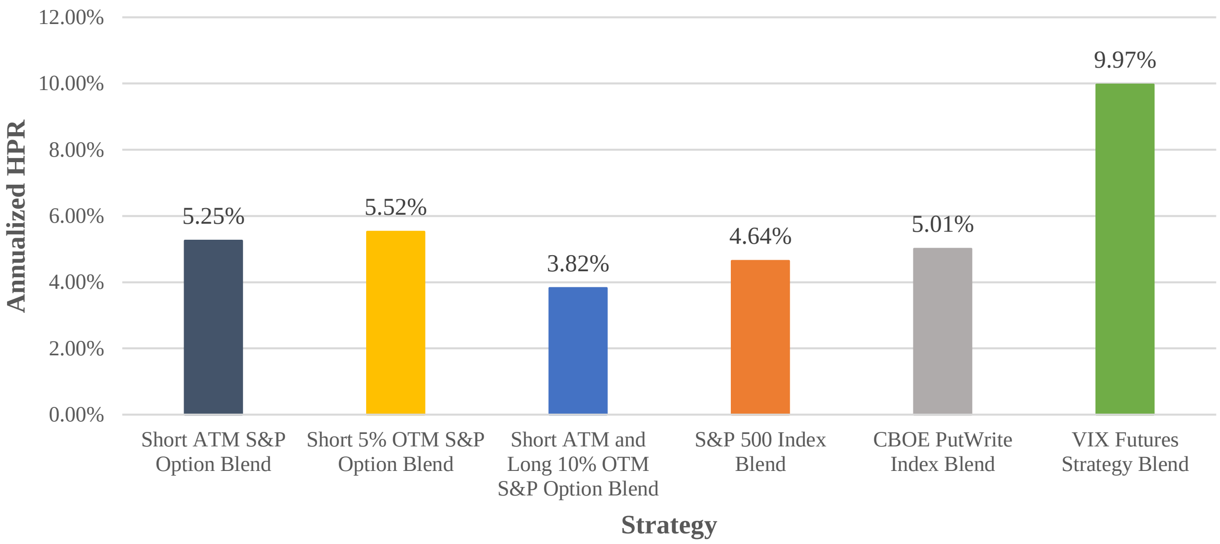
In conclusion, while the combined VIX strategy appeared to support past findings of impressive outperformance since inception, it experienced far less impressive returns after the 2008 GFC crisis. A severe and prolonged drawdown since the end of 2012 contributed most significantly to the overall underperformance after the crisis, despite relatively similar conditions being experienced as those before the 2008 GFC. It could be argued that the underperformance of the strategy raises questions regarding the persistence of the strategy in the long-run. The strategy did however generate a strong performance during the 2008 GFC, suggesting that the strategy may warrant implementation only when the VIX futures curve is in backwardation.

4.2.3 30/30/40 volatility/equity/bond portfolios vs the 60/40 equity/bond portfolio

- Findings for the full sample period

Now that the performance of several option-selling strategies, a bull put spread strategy as well as a VIX futures strategy has been reviewed, an investigation into how each would have contributed to the performance of a traditional portfolio over time is conducted. Each option-selling strategy as well as the VIX futures strategy was combined in a 30/30/40 volatility/equity/bond portfolio and compared with a traditional 60/40 equity/bond portfolio from 21 November 2005 to 30 June 2016. For example, the Short ATM S&P Option Blend was made up of 30% short ATM S&P 500 Index options strategy, 30% S&P 500 Index and 40% iShares 20+ Year Treasury-bond ETF (TLT). Each portfolio was rebalanced at the end of each calendar month, and figure 20 below illustrates the annualized HPR per portfolio. It is evident that the bull put spread strategy blend generated the least return on an absolute basis, with all other volatility blended portfolios outperforming the traditional 60/40 portfolio on an absolute basis. The VIX futures strategy blend generated the highest annualized HPR of 9.97% followed by the short 5% OTM S&P option strategy blend.

Figure 20: Annualized HPR per 30/30/40 volatility/equity/bond Portfolio



In terms of risk-adjusted performance, figure 21 below highlights the Sharpe ratios generated per portfolio and both the traditional 60/40 and the bull put spread strategy blend experienced the lowest Sharpe ratio of 0.42. The VIX futures strategy blend generated the highest Sharpe ratio of 1.21 followed by the 0.64 experienced by the short 5% OTM S&P option strategy blend.

Figure 21: Sharpe ratio per 30/30/40 volatility/equity/bond portfolio

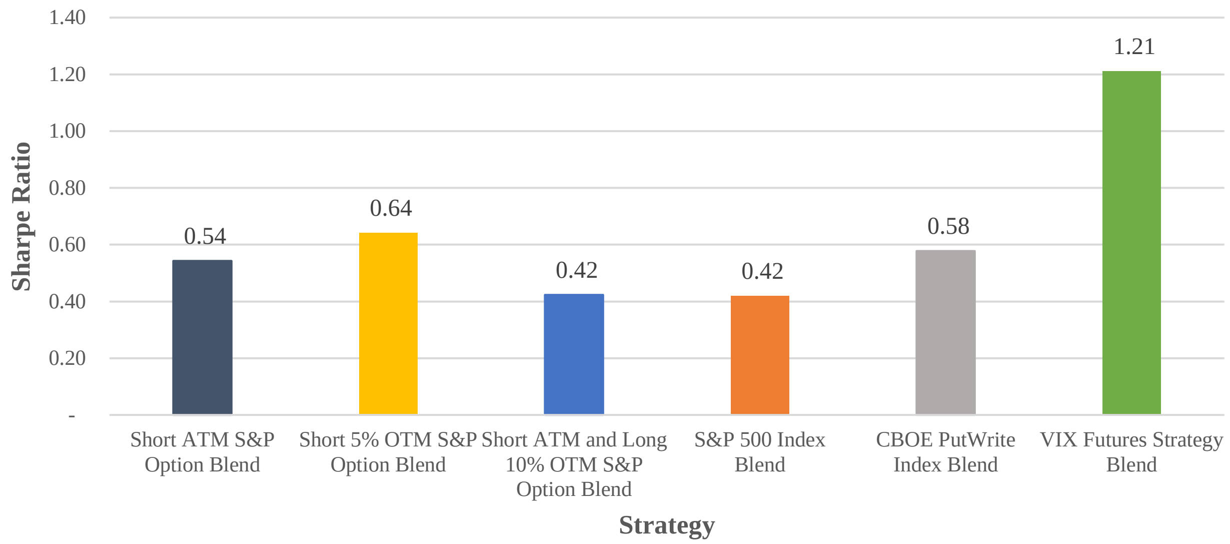


Figure 22: Best and worst 6-month HPR per 30/30/40 volatility/equity/bond portfolio

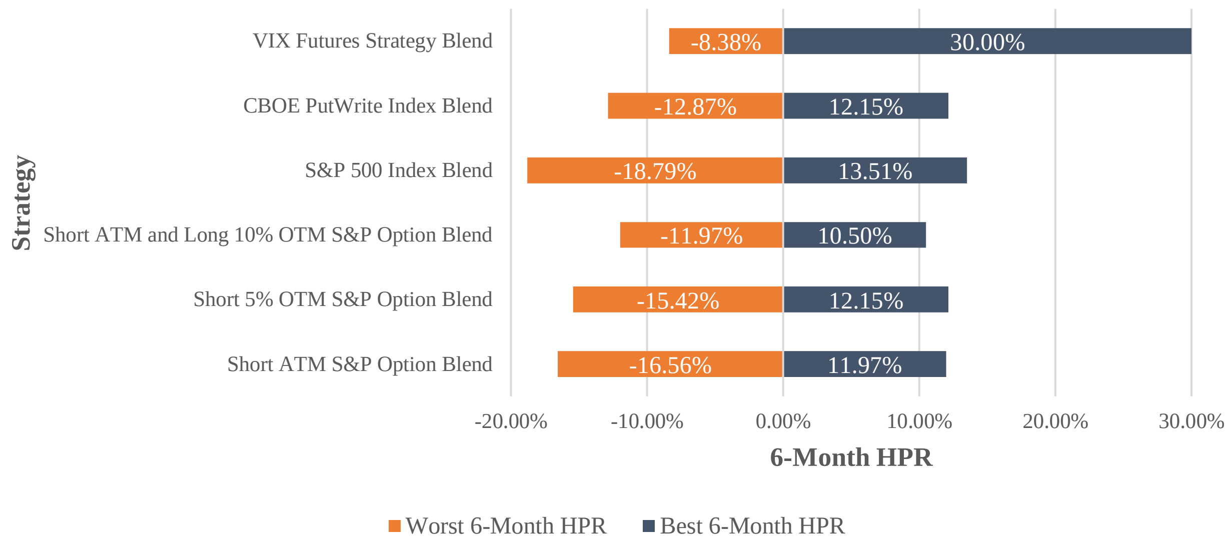


Figure 22 illustrates the best and worst 6-month HPR per portfolio, and it is again evident that the VIX futures strategy blend generated the most attractive risk-return profile given that it had both the highest positive 6-month HPR and the least severe negative 6-month HPR. The traditional 60/40 suffered the most severe negative 6-month HPR of -18.79% followed by the short ATM S&P options strategy blend with -16.56%.

Table 14 describes the summary statistics per strategy and it is evident that the introduction of volatility as an asset class in all forms investigated by this dissertation improved the tail-risk profile of the traditional 60/40 portfolio. The 60/40 portfolio suffered the most severe 95% and 99% CVaR's, as well as the deepest drawdown of -31.33%.

Table 14: Summary statistics per 30/30/40 volatility/equity/bond portfolio

	Short ATM S&P Option Blend	Short 5% OTM S&P Option Blend	Bull Put Spread Blend	S&P 500 Index Blend	CBOE PutWrite Index Blend	VIX Futures Strategy Blend
Annualized HPR	5.25%	5.52%	3.82%	4.64%	5.01%	9.97%
Annualized Volatility	7.59%	6.84%	6.39%	8.37%	6.71%	7.25%
Sharpe Ratio	0.54	0.64	0.42	0.42	0.58	1.21
VAR (95%)	-0.69%	-0.58%	-0.65%	-0.81%	-0.66%	-0.58%
CVaR (95%)	-1.19%	-1.04%	-1.00%	-1.31%	-1.04%	-1.05%
VAR (99%)	-1.42%	-1.31%	-1.22%	-1.52%	-1.24%	-1.39%
CVaR (99%)	-2.08%	-1.96%	-1.63%	-2.21%	-1.76%	-1.87%
Maximum Drawdown	-24.12%	-20.17%	-22.72%	-31.33%	-19.35%	-12.76%
Skewness	-0.03	0.11	-0.11	-0.05	-0.18	1.48
Excess Kurtosis	15.84	23.62	6.58	11.50	11.40	27.01
Minimum Daily HPR	-4.33%	-4.38%	-2.58%	-4.38%	-3.82%	-4.34%
Maximum Daily HPR	5.28%	5.39%	3.06%	5.19%	4.37%	5.55%

In terms of annualized volatility, the traditional 60/40 portfolio exhibited the highest volatility of 8.37%. The lowest annualized volatility of 6.39% was experienced by the bull put spread strategy blend, followed closely by the PutWrite Index blend and the short 5% OTM options strategy blend with figures of 6.71% and 6.84% respectively. Unsurprisingly, the maximum drawdown suffered by the traditional 60/40 portfolio of -31.33% was most severe out of all back tested strategies, with the least severe maximum drawdown of -12.76% being experienced by the VIX futures strategy blend.

- Findings for the sub-sample period 2009 to 2016

The comparison between volatility blended portfolios and the traditional 60/40 portfolio was conducted for the period 2 January 2009 to 30 June 2016. This period was chosen to investigate whether the introduction of volatility into traditional 60/40 portfolios still resulted in risk-return improvements.

Figure 23 below describes the annualized HPR per portfolio. The 60/40 portfolio generated the highest annualized HPR of 8.63% over the period, followed by the PutWrite Index blend which generated 8.13%. This is somewhat unsuprising given our previous findings of strong equity performance following the 2008 GFC. As with the full sample period, the lowest annualized HPR was generated by the bull put spread strategy blend. The VIX futures strategy blend returned considerably less in the period following 2009 indicating again that the market anomaly that may have existed up to the end of the GFC has subsequently been traded away.

Figure 23: Annualized HPR per 30/30/40 volatility/equity/bond portfolio

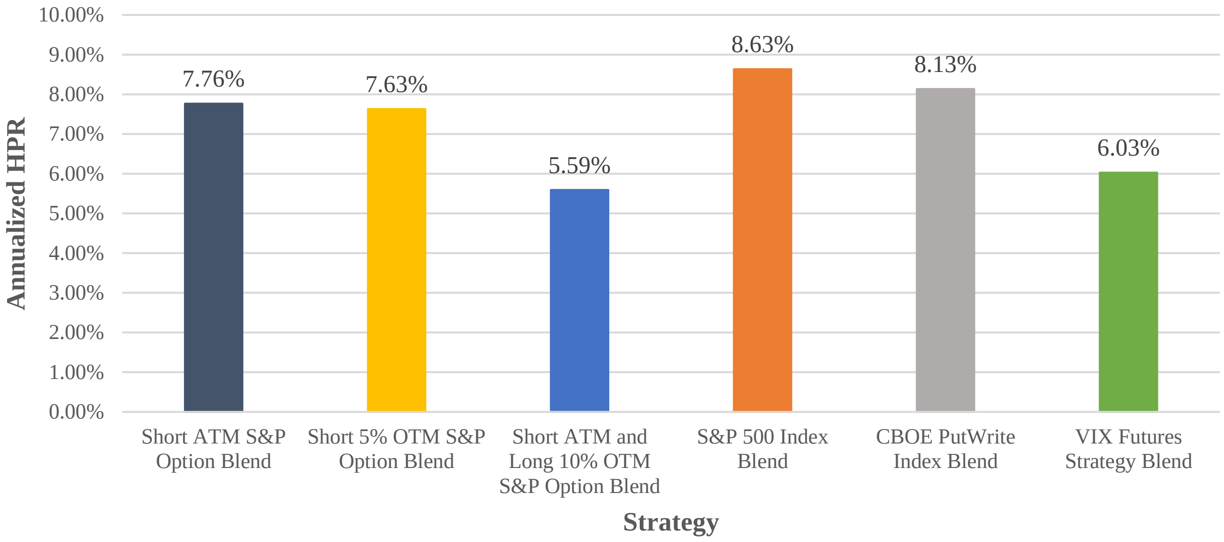
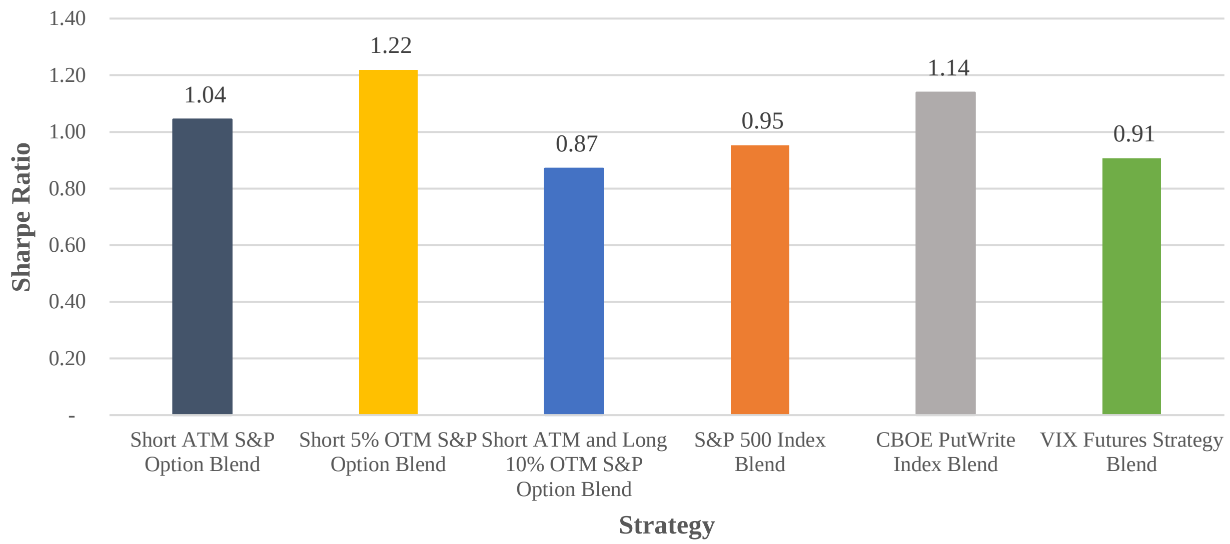


Figure 24: Sharpe ratio per 30/30/40 volatility/equity/bond portfolio



Regarding risk-adjusted performance, figure 24 above illustrates the Sharpe ratios generated per portfolio and both the traditional 60/40. The highest Sharpe ratio of 1.22 was generated by the short 5% OTM S&P option strategy blend, followed by 1.14 achieved by the PutWrite Index blend. The 60/40 portfolio achieved the third highest Sharpe ratio, ahead of the bull put strategy blend and the VIX futures strategy blend. Figure 25 below suggests that the traditional 60/40 portfolio exhibited substantially better performance in the period following the 2008 GFC than it did across the entire period. Despite this strong performance, it is evident from figure 25 that the option-selling strategies still managed to deliver competitive results when weighing best and worst 6-month HPRs.

Figure 25: Best and worst 6-month HPR per 30/30/40 volatility/equity/bond portfolio

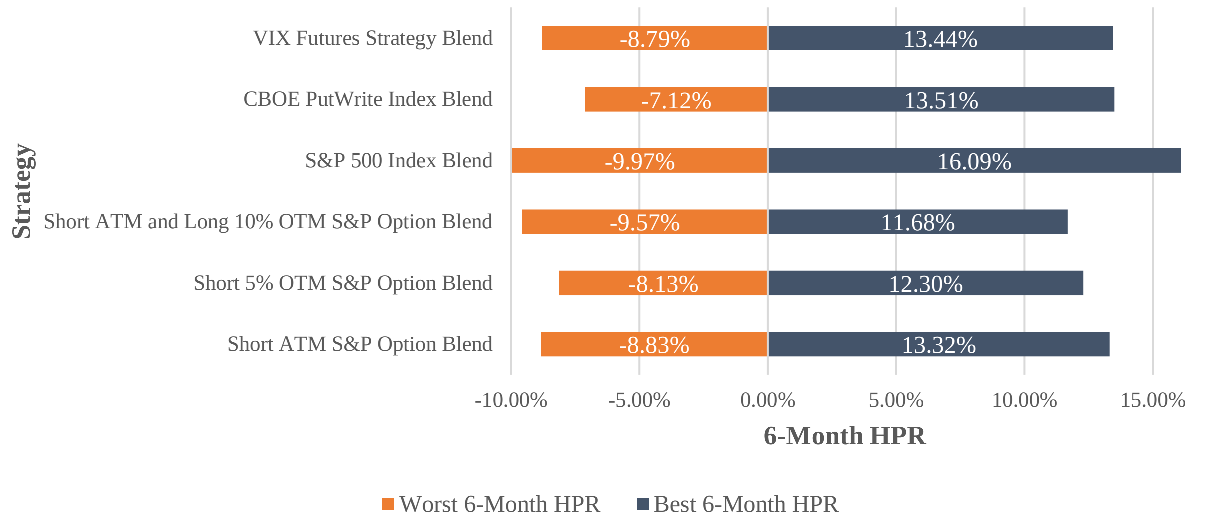


Table 15 below indicates that the tail-risk improvements attained with the 30/30/40 volatility/equity/bond portfolios still hold. Specifically, the daily 95% CVaR for the 60/40 portfolio was greater than each of the individual volatility blended portfolios, with the same being true of the daily 99% CVaR. Additionally, the most severe maximum drawdown was also suffered by the traditional 60/40 portfolio.

Table 15: Summary Statistics per 30/30/40 volatility/equity/bond portfolio

	Short ATM S&P Option Blend	Short 5% OTM S&P Option Blend	Bull Put Spread Blend	S&P 500 Index Blend	CBOE PutWrite Index Blend	VIX Futures Strategy Blend
Annualized HPR	7.76%	7.63%	5.59%	8.63%	8.13%	6.03%
Annualized Volatility	7.34%	6.18%	6.31%	8.97%	7.05%	6.54%
Sharpe Ratio	1.04	1.22	0.87	0.95	1.14	0.91
VAR (95%)	-0.72%	-0.57%	-0.66%	-0.92%	-0.66%	-0.63%
CVaR (95%)	-1.17%	-0.97%	-1.00%	-1.41%	-1.14%	-1.00%
VAR (99%)	-1.45%	-1.23%	-1.26%	-1.71%	-1.38%	-1.26%
CVaR (99%)	-1.88%	-1.67%	-1.52%	-2.15%	-1.86%	-1.63%
Maximum Drawdown	-17.60%	-15.97%	-16.63%	-21.03%	-16.30%	-11.23%
Skewness	-0.31	-0.32	-0.20	-0.15	-0.33	-0.15
Excess Kurtosis	7.15	10.47	4.84	5.46	8.67	9.15
Minimum Daily HPR	-3.37%	-3.31%	-2.43%	-3.71%	-3.69%	-3.94%
Maximum Daily HPR	3.06%	3.03%	2.23%	3.85%	3.31%	2.73%

In summary, while the 60/40 portfolio generated the highest annualized HPR from 2009 to 2016, the option-selling strategies generated competitive annualized HPRs, with higher Sharpe ratios than the traditional mix. Both across the full sample period and sub-sample period, all volatility blended portfolios improved the tail-risk profile of the traditional 60/40 portfolio.

4.3 MANAGED VOLATILITY TRADING RULE

4.3.1 The relationship between volatility levels and subsequent returns

- S&P 500 Index

In order to determine whether a managed volatility trading rule that regulates equity exposure depending on the level of the prevailing rate of volatility is feasible, the relationship between the prevailing level of volatility and the returns experienced in subsequent periods is firstly determined. If higher volatility levels went inadequately rewarded as was found by past research, an investigation into reducing equity exposure during periods of elevated volatility and increasing equity exposure during periods where volatility was below certain thresholds could be investigated.

Figure 26 illustrates the result of 1,140 10-trading day periods, sorted into deciles according to annualized volatility levels and with subsequent 10-trading day average returns plotted. In order to assign the same number of 10-trading day periods per decile, S&P 500 Index data from 3 January 1972 to 9 March 2016 was used such that each decile had an even 114 10-trading day periods. Decile 1 contained 114 10-trading day returns subsequent to the 114 least volatile 10-trading day periods, and decile 10 contained 114 10-trading day returns subsequent to the 114 most volatile 10-trading day periods. Table 16 describes the summary statistics per decile over the period.

Figure 26: Average S&P 500 Index HPR per volatility decile

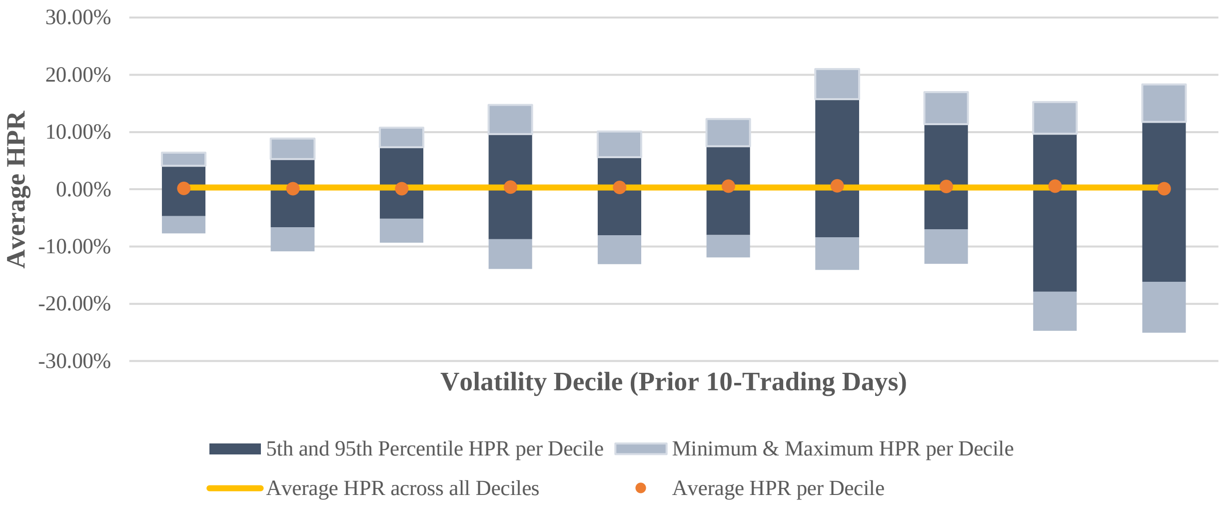


Table 16 shows that the average HPR across all deciles was 0.31% with deciles 4 to 9 experiencing similar or higher average HPRs than average with figures of 0.35%, 0.29%, 0.54%, 0.56%, 0.46% and 0.50% respectively. Deciles 1 to 3 experienced average HPRs that were below the mean with figures of 0.15%, 0.07% and 0.09% respectively, decile 10 whose returns were preceded by the highest levels of volatility experienced an average HPR of 0.08% which was also below the mean.

The excess kurtosis across deciles varied somewhat with deciles 2 and 3 experiencing excess kurtosis of 0.08 and -0.03 respectively, similar to that of a normal distribution. All deciles apart from decile 7 and 8 had positive excess kurtosis consistent with the fatter tails and sharper peaks associated with equity returns. All deciles apart from deciles 7 and 8 exhibited negative skewness that are also typical of equity returns.

Deciles 9 and 10 had greater return dispersions than the other deciles with ranges (maximum HPR minus minimum HPR) of 27.90% and 27.57% respectively compared to only 8.75% for decile 1 for example. This finding suggests that historically, volatility has been mean-reverting. There was also evidence of outliers across most deciles given large differences between 5th and 95th percentiles and minimum and maximum values. The t-test described in equation 11 which compared the mean of each deciles average HPR to the mean HPR of the entire dataset was computed and showed that no decile had a statistically significant different mean HPR than the overall mean HPR at a 5% level of significance.

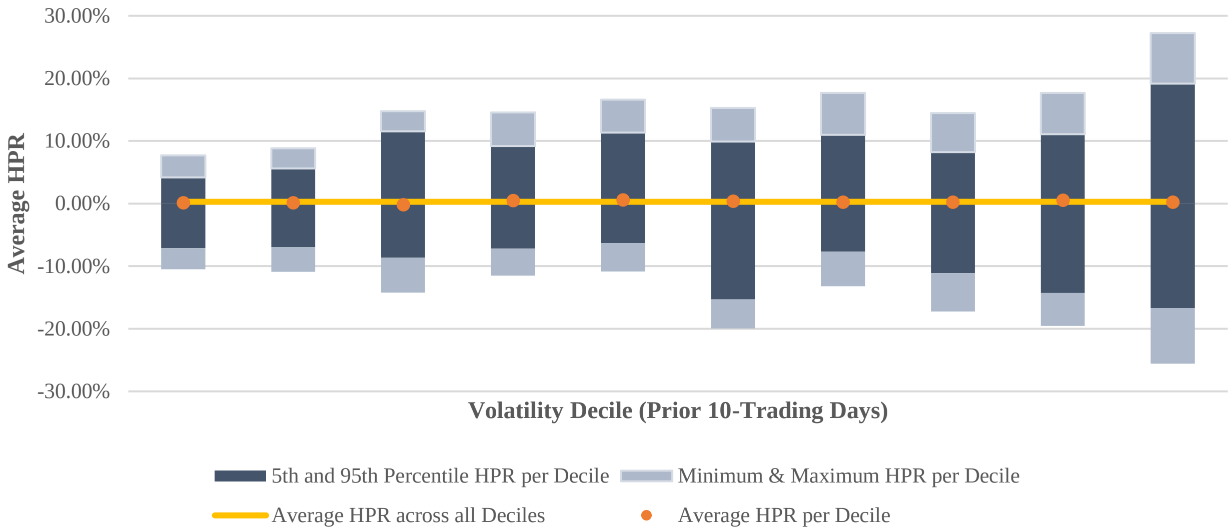
Table 16: S&P 500 Index summary statistics per volatility decile

Decile:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mean HPR	0.15%	0.07%	0.09%	0.35%	0.29%	0.54%	0.56%	0.46%	0.50%	0.08%
Kurtosis	0.80	0.08	-0.03	1.79	0.53	0.37	4.07	0.40	3.70	1.21
Skewness	-0.57	-0.37	-0.07	-0.32	-0.57	-0.32	0.62	0.12	-1.26	-0.64
Max HPR	4.09%	5.29%	7.34%	9.63%	5.63%	7.53%	15.75%	11.39%	9.69%	11.75%
Min HPR	-4.66%	-6.67%	-5.13%	-8.73%	-8.03%	-7.98%	-8.37%	-7.01%	-17.88%	-16.16%
P-Value	0.29	0.27	0.33	0.87	0.93	0.36	0.41	0.64	0.59	0.61

- MSCI EAFE Index

The same tests were conducted on the MSCI EAFE Index, and Figure 27 illustrates the results of 1,160 10-trading day periods from 3 January 1972 to 20 June 2016. The summary statistics described in table 17 showed that only decile 3 experienced a negative mean HPR of -0.18% with mean HPRs fairly similar to the overall mean HPR of 0.29%. Other than decile 3, deciles 1,2,7,8 and 10 all underperformed the mean HPRs with results of 0.15%, 0.16%, 0.24%, 0.25% and 0.22%. The decile with the highest HPR was decile 5 followed closely by decile 9 with results of 0.58% and 0.56% respectively.

Figure 27: Average MSCI EAFE Index HPR per volatility decile



Excess kurtosis was positive across all deciles and was generally high meaning that distributions were generally leptokurtic characterized by tall peaks and fat tails. Most deciles exhibited negative skewness except for deciles 4, 5 and 7. Deciles 6, 9 and 10 had large ranges with fairly large differences between minimum and maximum values and 5th and 95th percentiles respectively.

Similar to S&P 500 Index, table 17 below shows that lower deciles experienced average returns with a high degree of concentration around the mean with relatively small ranges. Also consistent with the S&P 500 Index, decile 10 was found to exhibit the highest level of return dispersion, most severe negative returns as well as an average HPR that underperformed the mean.

The t-test's again revealed that no decile had an average return that was significantly different from the mean of the entire dataset at a 5% level of significance. This finding is consistent with that of the S&P 500 Index.

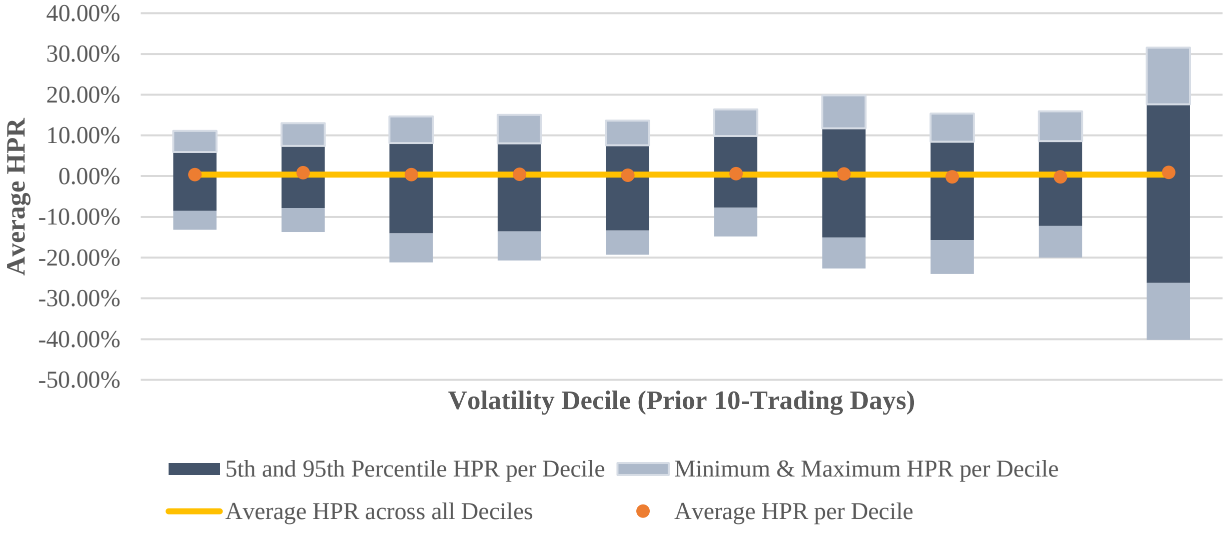
Table 17: MSCI EAFE Index summary statistics per volatility decile

Decile:	1	2	3	4	5	6	7	8	9	10
Mean HPR	0.15%	0.16%	-0.18%	0.49%	0.58%	0.40%	0.24%	0.25%	0.56%	0.22%
Kurtosis	0.53	1.61	3.09	0.29	0.55	4.25	0.13	0.26	1.40	2.85
Skewness	-0.62	-0.52	-0.29	0.13	0.15	-0.61	0.19	-0.36	-0.54	-0.04
Max HPR	4.20%	5.63%	11.55%	9.20%	11.33%	9.88%	10.96%	8.23%	11.10%	19.18%
Min HPR	-7.11%	-6.99%	-8.63%	-7.17%	-6.31%	-15.29%	-7.66%	-11.10%	-14.29%	-16.66%
P-Value	0.46	0.51	0.08	0.46	0.30	0.73	0.88	0.91	0.46	0.88

- MSCI EM Index

In terms of emerging markets, figure 28 illustrates the result of 740 10-trading day periods on the MSCI EM Index from 1 January 1988 to 12 May 2016. A high degree of dispersion in returns was evident with decile 10 having a range of 43.81% compared to just 14.52% for decile 1. All other deciles exhibited relatively low degrees of dispersion in returns with the lower deciles again experiencing the smallest ranges consistent with the findings of developed markets.

Figure 28: Average MSCI EM Index HPR per volatility decile



Consistent with the findings of the developed market indices was that no decile had an average HPR that was statistically significant from the overall average return of 0.37%. Table 18 shows that the highest average HPR was found in decile 10 of 0.92% followed closely by decile 2 with a 0.82% average HPR. Deciles 8 and 9 were the only two deciles that experienced negative average HPRs of -0.21% each.

The excess kurtosis found in all deciles were relatively higher than those of the developed markets. Decile 10 had the highest kurtosis of 2.15 followed by decile 3 with 2.02. Deciles 6 and 9 displayed negative excess kurtosis of 0.22 and 0.29 respectively.

Table 18: MSCI EM Index summary statistics per volatility decile

Decile:	1	2	3	4	5	6	7	8	9	10
Mean HPR	0.37%	0.82%	0.32%	0.46%	0.16%	0.60%	0.52%	-0.21%	-0.21%	0.92%
Kurtosis	1.20	0.25	2.02	1.96	1.55	-0.22	1.57	0.68	-0.26	2.15
Skewness	-0.43	-0.49	-0.89	-0.78	-0.57	-0.09	-0.55	-0.62	-0.22	-0.82
Max HPR	5.95%	7.39%	8.11%	8.06%	7.58%	9.83%	11.75%	8.42%	8.56%	17.64%
Min HPR	-8.57%	-7.84%	-14.00%	-13.57%	-13.33%	-7.74%	-15.01%	-15.71%	-12.24%	-26.17%
P-Value	0.98	0.23	0.90	0.85	0.61	0.61	0.79	0.28	0.25	0.53

- MSCI FM Index

Figure 29 illustrates the result of 640 10-trading day periods from 3 June 2002 to 18 March 2016 on the MSCI FM Index. It is important to note that the data for frontier markets began in 2002 compared to 1988 for the MSCI EAFE Index and the MSCI EM Index and 1972 for the S&P 500 Index and therefore has a smaller sample size.

Figure 29: Average MSCI FM Index HPR per volatility decile

Decile 2 achieved the highest average HPR of 1.07% for the period followed by decile 9 with 1.00%. The lowest return was experienced by decile 10 of -1.29% followed by decile -0.31% experienced by decile 8. Decile 10 again experienced the highest the highest range as well as the lowest negative return of -14.70%. The highest single period return was 12.58% experienced by decile 9.

Table 19 shows that negative excess kurtosis was found in deciles 2 and 6 of -0.19 and -0.24 respectively indicating that their distributions was slightly mesokurtic with relatively thinner tails and flatter peaks than a normal distribution of returns. Excess kurtosis was relatively high compared to the others in decile 3 of 6.97 which was followed by decile by a much lower 1.81 in decile 1.

Negative skewness that is normally associated with equity returns of -0.24, -2.32, -0.77, -0.83, -0.42, -0.66 and -0.53 was found in deciles 1, 3, 4, 5, 6, 7 and 10 respectively. Positive skewness of 0.01, 0.45 and 0.27 was found in deciles 2, 8 and 9. In terms of the t-test to determine if the average return of any decile was significantly different from the overall mean, decile 2 was found to be statistically significantly different at a 5% level of significance.

Table 19: MSCI FM Index summary statistics per volatility decile

Decile:	1	2	3	4	5	6	7	8	9	10
Mean HPR	0.41%	1.07%	0.26%	0.30%	-0.01%	0.40%	0.29%	-0.31%	1.00%	-1.29%
Kurtosis	1.81	-0.19	6.97	2.22	1.64	-0.24	0.79	0.64	0.67	0.70
Skewness	-0.24	0.01	-2.32	-0.77	-0.83	-0.42	-0.66	0.45	0.27	-0.53
Max HPR	6.13%	6.32%	3.15%	4.67%	5.07%	5.24%	7.28%	8.40%	12.58%	9.80%
Min HPR	-4.74%	-3.58%	-8.69%	-5.89%	-7.95%	-6.70%	-8.99%	-5.41%	-7.12%	-14.70%
P-Value	0.57	0.03	0.91	0.81	0.57	0.68	0.90	0.28	0.26	0.08

To sum up, lower deciles across all markets generally displayed the lowest levels of return dispersion and decile 10 across all markets generally displayed the highest level of return dispersion with an average HPR that was below the overall mean except in the MSCI EM Index. Higher average HPRs were found in developing markets as one would expect, and these were also generally accompanied by larger return ranges.

Individual decile average HPRs across all investigated markets differed to overall average HPRs except for decile 2 in the MSCI FM Index which was significantly different from the overall mean HPR at a 5% level of significance. However, this exception was in a decile with a relatively low volatility which displayed a HPR which outperformed the average overall HPR, indicating that our findings were congruent with those of Collie, Sylvanus and Thomas (2011) in that insufficient evidence exists to suggest that investors were efficiently rewarded for participating in markets following periods of relatively high volatility. This assertion was made by the authors on the S&P 500 Index, but our findings conclude that a similar phenomenon may exist in other developed as well as developing markets. The implication of this finding is that if investors are not sufficiently compensated for accepting risk particularly when volatility levels are elevated, then it may be inefficient to hold full equity exposures during these periods.

4.3.2 Managed volatility trading rule

The below section illustrates the performance of a trading rule that is based on the finding that high volatility is not necessarily adequately compensated for regulating equity exposure with a risk-free asset. Each day, the 42-trading day weighted volatility of each market was compared with the distribution of each market's long-run weighted volatility and exposures were allocated depending on which decile it was classified under. Equity was given a 100% allocation if the 42-day weighted volatility was below the 6th decile of historical weighted volatility, 67% allocation if it was between the 6th and 7th decile, 33% allocation if it was between the 7th and 8th decile and a 0% allocation if it is in a decile greater than the 8th. As each market index used in this section is based on US Dollar returns, the 3-month US T-Bill was used as a proxy for the risk-free asset that was given the balancing allocation on a daily basis.

- S&P 500 Index

The trading rule was first tested on the S&P 500 Index and proved impressive from a risk-return vantage point. According to table 20, the annualized HPR on the S&P 500 Index over the period was 7.03% compared to 5.91% for the trading rule with figure 30 illustrating how both strategies fared over time. The annualized volatility experienced on the S&P 500 Index of 17.12% was considerably higher than the 5.91% attained by the trading rule. However Sharpe ratios were comparable given the S&P 500 Index's relative outperformance on an absolute basis. When a paired t-test determining whether there was a difference in daily mean returns was conducted however, the p-value of 0.12 meant that returns weren't significantly different over the time-period investigated at a 5% level of significance.

Figure 30: S&P 500 Index vs. trading rule cumulative returns

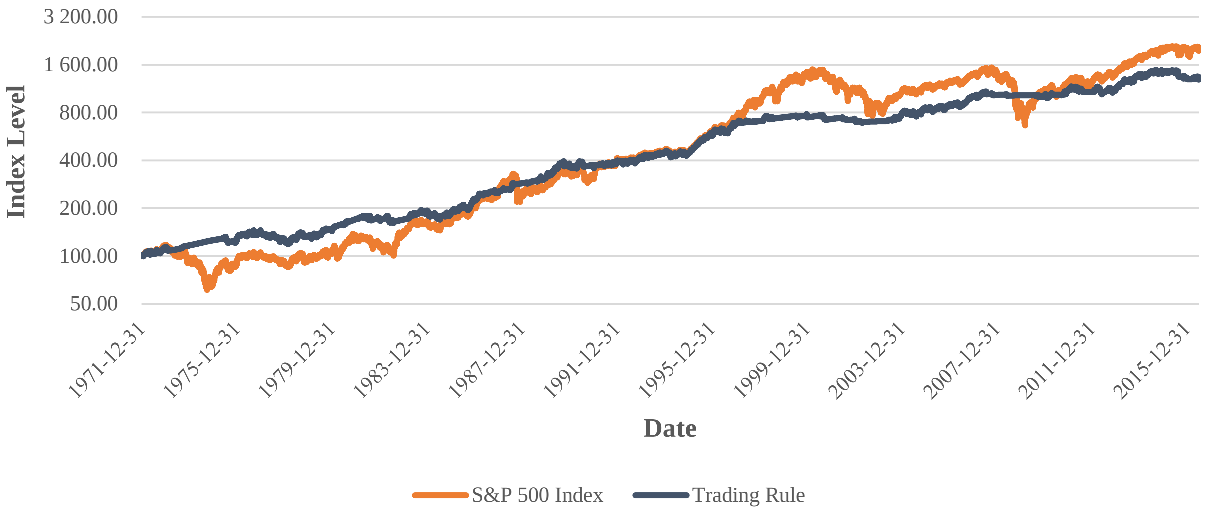
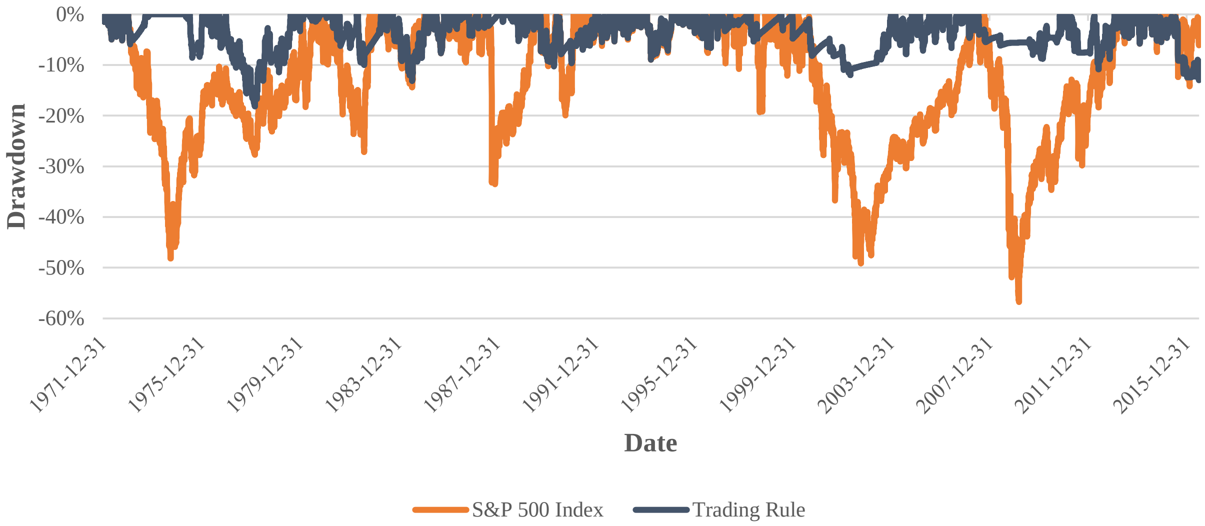


Figure 31: S&P 500 Index vs. trading rule drawdowns



While the trading rule may have underperformed the S&P 500 Index on an absolute basis, when observing drawdowns in figure 31, the trading rule proved to exhibit a better drawdown profile. The rising levels of volatility that preceded large drawdowns such as the 1987 Flash Crash led to non-participation that allowed the trading rule to exit the market early enough to avoid drawdowns as deep as were experienced by the S&P 500 Index.

It is reasonable to assume that not all future tail-events will be preceded by high levels of volatility. However, it is evident from figure 31 that the worst of both the 1987 Flash Crash and the 2008 GFC was avoided by the trading rule given elevated levels of volatility before the steepest drawdowns. Interestingly, the US recession experienced from 2001 to 2003 saw a long drawdown episode for both strategies meaning that the trading rule still experienced some equity exposure as volatility did not spike to the extent it did in previous drawdown episodes.

The maximum drawdown experienced by the S&P 500 Index was -56.78% compared with just -18.17% by the trading rule. This again makes the case that the trading rule is effective during periods of market losses as the trading rule seemed to underperform the S&P 500 Index during bull markets. It is clear that the S&P 500 Index outperformed the trading rule from the early 1980s up to the lead up to the dot-com bubble in the late 1990s, but the trading rule was able to make up considerable ground during the bubble and the 2008 GFC. Tail-risk measures again suggested that the trading rule had an appealing risk profile with daily 95% and 99% CVaR at -1.24% and -1.96% respectively vs -2.46% and -4.22% for the S&P 500 Index. The best 6-month HPR for the trading rule and the S&P 500 Index was 26.98% and 48.29% respectively, and the worst 6-month HPR was -11.94% and -46.64% respectively. Thus, it appears that there are considerable tail-risk improvements associated with the trading rule.

Figure 32: S&P 500 Index trading rule exposure illustration

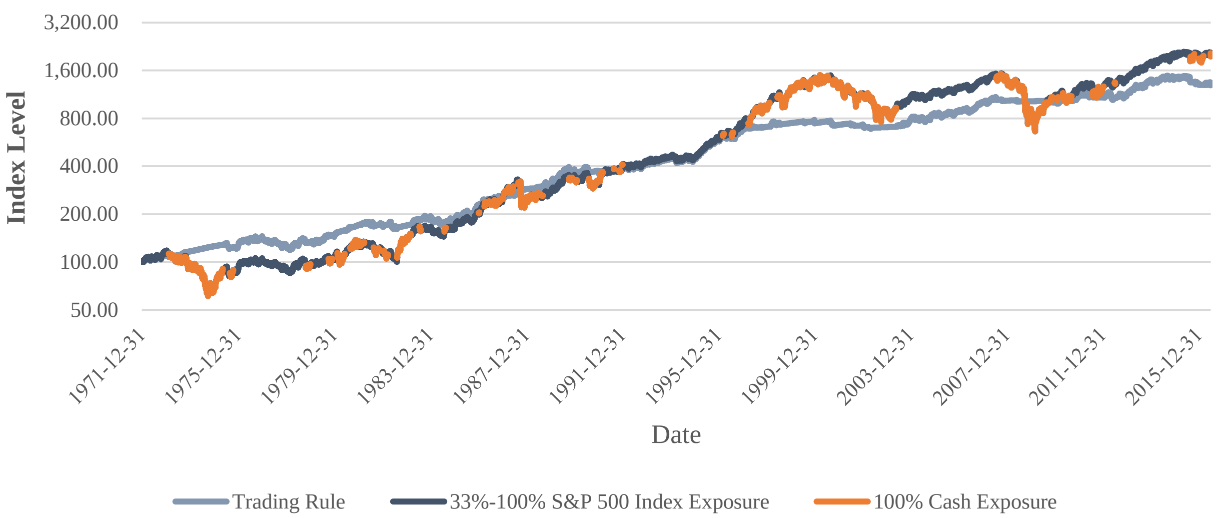


Figure 32 above illustrates the changes of S&P 500 Index exposure the trading rule had over the period together with the overall trading rule trendline. The light blue line illustrates the cumulative return of the trading rule over the period, and the orange line illustrates the cumulative return on the S&P 500 Index over the period which are identical to figure 30. The reason that the S&P 500 Index cumulative return is in different colours is to provide a visual illustration of periods of participation. That is, periods of dark blue indicate that some allocation between 33% and 100% was given to the S&P 500 Index. Periods of orange indicate that a 0% allocation was given to the S&P 500 Index. Thus, the sum of the dark blue periods on the cumulative return line of the S&P 500 Index would result in the light blue cumulative return line of the trading rule.

With a naked eye, one can observe that the trading rule did not participate in many of the larger drawdown episodes across the period. However, there were many occasions of needless switching between participation and non-participation caused by false signals. In fact, the average switches in equity exposure over the period were 11.87 per year which would naturally result in more transaction costs than a passively holding the S&P 500 Index. This is a drawback of this approach.

Ultimately, investors would have had an effective equity exposure of 53.53% over the period which captured much of the bull markets and tended to avoid the brunt of the bear markets and crises. Despite the appealing results, the high relatively large number of switches, false switches, and relatively low effective equity exposure presents a case that the above trading rule might be most effective as a replacement for a part of equity allocation as opposed to the entire allocation. The main reason for this is that many investors may require holding a minimum effective strategic asset allocation to equity but during any given year, the trading rule could have a 0% exposure to equity. Thus in a 60/40 portfolio for example, the trading rule could perhaps be applied to half of the equity exposure for example.

Further, it is important to note that the return on the risk-free asset was considerably higher than the current near-zero rate. Specifically, the average 3-month US Treasury bill rate during the 1970s was 6.40%, 8.97% during the 1980s and 4.98% during the 1990s. Thus, during periods of non-participation by the strategy in the 1970s, 1980s and 1990s, a higher return on cash was earned when compared with current rates. The implication of this is that the strategy may not perform as well in the future when equity is allotted no allocation given the probability of low interest rate environments to persist.

Table 20: S&P 500 Index vs. trading rule summary statistics

	Trading Rule	S&P 500 Index
Annualized HPR	5.91%	7.03%
Annualized Volatility	7.85%	17.12%
Sharpe Ratio	0.14	0.13
VaR (95%)	-0.81%	-1.60%
CVaR (95%)	-1.24%	-2.46%
VaR (99%)	-1.52%	-2.88%
CVaR (99%)	-1.96%	-4.22%
Maximum Drawdown	-18.17%	-56.78%
Effective Equity Exposure	53.53%	100%
Average Annual Switches	11.87	0

- MSCI EAFE Index

Figure 33 below illustrates the performance of the trading rule compared to the MSCI EAFE Index. While the trading rule kept pace with the MSCI EAFE Index initially, the MSCI EAFE Index began outperforming the trading from approximately the fourth quarter of 1985 up to the 2008 GFC. Thereafter, the MSCI EAFE Index showed a strong initial recovery with up to the fourth quarter of 2009, promptly outperforming the trading rule suggesting that the trendline of the trading rule does not seem to compete with the MSCI EAFE Index during a bull market. On an absolute basis, the trading rule generated an annualized HPRs of 5.65% compared with the 7.15% generated by the MSCI EAFE Index. Despite the absolute underperformance suffered by the trading rule, the t-test revealed that the mean returns did not differ significantly at a 5% level of significance.

Figure 33: MSCI EAFE Index vs. trading rule cumulative returns

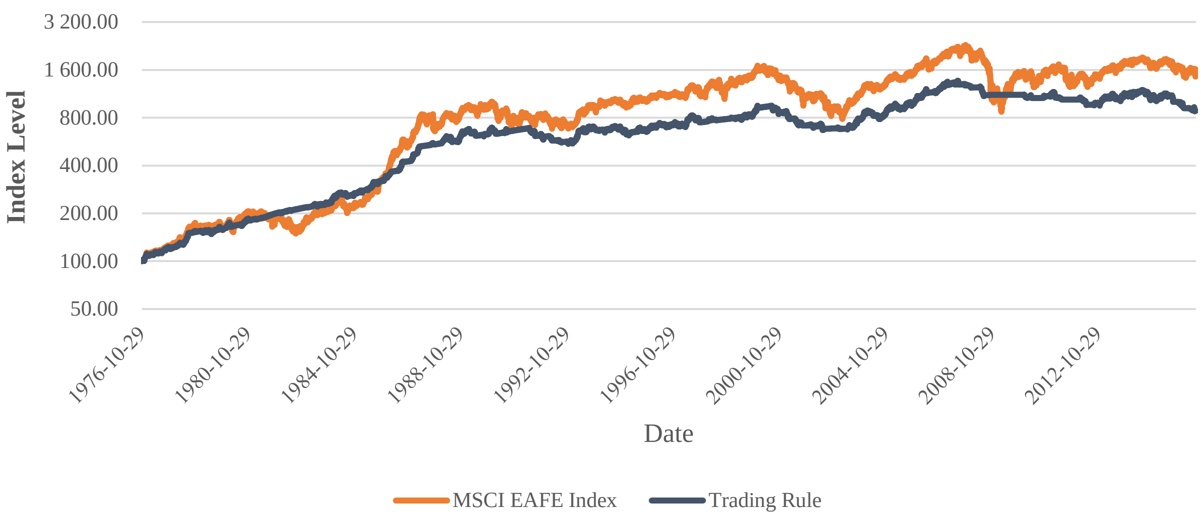


Figure 34: MSCI EAFE Index vs. trading rule drawdowns

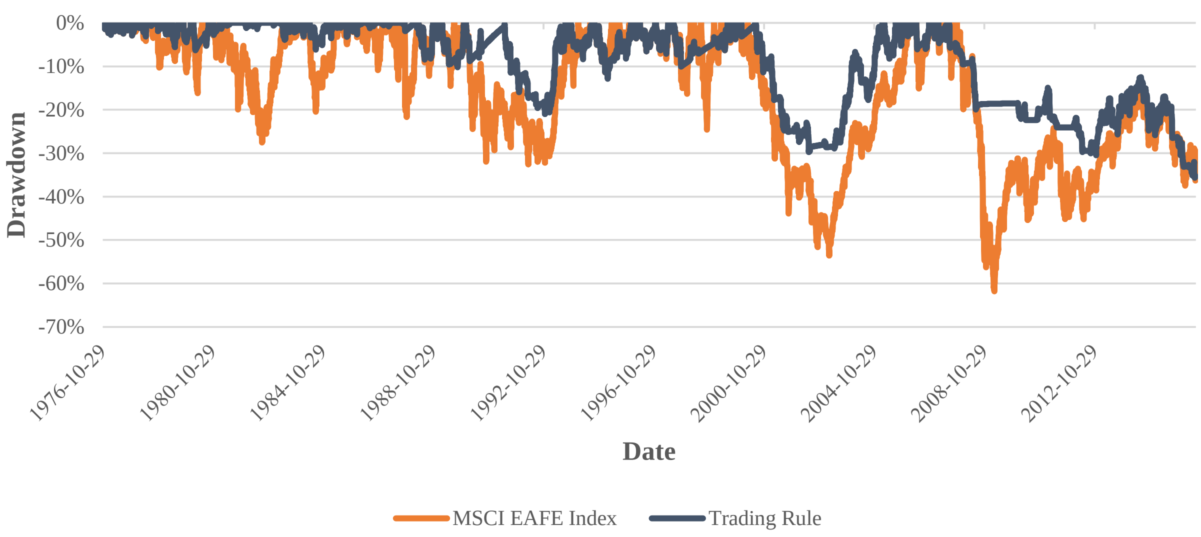


Figure 34 illustrates the drawdowns of both strategies, and it is evident that the drawdown protection brought about by the trading rule was not as impressive as in figure 31. The early 2000s highlight a weakness of the trading rule in that it offers little respite when losses occur gradually without the spikes in volatility associated with sudden losses. Additionally, the fact the trading rule did not issue a participation signal early enough after the GFC to participate in the recovery meant that the drawdown was subsequently exacerbated.

Figure 35: MSCI EAFE Index trading rule exposure illustration

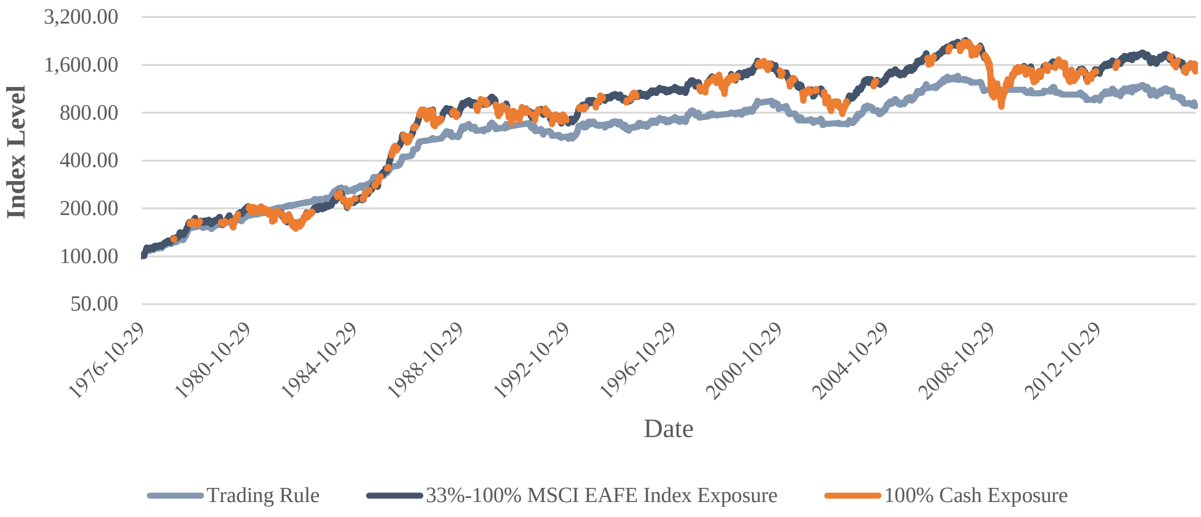


Table 21: MSCI EAFE Index vs. trading rule summary statistics

	Trading Rule	**MSCI EAFE Index**
Annualized HPR	5.65%	7.14%
Annualized Volatility	7.18%	15.96%
Sharpe Ratio	0.14	0.15
VaR (95%)	-0.73%	-1.54%
CVaR (95%)	-1.14%	-2.33%
VaR (99%)	-1.40%	-2.70%
CVaR (99%)	-1.85%	-3.89%
Maximum Drawdown	-35.68%	-61.85%
Effective Equity Exposure	47.70%	100%
Average Annual Switches	14.95	0

Figure 35 above highlights that a significant portion of the recovery after the GFC was missed by the trading strategy with 14.95 switches on average per annum across the period. Despite this, the trading rule still experienced significantly less volatility than the MSCI EAFE Index (7.18% and 15.96% respectively as shown in table 21). Additionally, the 1-in-100 day CVaR was -1.85% for the trading rule compared to -3.89% for the MSCI EAFE Index. With an effective equity exposure of just 47.70% however, the trading rule again presents a challenge for investors who have fixed strategic asset allocations in mind, suggesting that it may be more appropriate to replace only a portion of existing equity allocation. The best 6-month HPR for the trading rule and the MSCI EAFE Index was 26.74% and 64.04% respectively, and the worst 6-month HPR was -17.71% and -50.65% respectively. Similar to the findings on the S&P 500 index, these statistics reveal that there are considerable tail-risk improvements associated with the implementation of the trading rule.

- MSCI EM Index

Figure 36 illustrates the results of the trading rule vs. the MSCI EM Index. It is evident that the rule performed marginally better than the MSCI EM Index on both a risk and return basis. The annualized HPR was 3.55% for the trading rule and 2.76% for the index over the period, however, mean returns did not prove to be significantly different at a 5% level of significance.

Figure 36: MSCI EM Index vs. trading rule cumulative returns

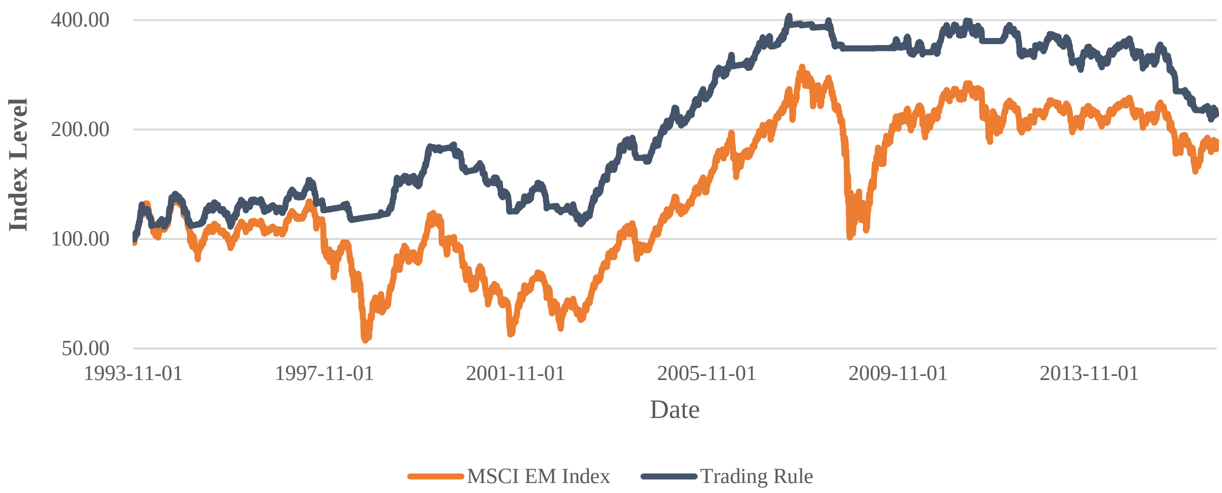
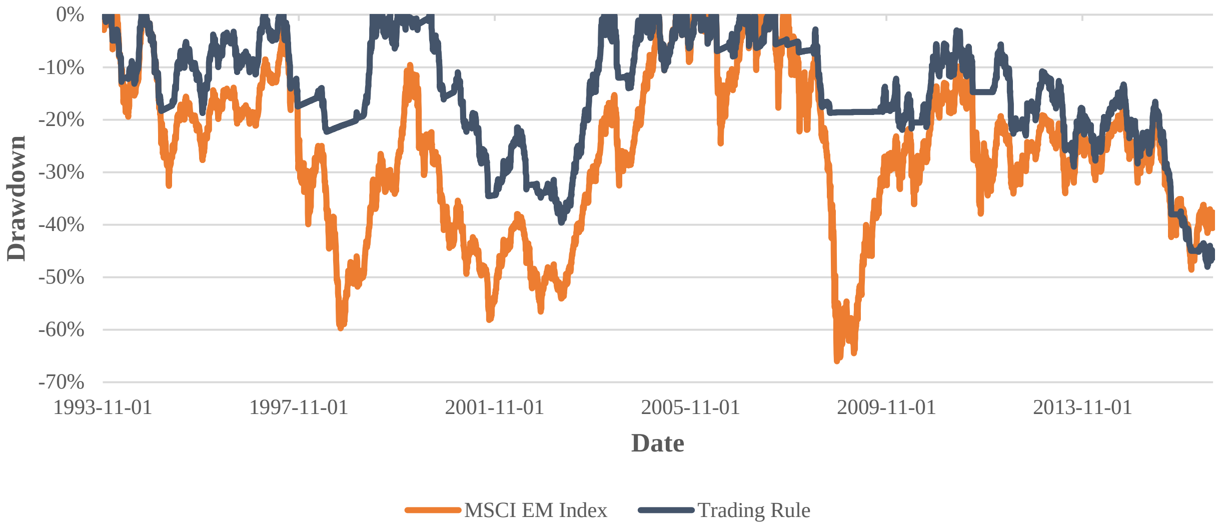


Figure 37 displays the drawdowns across the period, and it is interesting to note that while the trading rule performed well during the GFC, more gradual losses not associated with spikes in volatility resulted in unimpressive drawdown protection in the early 2000s and subsequent to the GFC. As expected, the MSCI EM Index's annualized volatility of 18.71% was higher than the 9.89% experienced by the trading rule.

Figure 37: MSCI EM Index vs. trading rule drawdowns



In terms of the tail-risk measures, table 22 shows that the trading rule experienced a 95% CVaR of -2.26% and a 99% CVaR of -2.49% compared to -4.08% and -4.88% respectively for the MSCI EM Index. Again the deepest drawdown of -66.06% was more severe in the case of the index compared with –48.05% for the trading rule. The best 6-month HPR for the trading rule and the MSCI EM Index was 39.23% and 77.50% respectively, and the worst 6-month HPR was -25.71% and -61.95% respectively. Again, these findings are consistent with those of the developed markets in that the trading rule appears to contribute toward tail-risk improvements.

The 51.43% effective equity exposure experienced by the trading rule was similar to the effective exposure found developed markets and yet again presents an issue when a fixed asset allocation to equity is desired. Similar to developed markets, there were a few periods of a 0% equity allocation during which equity was experiencing upward momentum, particularly during periods of recovery. Average annual switches were found to be 12.22 which was higher than for the S&P 500 Index and MSCI EAFE index trading rules which can be viewed in figure 38 below. Given that volatility levels were also found to be higher in emerging markets than developed markets, one would expect this to result in more switches in allocation. The inherent disadvantage of this is that higher transaction costs would have had to be incurred which would have led to a larger drag on performance relative to the other markets.

Figure 38: MSCI EM Index trading rule exposure illustration

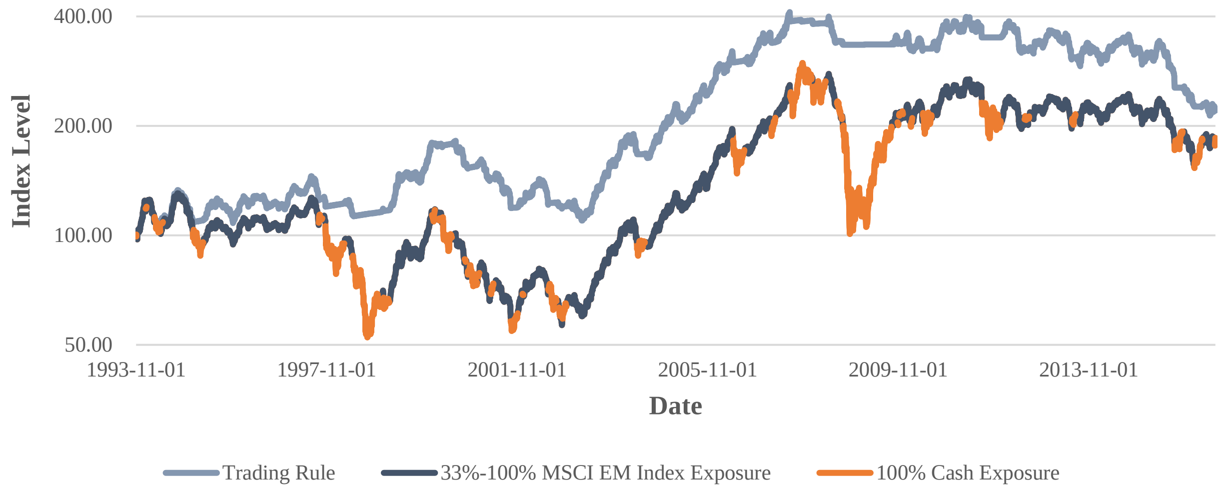


Table 22: MSCI EM Index vs. trading rule summary statistics

	Trading Rule	MSCI EM Index
Annualized HPR	3.55%	2.76%
Annualized Volatility	9.89%	18.71%
Sharpe Ratio	0.11	0.01
VaR (95%)	-1.07%	-1.87%
CVaR (95%)	-2.26%	-4.08%
VaR (99%)	-1.90%	-3.45%
CVaR (99%)	-2.49%	-4.88%
Maximum Drawdown	-48.05%	-66.06%
Effective Equity Exposure	51.43%	100%
Average Annual Switches	12.22	0

- MSCI FM Index

The final market investigated was the MSCI FM Index. Table 23 below shows annualized HPRs of -5.46% and 1.79% were generated by the MSCI FM Index and the trading rule respectively. Figure 39 illustrates that the trading rule initially generated similar returns to the MSCI FM Index, but a significant drawdown (largely avoided by the trading rule) in the early 2000s saw the trading rule begin its relative outperformance up to the end of the period.

Figure 39: MSCI FM Index vs. trading rule cumulative returns

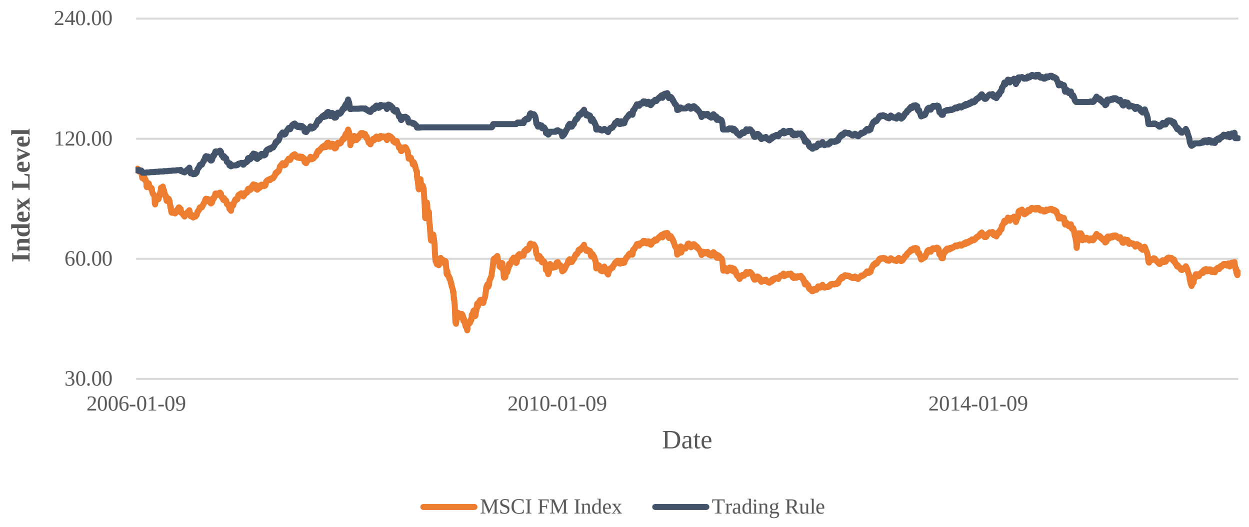
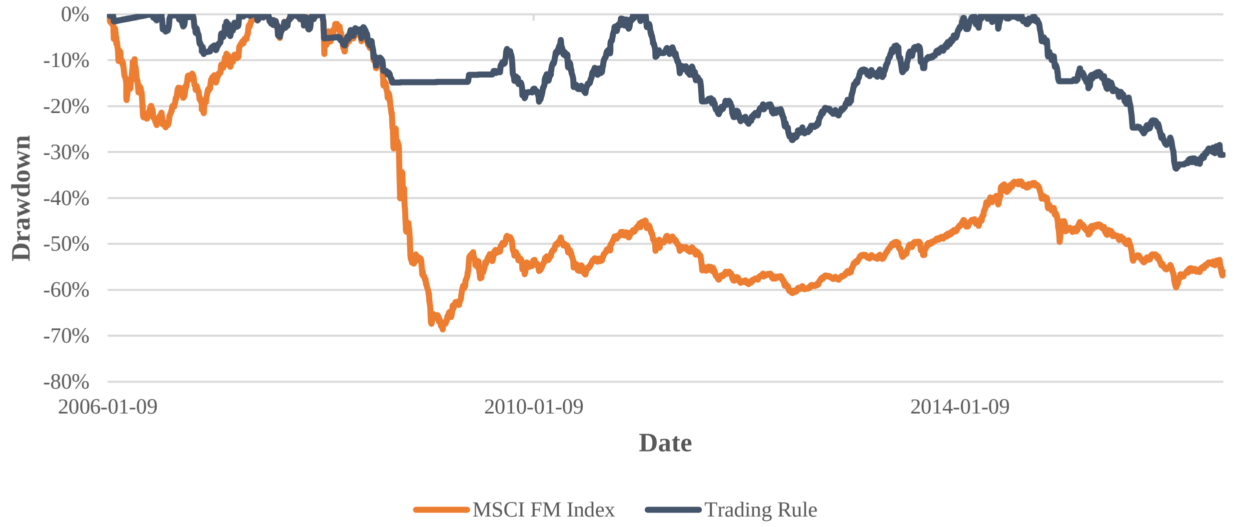


Figure 40: MSCI FM Index vs. trading rule drawdowns



The t-test conducted over daily returns confirmed that the mean daily returns of both the trading rule and the MSCI FM Index differed at a 5% level of significance. Figure 40 illustrates the drawdowns of both the trading rule and the index and it is clear that the 0% equity allocation decision at the beginning of subsequently severe drawdowns experienced in the early 2000s and the GFC helped the trading rule outperform the index.

The tail-risk measures show that the 95% daily CVaR for the index was -2.27% compared with a far lower 1.17% for the trading rule and the 99% daily CVaR was -4.31% for the index and -2.04% for the trading rule. The deepest drawdown experienced by the index was a considerably severe -68.62% compared with -33.61% for the trading rule. The best 6-month HPR for the trading rule and the MSCI FM Index was 25.35% and 49.05% respectively, and the worst 6-month HPR was -18.51% and -62.98% respectively. Thus, consistent with the findings of the other markets investigated in this dissertation, it appears that there are considerable tail-risk improvements associated with the implementation of the trading rule.

Given that there were prolonged periods of a 0% equity participation by the trading rule, figure 41 illustrates that there were an average of 8.79 switches per annum. This was lower than the other markets. There were also fewer false signals as there was a 72.26% effective equity allocation during the period.

Figure 41: MSCI FM Index trading rule exposure illustration

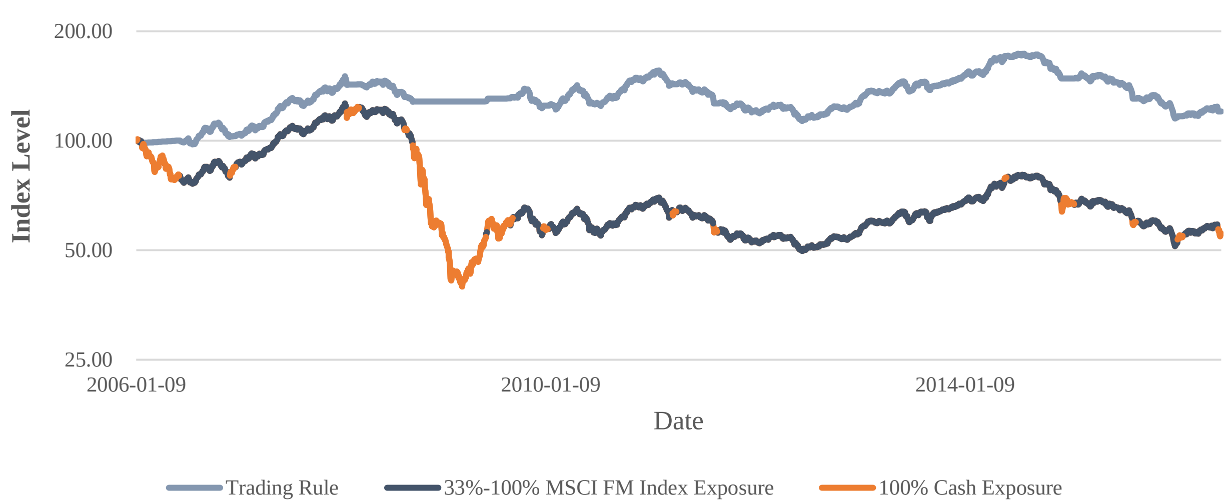


Table 23: MSCI FM Index vs. trading rule summary statistics

	Trading Rule	MSCI FM Index
Annualized HPR	1.79%	-5.46%
Annualized Volatility	7.14%	12.95%
Sharpe Ratio	0.10	-0.50
VaR (95%)	-0.74%	-1.21%
CVaR (95%)	-1.17%	-2.27%
VaR (99%)	-1.38%	-3.02%
CVaR (99%)	-2.04%	-4.31%
Maximum Drawdown	-33.61%	-68.62%
Effective Equity Exposure	72.26%	100%
Average Annual Switches	8.79	0

In summary, the application of the trading rule in each market appeared to have similar results in that tail-risk statistics as measured by daily 95% and 99% CVaR, maximum drawdown and worst 6-month HPR were considerably improved. Additionally, the trading rule generated superior Sharpe ratios in each market other than the MSCI EAFE Index. However, the relatively high number of trades required to implement the trading rule is a pitfall of the approach.

CHAPTER FIVE

CONCLUSION

The research question investigated in this dissertation is whether volatility, first, in the form of an asset class, and second, in the form of a risk management tool, can reduce the risk that a 60/40 equity/bond portfolio experiences inferior risk-adjusted performance in the future relative to what it had accomplished in the past. Regarding volatility exposure as an asset class, the historical risk and return characteristics of three fully-collateralized naked put option-selling strategies, a fully-collateralized bull put spread strategy and a fully-collateralized VIX futures strategy was investigated. The put option-selling strategies consisted of the CBOE S&P 500 PutWrite Index (PutWrite Index), a short at-the-money S&P 500 Index options strategy (short ATM options strategy) and a short 5% out-the-money S&P 500 Index options strategy (short 5% OTM options strategy). The bear put spread strategy involved being simultaneously short at-the-money S&P 500 Index options and long 10% out-the-money S&P 500 Index options with the same expiration date, and the VIX futures strategy involved being short VIX futures when the VIX futures curve was in contango, and being long VIX futures when the VIX futures curve was in backwardation.

The results indicate that the three options selling strategies outperformed the S&P 500 Index over the period with the PutWrite Index, short ATM options strategy and short 5% OTM options strategy generating annualized HPRs of 6.61%, 6.77% and 7.43% respectively, compared with the 4.97% generated by the S&P 500 Index. The option-selling strategies all had less severe drawdown profiles and more rapid recoveries than the S&P 500 Index, consistent with the findings of Rennison and Pedersen (2012), who attributed this phenomenon to the fact that option premiums are still consistently earned despite any drawdowns experienced. However, the more conservative bull put spread strategy underperformed the S&P 500 Index generating an annualized HPR of 2.37%.

Consistent with the findings of Simon and Campasano (2014), the VIX futures strategy outperformed the index considerably over the investigated period, generating an annualized HPR of 19.82%. However, when the sub-sample period from 2009 to 2016 was investigated, the VIX futures strategy underperformed the S&P 500 Index generating an annualized HPR of 7.34% compared to 13.88% generated by the index. The findings of Simon and Campasano (2014) suggest that the VIX futures strategy relies on the assumption that the VIX spot price will not change over time to the degree suggested by the VIX futures price. The findings of this dissertation indicate that investors were historically able to exploit this phenomenon by buying (selling) the VIX future at a discount (premium) relative to the VIX spot successfully up to the end of the 2008 GFC. However, after the 2008 GFC, it appears that the VIX futures basis has contracted, resulting in a contraction of profits. In other words, while the VIX futures strategy successfully exploited potential non-pricing of volatility clustering up to the 2008 GFC, it appears that since the 2008 GFC, much of this phenomenon has been traded away. Additionally, it is still unclear whether the VIX futures strategy can be classified as an asset class in the same way as short volatility exposure attained through option-selling strategies.

Each volatility strategy was also included as part of a 30/30/40 volatility/equity/bond portfolio and compared with the traditional 60/40 equity/bond portfolio. Over the full sample period, all volatility blended portfolios outperformed the traditional 60/40 portfolio on an absolute return basis and in terms of Sharpe ratios except for the bull put spread strategy blend, which generated the least return overall as well as an equal Sharpe ratio to the traditional mix. Additionally, all volatility blended portfolios were superior to the 60/40 portfolio in terms of tail-risk, experiencing less severe maximum drawdowns, annualized volatility and daily 95% and 99% Conditional Value-at-Risk levels.

When investigating the sub-sample period from 2009 to 2016, the strong equity recovery following the 2008 Global Financial Crisis resulted in the 60/40 portfolio experiencing the highest annualized return, but the returns achieved by the three option-selling strategy blends were only marginally less. The three option-selling strategy blends also generated larger Sharpe ratios than the 60/40 portfolio, and all volatility blended portfolios achieved a superior tail-risk profile to the traditional portfolio mix.

Regarding the investigation of volatility as a tool for dynamic equity allocation, based on the volatility-responsive trading rule developed in Collie, Sylvanus and Thomas (2011), a managed volatility trading rule was investigated that used recent realized volatility as a signal to regulate equity exposure in an effort to reduce equity drawdown risk. According to the trading rule, if recent realized volatility levels rose beyond a certain threshold, equity exposure was reduced and replaced with 3-month US T-bills and *vica versa*.

The trading rule was tested across 4 different indices aimed to represent the majority of global markets namely: The S&P 500 Index (US), the MSCI EAFE Index (developed markets excluding the US), the MSCI EM Index (emerging markets) and the MSCI FM Index (frontier markets). The trading rule experienced generally positive results across markets, generating competitive absolute returns, and generally achieving better risk profiles than the respective equity index's they were compared to. However, the trading rule presented practical implementation challenges such as a relatively high number of trades, the lowest of which was 8.79 trades on average per year on the MSCI FM Index, and the highest of which was 14.95 trades on average per year on the MSCI EAFE Index. Additionally, the approach may pose a challenge to investors who are mandated with fixed strategic asset allocation targets given that equity allocations could theoretically be 0% for extended periods.

In conclusion, the replacement of half of the equity allocation in a traditional 60/40 equity/bond portfolio with strategies that employ the consistent sale of naked, near-the-money options strategies have historically generated long-run returns analogous to the traditional portfolio mix with considerably improved tail-risk characteristics. Short volatility exposure attained through option-selling strategies has thus been shown to be an attractive asset class, and has presented historical evidence that its inclusion into a traditional 60/40 equity/bond portfolio is likely to reduce the risk of future risk-adjusted underperformance relative to past achievements. Additionally, although somewhat impractical, realized volatility is found to be an effective forward indicator to regulate equity exposure such that equity drawdown risk is reduced. This may further reduce the risk of traditional portfolios underperforming in future and may be especially useful to investors precluded from investing in volatility exposure as an asset class.

Future research may investigate whether delta-hedged option-selling strategies generate similar risk-adjusted returns as those examined in this dissertation. Further, only the sale of equity volatility was explored in this dissertation, and future research may investigate and contrast the risk-return characteristics after costs of implementation of the sale of volatility on other asset classes such as bonds, currencies, property and commodities.

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