

Assessment of Currency Hedging Strategies for International Equity Portfolios

Evidence from a perspective of a UK investor investing in the US

By

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Abstract

Even after several research studies being carried out to assess the performance of the hedging strategies, there is no universally accepted strategy that claims to improve the performance of the portfolio. Therefore, this research investigates the effectiveness of the hedging strategies from a perspective of a UK investor investing in the US markets considering a time interval from 1998-2018. The study examines the hedging strategies of No Hedge, Forwards, Options and Zero Cost Cylinder by using the risk adjusted return measure of Sharpe ratio.

The empirical results indicate that the No Hedge portfolio achieved higher Sharpe ratio for both the time interval of 1998-2018 and 2003-2018. The study also provides results for the period of financial crisis whereby the No Hedge portfolio showed improved performance suggesting that the risk reducing capacity of the hedging strategies are diminished during the period of crisis. An inverse relationship has been identified between the home currency depreciation and the performance of the No Hedge portfolio. Furthermore, the test of hypothesis indicates that there is no statistical difference between the performance of the hedging strategies. Along these lines, the findings of this study suggest that it is not beneficial for a UK investor to hedge the portfolio when investing in the US markets.

Keywords: International investments, Diversification, Exchange rate risk, Currency hedging, Sharpe ratio.

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1. Introduction

Harry Markowitz, the father of Modern Portfolio Theory (1952) state that an ideal portfolio of the assets is the one which helps to gain maximum returns for a given level of risk. This concept of Modern Portfolio Theory was broadened by Grubel (1968) claiming that the diversification of the portfolio by investing internationally is a source of global welfare gains due to trade and other international factor movements.

Evidence have been provided by Lessard (1976), Solnik et al (2004) and Chatsanga et al (2017) that international investments help to attain a higher level of profits due to the diversification benefit from investing in the potential international markets. Thus, they make a considerable case for international investments. So, to gain the benefits of diversification, a number of investors started to invest their money in the international markets. Also, Eun et al (1994) state that as the world capital market have become more and more cohesive, investors and institutions are investing internationally to diversify their portfolio. It has been stated in the literature of Brusa et al (2014) that the international equity markets and international portfolios have seen a drastic increase from 3% in 1980 to 30% in 2011.

But, apart from the gains and losses on the investor's portfolio when investing internationally, the portfolio is also exposed to the fluctuations in the currency exchange rate. This is known as the Currency exchange rate risk which might decline the value of the portfolio due to unpredicted fluctuations. Therefore, it is necessary to protect the exposed portion of the portfolio from the unpredicted losses. Papaioannou (2001) mentions that the major need for currency risk management became necessary after the breakdown of the Bretton Woods System and the end of US Dollar peg in 1973 when the dollar was permitted to freely trade in the world. A way to manage the exchange rate risk is to hedge the internationally invested portfolio. It is claimed that hedging helps to protect the portfolio from uncertain currency fluctuations. Evidences provided by Bush et al (2018), Zhou et al (2013), Schmittmann (2010), Hagelin et al (2004) and make strong case for hedging by stating that hedging the internationally invested portfolio can help to reduce the fluctuations and the volatility in the currency exchange rates, thus protecting the portfolio from currency risk and helping to boost the performance of the portfolios.

The most commonly used strategies for hedging the internationally invested portfolio are the No Hedge, Forwards and Options since several researches have been carried out on the use and effectiveness of these hedging strategies to hedge the portfolio. Limited researches have been carried out taking into consideration the Zero Cost Cylinder strategy. It is very important to select a suitable hedging strategy since different strategy might perform differently, depending on the country, currency and the time interval considered.

The empirical evidence regarding the use of hedging strategies also show mixed results because even after a number of researches carried out on the effectiveness of the hedging strategies, there is still a lot of ambiguity regarding the hedging strategy that helps to mitigate the risks and boost the performance of the portfolio. Vargas et al (2013), Topaloglu et al (2008), Maurer et al (2007) and Albuquerque (2007) discovered clear evidence in their literature that Forward hedging strategy helps to reduce the risk of the portfolio to improve the performance. But claims have been made by Jimenez et al (2018), Topaloglu et al (2011) and Wong (2002) that the portfolio hedged using the Option hedge strategy tends to outperform the portfolios hedged using other strategies since Option strategy helps to mitigate the standard deviation of the international portfolio thus obtaining better results. Researches carried out by Arunajith (2007) and Shah (2013) conclude that portfolio hedged using Zero Cost hedging strategy helps the investors to retain the accumulated profits by giving protection at the downside of the portfolio.

On the other hand, there are claims made by authors stating that hedging does not always help the investors to gain protection from the currency fluctuations. Researches carried out by Konrad (2015), Roon et al (2012) and Chang (2009) make a strong argument for No Hedge strategy while investing internationally stating that hedging does not always help to reduce the risk of the portfolio, but instead tends to increase the risks in many cases. Also, a number of times, it has been observed that decreasing standard deviation leads to decreasing returns thus depleting the performance of the portfolio.

However, despite a large number of past researches performed to assess the performance of the hedging strategy for providing improved results, there is no universally accepted strategy, which claims to reduce the risk and improve the performance of the portfolios at the same time by generating profits.

Since limited researches have been performed taking into consideration the use of Zero Cost Cylinder strategy and also considering the developed country markets of the UK and the US, this study addresses both the issues by considering an investor from the UK investing in the US markets by buying a portfolio that mimics the returns of S&P 500. In particular, the analysis focuses to determine the effectiveness of the currency hedging strategies involving the No Hedge, Forwards, Options and also Zero Cost Cylinder for hedging an international portfolio considering a time interval from 1998-2018. The objective of the study is to achieve the results for the hedging strategy that helps the investor in providing superior performance. The other objective of the study is to find out the performance of the hedging strategies during the period of financial crisis which occurred in the year 2000 and 2008.

The author aims to achieve the objectives of this research by making use of the risk-return performance measure of the Sharpe ratio. This methodology has been followed by Roon et al (2012), Kim (2012) and Du et al (2018) for finding the effectiveness of the hedging strategies for an internationally invested portfolio which is similar to this research.

The remainder of the study is organized as follows. Section 2 reviews the academic literature and researches performed regarding the exchange rate risk, types of hedging strategies and the decision on the optimal hedging strategy as concluded by the authors. Section 3 develops the research question. Section 4 outlines the methodology of the study. Section 5 presents the analysis and the findings of the study. Section 6 discusses the findings of the study relating it with the academic literature. Section 7 provides an insightful conclusion to the study undertaken.

2. Literature Review

One of the major purposes to construct a portfolio is to gain the desired level of return for the lowest level of risk by diversifying the assets based on their correlation (Markowitz, 1952). Thus, it is beneficial for the investors to look out for new asset classes in order to gain more diversification benefits. One of the ways to gain diversification benefit is to expand the holdings by investing internationally rather than holding the assets in a single country. Research carried out by Chatsanga et al (2017) state that investment in international markets can help to reduce the unsystematic risk by gaining more diversification opportunities to achieve higher profits from potential markets. Considering a US investor investing in Latin American countries to check the diversification benefits in investing internationally, Lessard (1976) concludes that the international investments showed positive results by generating more profits. Also, literature by Solnik et al (2004) concludes that due to the low correlation between the countries, the investor investing internationally tends to gain more profits due to diversification. Therefore, there has been an increasing number of investments by the investors in the foreign markets and international equities to diversify their portfolio. This is the reason why Brusa et al (2014) saw an increase in the international equity portfolios as mentioned above. But, in this increasing market globalization and internationalization era, Garbaccio (2000) state that the economic environment is highly volatile and uncertain. This uncertainty can thus be reflected in increased fluctuations on exchange rates, interest rates and the risk-free rates which can put risk on the international investment.

2.1. Risk of Investing Internationally:

When investors invest internationally, they introduce a new asset class to their portfolios, known as currencies (Bush et al, 2018). This asset class of currencies is often accompanied by the risk of the currency exchange rate. Currency exchange rate risk is defined by Madura (1989) as the risk which is due to the movements or fluctuations in the foreign exchange rate leading to the change in the value of the portfolio of the investor. When the portfolio is exposed to exchange rate risk, it may deteriorate the returns and thus the performance of the internationally invested

portfolio. It is said that from all the risks affecting the international equity portfolios, about 40% consist of currency exchange rate risk (Schmittmann, 2010). But although investing internationally have disadvantages of exchange rate fluctuations, Chiou (2008) argues that the benefits gained from diversifying the portfolio internationally still compensate for its disadvantages.

2.2. Managing the Currency Exchange Rate Risk:

Although the fluctuations in the currency rates are uncertain, the risk associated with it can still be managed. One of the ways to manage the exchange rate risk is to hedge the internationally invested portfolio. The main goal of hedging is to reduce the overall risk of the currencies in the portfolios by minimizing the uncertainty of the unexpected fluctuations in the exchange rates with the help of the derivatives. Several researches have been performed that provide evidence that hedging the internationally invested portfolio benefits the investor. Bush et al (2018) state that the portfolio volatility of the international invested equities is expected to be lower for a currency hedged portfolio rather than exchange rate risk exposed portfolio. Hedging the exposed portion of the portfolio to currency risk is similar to replacing the highly volatile currencies with a strategy which have low volatility (Schmittmann, 2010). Also, in a research performed by Du et al (2018) from the perspective of Chinese investor investing in US markets, to examine the performance between the hedged and the unhedged portfolios, concluded that the hedged portfolio had significantly higher Sharpe ratios as compared to the unhedged portfolios suggesting that hedged portfolio had better portfolio performance. Perold and Schulman (1988) argue that hedging the international portfolio is a 'Free Lunch' of less risks and zero returns of currency portfolio since it helps to reduce the currency risk without reducing the returns. Zhou and Wang (2013) and Hagelin and Promborg (2004) also make a strong case by providing evidence that the use of currency hedging instruments help to mitigate the risk and reduce foreign currency exposure. Maurer et al (2007) also state that the performance of the internationally invested portfolio showed improved results and a clear reduction of risks for the hedged portfolio no matter the hedging strategy being used. Thus, from results of these literature, it can be said that the foreign exchange risk can be reduced by hedging.

2.3. Types of Hedging strategies:

Although there are works of literature to support that hedging provides positive results to the investor but it is very important to select an appropriate hedging strategy since different strategy might perform in a different manner considering the currency, time interval and the market conditions like the period of market boom and crisis. Numerous researches have been performed considering the common hedging strategies of Forwards, Options and No Hedge to find their effectiveness. Limited researches have been carried out considering the Zero Cost Cylinder to hedge the portfolios.

Forwards contract is an agreement where one party who owns the contract has an obligation to buy or sell the asset in the future at a pre-decided price. While on the other hand, an Option contract is the right but not the obligation to buy or sell the underlying asset in the future at a certain price to the counterparty (Hull, 2015). There are two types of Options - Call Option and the Put Option. The Call Option gives the holder of the Option the right to buy an asset and the Put Option gives the holder the right to sell the assets by a future date at a certain pre-decided price. No hedge does not involve any hedging but instead leaving the portfolio exposed to the currency rate fluctuations. Zero Cost Cylinder, also known as Risk Reversal strategy is a combination of Long (buying) Call Option and Short (selling) Put Option, with both the options out of the money i.e. the Strike prices of Call and Put option are above and below their underlying asset respectively (Wystup, 2017). The strike price of both the Options are considered in such a way that that the premium of buying the Call Option is set off with the premium received by selling the Put Option thus making it Zero-Cost Strategy.

2.4. Optimal Currency Hedging strategy:

Even after a number of researches carried out to find the efficiency of currency hedging strategies for international investors, there is no optimal strategy which claims to improve the performance of the portfolio. Some literature have concluded that not hedging the portfolio or using No Hedge strategy helps to improve the performance of the portfolio compared to hedging whereas other literature are of the view that using

the strategy of Forwards or Options helps to improve the portfolio performance. Research also states that hedging the portfolio using Zero Cost Cylinder helps to maintain the profits of the portfolio.

To assess the currency hedging decision for an American investor investing internationally, Topaloglu et al (2008) performed a research to assess the strategies of Forwards and Options as a mean to control the currency risk. The authors made use of a model which helps to minimize the risks of the portfolio for a particular level of return. Their results showed that Forward strategy helped to achieve higher performance of the portfolio as compared to Option strategy. Also, on considering combinations of various currency Options, the authors concluded that the portfolio performance showed improvements but still the Forward strategy performed significantly better. Maurer et al (2007) also performed a study considering a German investor investing in 4 major countries, the UK, Swiss, Japan and USA to find the effectiveness of the portfolio to control risk by using hedging strategies. The authors made use of the Sortino ratio which helps to identify the risk adjusted returns just by considering the downside risk. The results of their study indicated that the portfolio hedged using Forward strategy had higher Sortino ratio as compared to that of Option or No Hedge strategies thus suggesting that the performance of the Forward hedged portfolio is better than the other strategies. In an attempt to find a better derivative hedging strategy between the Forwards and the Options to help pay off against currency exchange rate risk, Albuquerque (2007) in his study concluded that the portfolio hedged using Forward strategy dominated in performance as compared to the portfolio hedged using Option strategy.

While measuring the effectiveness of the hedging strategies of Forwards and Options from a perspective of European investor, Vargas et al (2013) stated that depending on the Strike prices of the Options, different results were obtained. But the author concludes that for most of the strike prices, the Forward hedging strategy was proved to be more effective than the Option hedging. The authors also continue that the investors are benefited by buying a Forward contract rather than paying an upfront premium for Options since Forward contract do not require any premium payment. To assess the impact of hedging strategies of Forwards, Option and No Hedge for the portfolio exposure between Indonesian Rupiah and US dollar, Hendrawan (2017) conclude that Forward hedge strategy has proved to be beneficial in managing the

currency exposure for the international portfolio rather than Options and No Hedge. Also, on measuring the effectiveness of portfolios during the mortgage crisis period of 2008, the author states that Forward hedging provided better results to the investors since it helped in providing lower losses as compared to the other strategies of No Hedge and Option which provided greater losses.

Taking into consideration the literature that carried out industry survey regarding the hedging tools, it has been discovered that the maximum number of firms prefer using Forwards as a hedging derivative tool. In a survey carried out by Marshal (2000) to find out which currency hedging strategy is used by large British and American companies; the author determines that most of the companies favored using Forwards as their hedging strategy rather than using other strategies like the options and the futures. Also, in researches carried out by Mittal (2015) and Prasad et al (2017) on Indian companies, the authors learned that forward contract was the most commonly used strategy to hedge against the currency fluctuations and its risks due to its flexibility and its ability to provide stability of losses even in case of major fluctuations.

Researches have also been carried by authors whereby they conclude that hedging the portfolio using Options have proved to be beneficial to the investors to add on to their portfolio performance. To check the validity of the hedging strategy for a Columbian investor investing in US markets, Jimenez et al (2018) concluded that hedging does help to mitigate the standard deviation, thus improving the performance of the portfolio but they claim that better performance results were obtained when currency Options were used to hedge the portfolio. Similarly, Topaloglou et al (2011) used a programming model to evaluate the performance of the internationally diversified portfolio using Option and Forward strategy to hedge the portfolio. Their results indicate that the portfolio showed the worst performance when the No Hedge strategy was used but improved performance was gained when Forward strategy was used to hedge the portfolio. But the author concluded that significant improvement in the performance was achieved when Option strategy were used to hedge the portfolio.

In order to examine the optimal hedging strategy for an exporting firm which faces currency exchange rate risk, Wong (2002) considers the strategies of Options and Futures and concludes that taking a long position in a put Option would help the firm to gain a better position for the firm thus making Options as an optimal strategy. Also,

in an attempt to look out for hedging strategies to help a gold exporting firm in China, Zhang et al (2018) used Conditional Value at Risk (CVaR), that measures the risk of loss in investment if the loss crosses beyond a certain level. The authors find results that currency Options helps to significantly reduce the CVaR, thus reducing the risk of the portfolio and boosting its performance.

Zero Cost Strategy is also known as currency collar or a cylinder strategy. At maturity, if the Spot rate is above the Call Strike price, then the Call Option is exercised and the asset is bought at the pre-decided Call Strike price but if the Spot rate is below the Put Strike price, then the Put Option is exercised (Wystup, 2017). Therefore, it can be said that the risk on the potential upside is financed by the risk on the potential downside. Thus Moosa (2004) argues that Zero Cost Cylinder works as a perfect tradeoff between the future gains and future losses.

Arunajith (2007) state that Zero Cost hedging strategy helps to seek protection to the portfolio for free since it is a cost-effective strategy by providing a limit to the upside movement and giving the investors a chance to participate in the downside movements of the exchange rate. This is the reason that Shah (2013) stated that Zero Cost Cylinder is a perfect strategy for investors who want to protect their already earned positive return on their portfolio from the downfall in future returns. Therefore, it can be said that Zero Cost hedging gives the freedom to the investors to hedge their portfolios along with giving it protection against future losses and maintaining the potential profits.

But on carrying out research to find the effectiveness of hedging strategy of Zero Cost Cylinder, Basson et al (2018) conclude that the strategy only reaps the benefits to the portfolio if the underlying asset rises in value. The author continues that this strategy does not perform well in case of high volatility in the market since there are high chances of generating larger losses but it tends to provide a well-performed portfolio when the markets are high performing and follow moderate volatility. Also, in a research carried out by Bartonova (2012) to demonstrate the use of Zero Cost strategy to hedge the currency exchange rate concluded that in many of the cases considered, the options were forced to limit the profits. This is because the Put Option was not exercised even once and Call Option was exercised a number of times thus limiting the upside potential. The author also relates this strategy to a costless insurance policy in a way that since the investor is not paying for the strategy, a bare minimum cover

is received likewise hedging benefits are limited. Therefore, Zero Cost strategy is beneficial by not paying the premium to buy the Options and gaining protection on the downfall but there are literature to state that it limits the upside potential thus reducing the returns.

On the contrary, there are empirical evidence provided by authors which help to conclude that hedging does not always help to significantly improve the performance of the portfolio thus suggesting to not hedge the portfolio and keep it exposed to currency rate fluctuations to gain better performance.

Konrad (2015) in his literature on currency hedging for international portfolios state that hedging is effective in a way that helps to limit the volatility of the returns of the internationally invested portfolio due to the fluctuations. But hedging strategies comes along with its cost, so many times although the volatility is decreased, these costs reduce the performance and the returns of the hedged portfolio. Also, while carrying out research on the MSCI index data for 5 major base currencies of USD, AUD, EUR, GBP, and JPY, Chang (2009) found results that hedging does not always help to reduce the risks of the portfolio and considering a long-time interval, excess returns are gained without hedging the portfolio. The author continues that in many cases, the results indicated that the returns of the portfolio were reduced along with the reducing risks and volatility. Thus, it can be said that hedging tends to decrease the portfolio performance since it fails to improve the risk-return tradeoff.

Roon et al (2012) also carried out research on currencies of developed countries to find out the benefits of hedging, other than focusing on currency volatility. Their results show that currency hedging does help to reduce the variance of the portfolio, thus the portfolio risk but their results were similar to that of Chang (2009) since, in this case also the performance of the portfolio is not improved as risk reduction leads to reduced portfolio returns. Also, the method of risk-adjusted return of Sharpe ratio was used to compute the performance and their results conclude that the Sharpe ratio of portfolio does not improve when the portfolio is hedged and, in some cases, unhedged portfolio has higher Sharpe ratio compared to the hedged portfolio which concludes that hedging does not improve the performance of the portfolio. Also, Froot (1993) argues that hedging helps to reduce the fluctuations of the currency portfolio when investing internationally for a shorter time horizon. But considering a longer

time horizon, the author states that hedging tends to increase the volatility compared to the unhedged portfolios, thus suggesting to not hedge the portfolios.

Kim (2012) carried her analysis on a US investor investing in the Russian market and having a portfolio identical to MSCI Russian index to find the performance difference between the hedged and the unhedged portfolio. On using z-statistics of Jobson and Korkie (1981) as corrected by Memmel (2003) to check for difference between the Sharpe ratios of both the portfolios, the results of the z-test fail to reject the null hypothesis that both the Sharpe ratios are similar, suggesting that there does not exist much statistical difference between the Sharpe ratios of the portfolios and thus the performance of both the portfolios are identical and not different.

Also, on carrying out research on investors of emerging country investing internationally in developed country markets, Walker (2008) state that although hedging should help to increase the returns of the portfolio and thus boost the portfolio performance by providing profits, it does not help to improve the performance. This is because the author claims that the currencies of emerging market are positively correlated to global markets, thus making the currencies of developed countries to act as a natural hedge against the negative market return. Thus, the results from this research indicate that the investors from emerging countries are beneficial by not hedging the portfolios when investing in developed markets.

So, although investors expect a Free Lunch (profits without any risk) from currency hedging, the literature by these authors provide evidence to state that No Free Lunch exist while hedging the internationally invested portfolio.

Therefore, considering the past researches and the literature carried out, it has not been clear if hedging really helps to mitigate the risks and improve the performance as compared to not hedging the portfolio. Even if hedging helps to reduce the volatility of the portfolio, the big question is whether which hedging strategy helps to gain better portfolio results. Though from the literature considered in the study, maximum of them conclude that Forward hedging is beneficial to the investors, there is no single hedging strategy which is universally accepted that has proved to actually lower the risks of the portfolio and at the same time boost the performance by providing higher profits.

3. Research Question

Even after a number of past researches performed to test the effectiveness of the hedging strategies for an investor investing internationally, there is still a lot of uncertainty regarding the hedging strategy which helps in providing the portfolio with better performance. Some literatures claim that Forward hedging helps the investor to gain better portfolio performance by generating more returns, whereas some authors conclude that Option hedging strategy helps to reduce the risk and thus boost the performance. Researches also state that hedging the portfolio using the Zero Cost hedging strategy helps the investor by providing the investor with downward protection.

On the other hand, there are arguments made by authors for No Hedge strategy stating that hedging helps to reduce the standard deviation of the portfolio but at the same time reduces the returns, ultimately depleting the performance of the portfolio.

Limited researches have been performed considering the Zero Cost hedging strategy along with the other strategies to hedge the portfolio of an international investor. Also, limited study is carried out considering the US and the UK which are among the two developed countries. Thus, the research question that this study aims to answer is:

“Which hedging strategy helps to gain better portfolio performance for a UK investor investing in the US markets?”

The research takes into consideration the commonly used strategies of No Hedge, Forwards, Options and also considers the Zero Cost hedging strategy to access the portfolio performance for a UK investor investing in the US markets for a time interval of 21 years from 1998-2018.

During the time interval considered, two major financial crisis took place, the Dot Com Bubble which occurred in the year 2000 and the Financial Crisis which took place in the year 2008.

Thus, the other objective of this research is to study the period of financial crisis and access the effectiveness of the hedging strategies during those periods to understand which hedging strategies help to gain achieve better portfolio performance.

4. Methodology

In order to analyze currency hedging strategies for an international portfolio, the author considers a UK based investor who is investing in US markets by buying a portfolio that mimics the returns of the S&P 500 index. This operation involves a risk related to currency exchange fluctuation. The investor can choose to not hedge the portfolio and keep it exposed. This is called No Hedge portfolio. If the investor is worried about the possible currency exchange fluctuations, he might hedge the portfolio using Forward, Option or Zero Cost Cylinder Strategy.

Various researches have been carried out to access the performance of the returns of the portfolio hedged using the currency hedging strategies. The common performance measures used by the researchers are the Value at Risk (VaR) and the Conditional Value at Risk (CVaR), Sharpe Ratio and Sortino ratio.

VaR is a measure which helps to identify the level of risk in the portfolio or investment at a given probability over a time period but CVaR helps to identify the loss in a portfolio if the loss crosses the VaR breakpoint (Hull, 2015). They both are risk assessment measure.

Topaloglou et al (2007) and Vargas et al (2013) makes use of risk measurement method of CVaR in their research for finding the effectiveness of hedging strategies for international investments stating that CVaR helps in identifying and measuring the downside risk. Thus, assisting them in mitigating the risk of the portfolio. Sortino ratio which is a risk measure to find the performance by comparing the returns to the downside risk is used by Maurer et al (2007) to find better performance between Option and Forward hedged portfolios.

Sharpe ratio was named after its developer William F. Sharpe which is a performance measure that helps to find the excess return to that of the standard deviation of the returns of the portfolio. The higher the Sharpe ratio, the greater is the risk-adjusted return of the portfolio. Thus, it is easy to use since Sharpe (1994) mentioned that Sharpe ratio can be computed just by using two variables, the risk and the returns of the portfolio. Kim (2012) states that the Sharpe ratio is one of the most commonly

used measures to find the performance of the portfolio. There are evidence provided by Schuhmacher and Eling (2011, 2012) in their research on the performance measurement methods, stating that Sharpe ratio has the potential and is equally comparable to the other performance measures like the VaR, CVaR, the hedge ratio, and Sortino ratio. The author also states that all the other performance measurement matrices are just an increasing function to the existing method of Sharpe ratio which means that the results obtained using Sharpe ratio when compared to the results acquired by other performance measurement methods are expected to be similar. There are similar researches performed by Du et al (2018), Kim (2012), Roon et al (2012) which provides empirical evidence for the use and effectiveness of Sharpe ratio for performance measurement of portfolios when investing internationally. The author not only intends to measure the performance of the portfolio by considering the risk but also by examining the returns generated by the portfolio. These parameters are considered by the use of Sharpe ratio. Thus, looking at the simplicity and the ability to be compared to the other methods, this research takes into consideration the measure of Sharpe ratio to find the effectiveness of the hedging strategies and the performance of the portfolios.

Sharpe ratio can be computed using the following formula:

$$\text{Sharpe Ratio} = \frac{R_P - R_F}{\sigma_P}$$

where, R_P stands for mean return to the portfolio, R_F is return of the risk-free asset and σ_P is the standard deviation of returns on the portfolio.

There is also an alternative way to compute the Sharpe ratio by considering the denominator to be the standard deviation of the excess returns of the portfolio ($R_P - R_F$), rather than the standard deviation of the portfolio returns but De Fusco et al (2007) state that the both the standard deviation calculations generally tend to yield very similar results. Therefore, for performing this research, the standard deviation of portfolio returns has been considered.

To compute the Sharpe ratio of a portfolio, returns on the portfolio (R_P), returns on the risk-free rate (R_F) and the standard deviation for returns on the portfolio (σ_P) must be calculated.

4.1. Data Collection:

The analysis is based on average monthly Sharpe ratio for a time period of 21 years from 1998-2018. For calculating the returns of the different portfolios Spot rate (GBP/USD), one-month Forward rate (GBP/USD) and the S&P 500 returns data have been acquired from the Bloomberg Terminal. For calculating the premium for the Option strategy, a macro function using the Black Scholes model have been implemented and used in a VBA (Appendix 4), taking into consideration the Spot rate, GBP interest rate, USD interest rate, volatility and the Strike price. All this data has also been obtained from Bloomberg terminal.

For calculating the 1-month Call and Put Strike price for Zero Cost Strategy, Risk Reversal rate is required. The risk reversal rate data is only available from the year 2003, therefore Zero Cost Strategy is analyzed from 2003-2018 due to lack of data. This data is accessed from Bloomberg.

To calculate the Call Strike price and the Put Strike price for Zero Cost Cylinder strategy, a VBA code is used to find the strike prices in a way to set off the premium. (Appendix 3).

The risk-free rate - Sterling Overnight Index Average (SONIA) rate is obtained from the Bank of England website.

4.2. No Hedge Portfolio:

4.2.1. Returns of the Portfolio

Since the returns of a UK based investor are being analyzed, the investment strategy is to purchase USD Dollars by selling the Sterling at the start of the investment period. So, for the No Hedge strategy, the investor will buy Dollars at a spot rate (S_T) on the first day of every month (T) and sell that after a month at a future spot rate (S_{T+1}).

The returns are realized when the investor sells at Future Spot rate (S_{T+1}) after a month. They are calculated on the 1st day of every month for the previous one-month period for which the returns are realized.

Since the returns are considered on a continuous compounding basis, Log returns are used.

$$\text{Return for Currency Portfolio (No Hedge)} = \text{Log} \left(\frac{S_{T+1}}{S_T} \right)$$

Thus, monthly returns are calculated for each month from 1998-2018. The returns which the investor earns are in Dollar currency (R_D). So, the currency needs to convert to get the returns in Sterling (R_S), as the UK is the home country. Since the foreign exchange returns are expressed using logarithmic returns, the returns in GBP/USD can be computed by simply multiplying the returns on the USD/GBP by -1.

$$R_S = R_D \times -1$$

Returns for the portion invested in the portfolio that mimics S&P 500 are also calculated in the same manner as the currency returns are computed, by using the Log Returns. The investor would buy stocks at Price (P) on the first day of every month (T) and sell them after a month ($T+1$) for a price (P_{T+1}).

$$\text{Returns for S\&P 500} = \left(\frac{P_{T+1}}{P_T} \right)$$

In this manner, the returns of the portfolio of S&P 500 are calculated for each year from 1998-2018.

Since the investor sells the currency and the stock after a month, the returns are realized after a month. Therefore, on the 1st day of each month, the total portfolio returns are calculated by adding the returns of the stocks and the currency returns for the previous month for which they are realized.

Average monthly returns are computed for the total portfolio for a period of one year each.

To compute average monthly returns for a period of one year each, an average is considered for all the monthly returns in that period.

$$\text{Total returns for a particular period} = \frac{R_J + R_F + R_M + \dots + R_D}{12}$$

where, R_J refers to the return for the month of January, R_F refers to month of February and R_D refers to the average monthly returns for the month of December.

In this manner, the average monthly returns for a period of one year are computed for time interval of 21 years from 1998-2018.

4.2.2. Standard Deviation of the Portfolio

The monthly Standard Deviation of returns (σ) for a period of one year is calculated taking into consideration the average monthly returns of the portfolio in that particular period. Since the returns of the portfolio represent the sample observations, formula to compute the standard deviation for sample is used, where the numerator represents the sum of the returns of each month minus the mean returns of the portfolio for the period considered. The 'n' in the denominator represents the number of observations in the sample. Similarly, the standard deviation for each period is computed taking the same approach.

$$\text{Standard Deviation}(\sigma) = \sqrt{\frac{\sum (xi - \mu)^2}{n - 1}}$$

Thus, using the formula above, the monthly standard deviation of the returns for a period of one year is computed. So, for a total period of 21 years, 21 monthly standard deviations are computed.

4.2.3. Risk-free rate for the portfolio

LIBOR was often used as a substitute for the risk-free rate. But, after the experience of the credit crisis, the practitioners were looking for a better proxy for risk-free rate for valuing derivatives and therefore many banks switched their risk-free rate from LIBOR to Overnight Indexed Swap (OIS). OIS is a swap where a fixed rate is exchanged for geometric average of overnight rates during that period. “The Overnight Indexed Swap rate is a good proxy for risk-free rate since it is very close to risk-free” (Hull, 2015 p. 203). Since the UK is the home country, the brokered overnight rate in the UK used. It is termed as Sterling Overnight Index Average (SONIA).

Therefore, the average monthly SONIA rate is considered as the risk-free rate for this research. But SONIA rate is expressed in an annual basis. Since the returns and the standard deviation of the portfolio are considered on a monthly basis to compute the monthly Sharpe ratio, the risk-free rate (SONIA) is divided by 12 to adjust it on monthly basis.

4.3. Forward Hedged Portfolio:

4.3.1. Returns of the Portfolio

For the Forward strategy, the investor will buy at the Spot rate (S_T) at the start of each month and sells after a month at a Forward Rate (F_{T+1}). The returns are realized when the investor sells after a month. Thus, the returns are calculated on the 1st day of every month for the previous month period for which they are realized. Log normal returns are used to calculate the realized returns.

$$\text{Return for Currency Portfolio (Forwards)} = \text{Log} \left(\frac{F_{T+1}}{S_T} \right)$$

The returns of the portfolio that mimics the S&P 500, the returns of the portfolio, the standard deviation of the returns of the portfolio and the risk-free rate are calculated in the same manner as computed for the No Hedge strategy.

4.4. Option Hedged Portfolio:

4.4.1. Returns of the Portfolio

Since at the start of the month (T) investor buys Dollars and later after a month ($T+1$), sells Dollars and buys Sterling, therefore, he needs a Sterling Call Option which gives him the right to buy Sterling.

For calculating the returns for option strategy, the Spot price (S_T) and the Strike Price (K) are considered. The Strike price is the rate at which the option gets exercised. Since it is a call option, it can only be exercised if the spot price after a month (S_{T+1}) is greater than the Strike Price (K).

$$\text{Payoff for the Call Option} = \text{Max} \{0, (S_{T+1} - K)\}$$

So, if the Spot Price after a month is greater than Strike Price, the call option is exercised and the investor earns a profit of the difference between the Spot and the Strike price but if the Strike Price is greater than Spot Price, the payoff is 0 since the call option cannot be exercised.

Since the investor is buying the Option, a premium has to be paid to the other party. A VBA code is used to calculate the premium for buying the Call Option using the Black-Scholes Model (Appendix 4).

After a month, at maturity, when the call option is exercised, the investor buys Sterling at S_{T+1} , but the cost of Premium and the Option Payoff has to be considered in calculating the cost of buying Sterling. Therefore, the cost which the investor pays for buying the currency after exercising the Option including the premium and the payoff can be defined as Effective Spot Rate (S^*).

$$\begin{aligned} \text{Effective Spot Rate } (S^*) \\ = \{(S_{T+1}) + (\text{Premium of the Option}) - (\text{Option Payoff})\} \end{aligned}$$

The returns of the currency portfolio are calculated after a month ($T+1$) when they are realized by taking a Log Return of the Effective Spot Rate (S^*) and the Spot rate (S_T) while buying the currency.

$$\text{Return for Currency Portfolio (Options)} = \left(\frac{S^*}{S_T} \right)$$

The returns of the portfolio similar to the S&P 500, the total returns of the portfolio, the standard deviation of the returns of the portfolio and the risk-free rate are calculated in the same manner as computed in the strategies above.

4.5. Zero Cost Cylinder Portfolio:

4.5.1. Returns of the Portfolio

To exercise the Zero Cost Cylinder strategy, the investor needs to buy a Call option and sell a Put option with their Strike prices set in such a way that the price of the Call and the Put option is equal to zero, costing the investor zero premium. So, the Strike prices of the Call and the Put Option are calculated by using a VBA function (Appendix 3).

After a month, at maturity of the strategy, the investor is considering to buy Sterling at a Spot rate by exercising the Call option or the Put option. But a Call option can only be exercised if the Spot rate after a month (S_{T+1}) is above the Call Strike Price (K_C) and the Put option can only be exercised if the Spot rate after a month (S_{T+1}) is below the Put Strike Price (K_P). Therefore, the Spot rate at which the investor buys the Sterling currency is known as Effective Exchange Rate (S^*). It means that, if after a month, the Spot price is above the Call Strike price, the Call option will be exercised and the Effective Exchange rate (S^*) will be considered as the Call Strike price, if the Spot price is below the Put Strike price, then Put option is exercised and S^* will be the Put Strike price and if the spot price is in between the Call strike and the Put Strike price, then the investor buys the currency at the Spot rate (S_{T+1}) prevailing at the time of maturity.

Effective Exchange rate can be calculated as:

$$\text{Effective Exchange Rate } (S^*) = \text{If } \{(S_{T+1} > K_C, K_C), (S_{T+1} < K_P, K_P), (S_{T+1})\}$$

Therefore, the returns of the Currency portfolio are calculated by computing the Log return of the Effective exchange rate and the Spot rate (S_T) at the time of buying the Options.

$$\text{Return for Currency Portfolio (Zero Cost Cylinder)} = \text{Log} \left(\frac{S^*}{S_T} \right)$$

The returns of portfolio similar to S&P 500, the total returns of the portfolio, the standard deviation of the portfolio returns and the risk-free rate are computed in the same manner as calculated in the strategies above.

4.6. Computation of the Sharpe Ratio:

After the average monthly returns of the portfolio (R_P), the monthly standard deviation of the returns of the portfolio and the average monthly risk-free rate (R_F) are computed for the portfolios hedged using the strategies of No Hedge, Forwards, Options and Zero Cost Cylinder, the average monthly Sharpe ratios are calculated for period of one year from 1998-2018 using the formula

$$\text{Sharpe Ratio} = \frac{R_P - R_F}{\sigma_P}$$

Also, average monthly Sharpe ratios are calculated for an overall interval from 1998-2018 and from 2003-2018 by taking into consideration the average monthly portfolio returns, average monthly risk-free rate and the average monthly standard deviation of the returns for the entire period of 1998-2018 and 2003-2018.

4.7. Test of Hypothesis:

To test if there is any significant difference between the Sharpe ratios of portfolio hedged by all the four strategies, z-test statistics can be used which is based on the research performed by Jobson and Korkie (1981) and corrected by Memmel (2003), in which they derive the z-statistics for Sharpe ratio which follows an asymptotic

distribution. This test was also adopted by Kim (2012) and Du et al (2018) for carrying out their hypothesis test to check the difference between the Sharpe ratios of hedged and unhedged portfolios when they performed similar research.

But Ledoit and Wolf (2008) argue that the z-statistics test is not a robust test since it only takes into consideration the normal distribution and is not valid when the tails are heavier. The authors claim that more valid method can be considered like the HAC inference method of Andrews (1991) and Andrews and Monahan (1992) or studentized time series bootstrap method by Ledoit et al (2008). This research takes into consideration the use of HAC inference method to compute the *p-value* due to its simplicity.

The equation for HAC inference mentioned by Ledoit et al (2008) is as follows:

A two-sided p-value for the null hypothesis is given by

$$\hat{p} = 2\Phi\left(-\frac{|\hat{\Delta}|}{s(\hat{\Delta})}\right)$$

where Φ denotes the cumulative distribution function for the distribution and $s(\hat{\Delta})$ is the standard error.

The null hypothesis (H_0) is that no statistical difference exists between the Sharpe Ratios of two strategies and the alternative hypothesis (H_a) is that there exists a statistical difference between the Sharpe ratios. They can be defined as

$$H_0: SR_1 - SR_2 = 0$$

$$H_a: SR_1 - SR_2 \neq 0$$

where SR_1 and SR_2 are the Sharpe ratio of the portfolio using the hedging strategies. Thus, after comparing the Sharpe ratio for four hedging strategy portfolios with each other, six *p-values* are computed to find if there exists any significant difference between them.

For this research, this '*p-value*' is computed using HAC inference on R programming Code as provided by Ledoit et al (2008) (Appendix 2).

5. Findings and Analysis

The average monthly Sharpe ratios for No Hedge, Forward, Option and Zero Cost hedged portfolio for a period of one year each from 1998-2018 have been computed. As seen in table 1, the results show that the Sharpe ratio of No Hedge portfolio and the Forward hedged portfolio dominated the other strategies for most of the period. They were followed by Zero Cost hedged portfolio. The Option hedged portfolio showed the worst performance, because at no given period of time did the portfolio outperform the performance of the other strategies due to lower Sharpe ratios. Since, Sharpe ratio measures the performance of the portfolio, taking into consideration the risk-adjusted returns, lower Sharpe ratio of Option hedged portfolio depicts that the portfolio generated lower returns or higher risk for a given level of returns. From appendix 1, it can be identified that the Option hedged portfolio was able to reduce the risks but not able to generate returns for the given level of risk, thus decreasing the Sharpe ratio.

5.1. Average Monthly Sharpe ratio for overall period of 2003-2018:

Since the data for the Zero cost hedging strategy is available only from 2003, average monthly Sharpe ratios are calculated for an overall period from the year 2003-2018 for all the strategies. The results show that the Sharpe ratio of the No Hedge portfolio was slightly higher as compared to the other hedging strategies with the Sharpe ratio of Forward hedged portfolio being the least.

The Sharpe ratio of No Hedge Portfolio was 0.109 followed by Option and Zero Cost hedged portfolios which were 0.096 and 0.092 respectively. Forward hedged portfolio showed the worst performance with the Sharpe ratio being lowest at 0.089.

The reason for higher Sharpe ratio was because the No Hedge strategy was able to generate returns of 0.639% which was higher as compared to the returns of the strategies of Forwards, Options and Zero Cost at 0.574%, 0.584% and 0.562% respectively (Table 2). Although Forward hedged portfolio did not generate the lowest returns, the Sharpe ratio of the portfolio was the lowest because hedging did not improve the performance of the portfolio but instead added more risk to the portfolio by generating a higher standard deviation of 4.58%. As in table 2, Option strategy had

the same level of risk as to the No Hedge strategy with the standard deviation of 4.33% but with the same level of risk, the No Hedge portfolio was able to generate a higher level of returns, thus providing a higher Sharpe ratio.

Table 1: Average Monthly Sharpe ratios for Portfolios

<i>Years</i>	No Hedge	Forwards	Options	Zero Cost Cylinder	Dominating Strategy
1998	0.187	0.270	0.161	-	Forwards
1999	0.203	0.219	0.180	-	Forwards
2000	-0.170	-0.377	-0.308	-	No Hedge
2001	-0.143	-0.142	-0.184	-	No Hedge
2002	-0.576	-0.473	-0.630	-	Forwards
2003	0.081	0.356	0.332	0.181	Forwards
2004	-0.086	0.492	0.177	0.112	Forwards
2005	0.201	0.036	0.144	0.117	No Hedge
2006	-0.160	0.174	-0.050	0.062	Forwards
2007	-0.135	-0.031	-0.114	-0.110	Forwards
2008	-0.180	-0.420	-0.334	-0.365	No Hedge
2009	0.104	0.153	0.091	0.167	Zero Cost Cylinder
2010	0.239	0.140	0.196	0.175	No Hedge
2011	-0.058	0.028	-0.014	0.037	Zero Cost Cylinder
2012	0.307	0.294	0.294	0.178	No Hedge
2013	0.432	0.583	0.544	0.476	Forwards
2014	0.507	0.319	0.431	0.486	No Hedge
2015	0.032	-0.059	-0.046	-0.071	No Hedge
2016	0.763	0.332	0.690	0.686	No Hedge
2017	0.202	0.942	0.433	0.308	Forwards
2018	-0.020	-0.127	-0.090	-0.016	Zero Cost Cylinder

Table 2: Average Monthly statistics for overall period from 2003-2018

	<i>No Hedge</i>	<i>Forwards</i>	<i>Options</i>	<i>Zero Cost Cylinder</i>
<i>Returns</i>	0.639%	0.574%	0.584%	0.562%
<i>Standard Deviation</i>	4.33%	4.58%	4.33%	4.29%
<i>Sharpe Ratio</i>	0.1090	0.0890	0.0960	0.0920

Looking at the risk of the Zero Cost hedged portfolio, it can be rightfully said that the portfolio was able to minimize the risk and provide the least standard deviation which was 4.29% compared to the other portfolios. However, with lower risks, the returns were also compensated leading to lower returns of the portfolio, thus reducing the Sharpe ratio. Since higher the Sharpe ratio of the portfolio the higher is the risk adjusted return of the portfolio, it can be said that the No Hedge portfolio provided better results of the portfolio by improving the performance of the portfolio compared to the other strategies.

5.2. Average Monthly Sharpe ratio for overall period of 1998-2018:

On computing the average monthly Sharpe ratios for an overall period from 1998-2018 for No Hedge, Forward and Option hedged portfolios, it has been identified that the Sharpe ratio of No Hedge portfolio was 0.0494, which was higher than the Forward and Option hedged portfolios with their Sharpe ratio being 0.044 and 0.031 respectively (Table 3). Looking at the risk and the return statistics of the portfolios, it can be said that the Option strategy helped to lower the risk of the portfolio by providing the least standard deviation, which is what hedging strategies are meant to be. But with the decline in the risk of the portfolio, there was a decline in the returns of the portfolio too. The returns of the portfolio, when hedged using the Option strategy, was as low as 0.38%. This is what declined the Sharpe ratio of Option hedged portfolio making it the lowest. On the other hand, the No Hedge and the Forward

hedged portfolio were able to generate returns of 0.47% and 0.45% on their portfolio. The standard deviation of both the portfolios of No Hedge and Forward hedged were equal at 4.75%. Therefore, due to slightly higher returns generated by No Hedge portfolio as compared to the Forward hedged portfolio with the same given level of risk, a higher Sharpe ratio was observed for No Hedge strategy. So, although the number of times the Forward hedged portfolio dominated the other strategies were equal to the No Hedge portfolio, it was not able to outperform the no Hedge portfolio. Therefore, again better performance was realized by not hedging the portfolio because the hedging benefits of lower risks have not been achieved as the standard deviation are equal.

Table 3: Average Monthly statistics for overall period from 1998-2018

	<i>No Hedge</i>	<i>Forwards</i>	<i>Options</i>
<i>Returns</i>	0.470%	0.446%	0.379%
<i>Standard Deviation</i>	4.75%	4.75%	4.61%
<i>Sharpe Ratio</i>	0.0494	0.0443	0.0313

5.3. The Period of Financial Crisis:

This research takes into consideration the period of the financial crisis, which affected the US market, where the investor is investing the portfolio. During the time interval taken into consideration for the research, two financial crises took place, the Dot Com Bubble that took place in the year 2000 and the Global Financial Crisis in the year 2008. During both the periods of 2000 and 2008, the returns of the portfolios, hedged using No Hedge, Forwards, Options and Zero Cost were negative. This was because the portfolio that mimics the returns of S&P 500 also delivered negative returns during the year of 2000 and 2008 as observed in figure 1. The negative returns led to a negative Sharpe ratio during this period of crisis. But still, it was noted that No Hedge strategy was able to generate a lower negative Sharpe ratio as compared to the other hedging strategies. The average monthly Sharpe ratio of the No Hedge portfolio in the

year 2000 was (-0.170), which was still higher when compared to the Forward portfolio (-0.377) and Option portfolio (-0.308). Also, during 2008 Financial Crisis, the Sharpe ratio of No Hedge portfolio was -0.180, higher than the strategy of Forward (-0.420), Option (-0.344) and Zero Cost strategy (-0.365). The reason for the higher Sharpe ratio of No Hedge portfolio compared to the other strategy during the period of crisis is because it was to gain lower negative return as compared to the rest of the strategy. From appendix 1, it can be identified that the No Hedge portfolio generated returns of -0.338% during the year 2000 whereas the Forward and Option strategy generated returns of -1.177% and -0.986% respectively. Also, during the period of 2008, the returns generated by No Hedge portfolio was -1.097% where on the other hand, the strategies of Forwards, Options and Zero Cost generated returns of -3.340%, -2.328% and -2.742% respectively.

It has been noted that the standard deviation of all the hedged portfolios were not significantly different from the standard deviation of the No Hedge portfolio during that period. This leads to the conclusion that during the period of crisis, the risk-reducing ability of the hedging strategy is diminished and thus hedging does not add value to the performance of the portfolios.

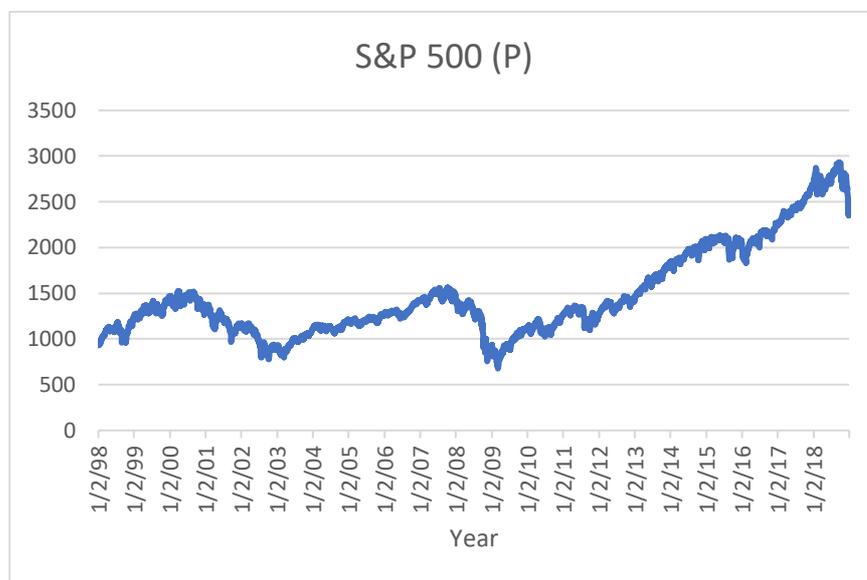


Figure 1: Returns of S&P 500

During the Crisis period of the year 2000 and 2008, it has been observed that in both the years, the Sterling (GBP) devalued in comparison to Dollar (USD) since on

2nd January, 2000, the Spot rate of Sterling/ Dollar was 1.636 which got depreciated to 1.493 on 31st December 2000. Also, the Spot rate declined from 1.981 to 1.459 from 1st January, 2008 to 31st December, 2008 (Figure 2)

Also looking at figure 2, there is a decreasing trend in the GBP/USD spot rate from 2014-2016. Consecutively during all the three years, the No Hedge strategy outperformed the performance of other strategies because No Hedge portfolio was able to generate higher Sharpe ratio. With having a standard deviation of equal or less value, the No Hedge portfolio had higher returns for all the three years from 2014-2016 (Appendix 1).



Figure 2: Sterling Spot rate against USD Dollar

But hedging the portfolio using the Forward and the Zero Cost strategy have proved to be beneficial when the Sterling is appreciating against the Dollar. Considering a time interval from 2002-2007, the Sharpe ratio of No Hedge strategy was higher only during the period of 2005, rest all the years, the Sharpe ratio of Forward hedged portfolio dominated the other hedged portfolio (Table 1). This can again be compared to the trend of GBP/USD spot rate, looking at figure 2, since during the year 2005, GBP/USD spot rate declined from 1.904 on 3rd January, 2005 to 1.723 on 30th December, 2005. But considering an overall period from 2002-2007, the GBP/USD spot rate appreciated from 1.447 on January, 2002 to 1.985 on 30th December, 2007.

Therefore, Forward hedge strategy dominated during those periods and the No Hedge strategy was not able to outperform the other strategies.

As mentioned above, the results of the average monthly Sharpe ratio for an overall time interval from 1998-2018 show that No Hedge strategy has a higher Sharpe ratio compared to other hedging strategies, by generating more returns. Comparing this result with the trend of the currency exchange rate of GBP/USD, it can be seen in figure 2 that the GBP/USD spot rate was 1.645 on January, 1998 but declined to 1.275 on 31st December, 2018. Therefore, there has been a decline in the value of Sterling against Dollar in an overall period. That can be one of the reasons why the No Hedge strategy was able to dominate the performance of the other strategies by offering a higher Sharpe ratio.

From this, it can be stated that the No Hedge strategy performs well when the home currency is depreciating against the foreign currency. This is because the investor is buying at a spot rate and selling at a prevailing spot rate after a month. Since the spot rate is declining, the investor buys the foreign currency when it is weak and sells when the foreign currency is appreciating. Thus, the investor earns on the profit of the currency exchange without the need to hedge. Therefore, it works as a natural hedge when the home currency is depreciating while investing in foreign markets. But the performance hedged using the strategy of Forwards and Zero Cost Cylinder is improved when the home currency is appreciating against the foreign currency.

5.4. Test of Hypothesis:

Although the Sharpe ratio of No Hedge portfolio is higher as compared to the Sharpe ratios of the other strategies, to see if there is any exist any statistical difference between the Sharpe ratios of the portfolios, a hypothesis test is performed. On performing the hypothesis test with null hypothesis as ‘No statistical difference between the Sharpe ratios of two strategies’, at 5% level of significance, it has been observed that the p values which were obtained after comparing the No Hedge portfolio with other strategies, were above the level of significance of 0.05 as stated in Table 4.

Table 4: *p-values for Hypothesis test*

	No Hedge	Forwards	Options	Zero Cost Cylinder
<i>No Hedge</i>	-	0.747	0.462	0.784
<i>Forwards</i>	0.747	-	0.816	0.38
<i>Options</i>	0.462	0.816	-	0.477
<i>Zero Cost Cylinder</i>	0.784	0.38	0.477	-

Considering all the p -values after performing the hypothesis test, as the p -values are above the level of significance, it indicates weak evidence against the null hypothesis which leads to failing to reject the null hypothesis. This helps to state that there is no statistical difference between the Sharpe ratios of the portfolio hedged using No Hedge and other hedging strategies. Also, apart from the No Hedge, the p -values for other strategies also denote that there is no statistical difference between the Sharpe ratios of the portfolios hedged using the Forwards, Options and Zero Cost Cylinder.

Therefore, this means that the investor is better off not hedging the portfolio since the results of the test of hypothesis state that no statistical difference exists between Sharpe ratios of Hedged and No Hedge portfolio. Thus, it is not beneficial for a UK investor investing in US market to hedge the internationally invested portfolio since hedging does not help to improve the portfolio performance.

The limitation of this study is that this study does not take into consideration the costs of hedging like the transaction cost and the brokerage fees for using the derivative instruments. Also, for testing the hypothesis for the difference in the Sharpe ratios, this research uses the HAC Inference method provided by Andrews (1991) and Andrews and Monahan (1992). Even though it is claimed to be a valid method to carry out the hypothesis test for Sharpe ratios, Ledoit et al (2008) state that it tends to be quite liberal when the sample size is small.

6. Discussion

On comparing the Sharpe ratios of the portfolios hedged using No Hedge, Forwards, Options and Zero Cost Cylinder strategy for an interval of one year from 1998-2018, this study finds that the Sharpe ratios for the No Hedge portfolio and the Forward hedged portfolio were higher than the Sharpe ratios for the other hedging strategies for maximum number of times. The Option hedged portfolio showed the worst performance due to lower Sharpe ratios for most of the years.

Considering the standard deviation of the portfolios during both the time intervals from 1998-2018 and 2003-2018, it has been identified that the lowest standard deviation for the portfolios are gained when the portfolios are hedged using the Option hedging and the Zero Cost hedging strategy. This goes in line with the claim made by Maurer et al (2007) and Bush et al (2018) who conclude in their literature that hedging the portfolio helps to reduce the volatility and the risk of the internationally invested portfolios.

For time interval of 1998-2018, the results indicate that the Option hedged portfolio is able to reduce the standard deviation of the portfolio hence, reducing the risk of the investment. This validates the findings made by Zhang et al (2018) who state that using an Option hedging strategy helps to reduce the fluctuations of exchange rate for an internationally invested portfolio. But the reason for the Option hedged portfolio to not outperform the portfolios hedged using the other strategies is because the Option portfolio was not able to generate higher returns for a given level of risk, thus depleting the Sharpe ratio.

Also, considering the time interval from 2003-2018, the results show that the volatility and the risk of the portfolio are minimized when Zero Cost strategy is used to hedge the portfolio. Thus, as Shah (2013) rightly stated, Zero Cost strategy does help to protect the investor from the downside future returns by reducing the risk and giving protection to the earned profits. But, it is also seen that with the reducing risk of the portfolio, the returns of the portfolio are also diminished. So, this supports the literature of Bartonova (2012) who argued that since the investor is not paying for

Zero Cost strategy, lesser benefits are received by limiting the upward potential as is the case of an insurance policy in which the buyer receives lesser benefits for lower policy amount.

When considering an overall period from 1998-2018, results suggest that the Sharpe ratio of No Hedge portfolio is higher than the Sharpe ratios of the portfolios hedged using other strategies. Also looking at the results for the period of 2003-2018, when the strategy of Zero Cost Cylinder is taken into consideration for hedging the portfolio, again it is found that the Sharpe ratio of No Hedge portfolio is greater than the other strategies.

Therefore, taking into consideration both the time intervals, the results demonstrate that higher Sharpe ratio is achieved by No Hedge portfolio as compared to the other portfolios. The major reason for the higher ratio was that although the No Hedge strategy did not reduce the volatility and mitigate the risks of the portfolio, it generated higher returns than the rest of the hedged portfolios thus achieving a higher Sharpe ratio. So, it can be said that the performance of the No Hedge portfolio dominated the performances of the portfolios hedged using the strategies of Forwards, Options and Zero Cost Cylinder due to higher Sharpe ratio. It supports the arguments by Roon et al (2012) and Chang et al (2009) that currency hedging helps to reduce the volatility and the risk of the portfolio but decreasing risk leads to lower returns, ultimately depleting the performance, thus concluding that the No Hedge strategy helps to achieve higher portfolio performance by providing more returns.

Although the average monthly Sharpe ratios for portfolio hedging using Forward and No Hedge strategy dominated the other strategies when comparing for an interval of one year from 1998-2018, the Forward hedged portfolio was not able to outperform the performance gained by the No Hedge portfolio. As a result, this contradicts the findings by Maurer et al (2007) and Hendrawan (2017) who concluded that the performance of the Forward hedged portfolio is superior to the No Hedge portfolio due to higher returns and lower risks, since in this study, the returns of the Forward hedged portfolio were lower than the No Hedge portfolio.

Considering the period of financial crisis of Dot Com Bubble (2000) and the Global Financial Crisis (2008), the results show that the performances of the portfolios are improved when No Hedge strategy is used by the investors since the Sharpe ratios of the No Hedge strategy during both the crisis period was higher as compared to the other strategies. The No Hedge portfolio was able to achieve lower negative returns than the portfolios hedged using other hedging strategies. Thus, making No Hedge strategy a better portfolio performer for the crisis period. Also, it can be stated from the results that during the period of crisis, the hedging strategies lose their risk-reducing capacity. This is in complete disagreement with the literature of Hendrawan (2017) whereby the author claims that during the period of crisis, the Forward hedging strategy provides better performance to the portfolio by providing lower negative returns and reducing the risks, which is not the case for this research result.

On performing the hypothesis test to check whether there exists any significant difference between the Sharpe ratios of the portfolios hedged with No Hedge, Forwards, Option and Zero Cost hedge, the results show that all the *p-values* obtained on comparing the Sharpe ratios of the portfolios with each are above 0.05 at 5% level of significance. Thus, the hypothesis test fails to reject the null hypothesis which means that there does not exist any statistical difference between the Sharpe ratio of the portfolios when hedged with No Hedge, Forwards, Options and Zero Cost Cylinder strategy. These results allude with the findings of the literature by Kim (2012) whereby the author on performing the hypothesis test fail to reject the null hypothesis suggesting that no statistical difference exists between the Sharpe ratios of hedged and No Hedge portfolio.

Since the results show that there does not exist any statistical difference between the Sharpe ratio of the portfolios using the strategy of No Hedge, Forwards, Option and Zero Cost Cylinder, there is no benefit in hedging the portfolio when investing international since the performance if not going to be statistically different. Hence, the results contradict the conclusions by Schmittmann (2010) and Topaloglou (2011) who state that the performance of the No Hedge portfolio is significantly poor compared to the hedged portfolio with Forwards and Options since this is not the case for this study.

Accordingly, the results from the analysis also contradict the arguments made by Perold and Schulman (1988) that currency hedging is a Free Lunch of risk reduction and zero expected returns of currency because the results state that as the risk of the portfolio declines due to hedging, it reduces the returns on the portfolio as well. Thus, the findings of the research are in context with the comments made by Chang (2009) and Roon et al (2012) by holding true that currency hedging is No Free Lunch. Therefore, the results of this study indicate that it is not beneficial for a UK investor to hedge the portfolio when investing internationally in the US markets.

One of the limitations of this research is that the cost of the hedging derivatives instruments like the transaction cost and the brokerage cost are not considered to measure the portfolio performance. Also, the test of hypothesis to check the difference in the Sharpe ratios for the portfolios have been performed using the HAC inference model by the methods of Andrews (1991) and Andrews and Monahan (1992). Although Ledoit et al (2008) claim this method to be valid, one of the drawbacks of this method is that it tends to be liberal for small sample size and sometimes fail to reject the true null hypothesis. Therefore, a more improved and robust method of studentized time-series bootstrap by Ledoit et al (2008) can be used to test the hypothesis for future studies.

Also, in this research, a relationship between the currency Spot rate and the currency hedging strategies have been identified. The results show that the No Hedge portfolio tends to perform well by providing higher Sharpe ratios when the home currency is depreciating. In this research, the performance of the No Hedge portfolio dominated the portfolios hedged using other strategies when the value of Sterling declined against Dollars. But No Hedge strategy has not been able to outperform the performance of the other strategies during the period when the home currency appreciated against the foreign currency i.e. when Sterling appreciated against Dollars.

When considering an overall period from 1998-2018, the value of Sterling is declining against the Dollar. This can be one of the reasons for the No Hedge strategy to outperform the other strategies for an overall period.

Hence, future research can be carried out for a similar topic but from a perspective of a US investor investing in the UK markets. It would be interesting to know the performance of the hedging strategies when the home currency (USD) is appreciating against the foreign currency (GBP).

7. Conclusion

This study was set out to check the effectiveness of the hedging strategies for a UK investor investing in the US markets. Specifically, this research investigated the performance of the portfolio when hedging strategies of No Hedge, Forward, Option and Zero Cost Cylinder was used. Although a number of past researches have been carried out, there is still a lot of uncertainty regarding the hedging strategy which helps to improve the performance of the portfolio. To test the effectiveness of the hedging strategies, a time interval from 1998-2018 was taken into consideration. This research also considers the period of financial crisis of the Dot Com Bubble in the year 2000 and the Financial Crisis in the year 2008. Sharpe ratio, which is the performance measurement ratio was used to carry out the research and compare the performance of the portfolios.

The results of the research indicate that the No Hedge portfolio was able to generate a higher Sharpe ratio compared to the other hedged portfolio, thus showing greater performance. Although the No Hedge portfolio was not able to reduce the standard deviation of the portfolio for the time interval from 1998-2018 and 2003-2018, it was still able to gain a higher Sharpe ratio due to its higher return generating capacity. The portfolios hedging using Options and Zero Cost Cylinder strategy showed improved results for standard deviation because both the hedging strategy were able to lower the standard deviation but with the lower risk it was observed that the returns were also reduced thus depleting the performance. When comparing the average monthly Sharpe ratio on year on year basis, it was found that the number of times the portfolio hedged using No Hedge and Forward strategy dominated the other strategies were equal. Also, the performance of Option hedged portfolio was identified to worse.

During the period of Financial Crisis, the No Hedge strategy was also able to improve the performance of the portfolio. It was concluded that during the period of Financial Crisis, the hedging strategies like the Forwards, Options and Zero Cost Cylinder were unable to reduce the standard deviation of the portfolio thus losing their risk-reducing capacity.

The results of the z-test also indicate that no statistical difference exist between the Sharpe ratios of the portfolios hedging using No Hedge strategy or hedged using the strategy of Forward, Options and Zero Cost Cylinder. Thus, it is not beneficial for a

UK investor to hedge the portfolio when investing in the US markets since no significant difference exist in the performance of the portfolios.

The research also identified a relationship between the trend in the currency exchange rate and the effectiveness of hedging strategies. It was found that the No Hedge strategy was able to improve the performance of the international portfolio when the home currency depleted against the foreign currency. For this research, the No Hedge strategy was able to provide improved results when Sterling devalued against USD Dollars. For most of the period, it has been observed that there was an overall decrease in the GBP/USD spot rate which maybe the reason for an overall better performance of the No Hedge portfolio. But the performance of the portfolio hedged using the Forward and the Zero Cost Cylinder strategy showed improvements when the Dollar depreciated against the Sterling. Accordingly, it would be interesting to carry out a future research on a similar topic but from a perspective of a US investor investing in the UK markets. It would help to determine the performance of hedging strategies when the home currency is appreciating. Also, a more robust test of studentized time series bootstrap could be contemplated in the analysis to carry out the test of hypothesis.

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Appendix

Appendix 1: Average monthly returns and standard deviation of the portfolio

Year	No Hedge		Forwards		Options		Zero Cost Cylinder	
	Returns	Risk	Returns	Risk	Returns	Risk	Returns	Risk
1998	1.851%	6.66%	2.242%	6.08%	1.579%	6.08%	-	-
1999	1.493%	5.22%	1.369%	4.27%	1.259%	4.58%	-	-
2000	-0.338%	4.85%	-1.177%	4.42%	-0.986%	4.79%	-	-
2001	-0.565%	6.89%	-0.510%	6.56%	-0.778%	6.50%	-	-
2002	-2.801%	5.43%	-1.748%	4.39%	-2.453%	4.41%	-	-
2003	0.670%	4.55%	1.682%	3.88%	1.542%	3.74%	0.962%	3.65%
2004	0.176%	2.19%	1.236%	1.77%	0.684%	1.82%	0.582%	1.95%
2005	1.173%	3.89%	0.475%	2.34%	0.873%	3.36%	0.743%	3.01%
2006	-0.008%	2.47%	0.635%	1.41%	0.311%	1.57%	0.514%	2.01%
2007	0.053%	3.05%	0.372%	3.06%	0.132%	2.92%	0.153%	2.85%
2008	-1.097%	8.23%	-3.340%	8.85%	-2.328%	8.12%	-2.742%	8.56%
2009	0.824%	7.48%	1.403%	8.90%	0.808%	8.36%	1.283%	7.41%
2010	1.278%	5.19%	0.851%	5.78%	1.095%	5.38%	0.934%	5.09%
2011	-0.186%	3.96%	0.188%	5.06%	-0.018%	4.36%	0.211%	4.50%
2012	0.813%	2.52%	1.225%	4.03%	0.880%	2.86%	0.645%	3.41%
2013	1.777%	4.03%	1.844%	3.10%	1.934%	3.49%	1.718%	3.54%
2014	1.561%	3.01%	1.002%	3.03%	1.314%	2.97%	1.436%	2.88%
2015	0.153%	3.60%	-0.227%	4.51%	-0.144%	3.94%	-0.224%	3.70%
2016	2.495%	3.23%	0.745%	2.15%	1.714%	2.44%	1.961%	2.81%
2017	0.604%	2.88%	1.673%	1.75%	0.988%	2.23%	0.860%	2.72%
2018	-0.057%	5.23%	-0.580%	4.93%	-0.443%	5.45%	-0.035%	5.16%

Appendix 2: R function to compute the *p*-values

```
Function: hac.inference (.GlobalEnv)
1 function(ret, digits = 3)
2 {
3     ret1 = ret[, 1]
4     ret2 = ret[, 2]
5     mu1.hat = mean(ret1)
6     mu2.hat = mean(ret2)
7     sig1.hat = sd(ret1)
8     sig2.hat = sd(ret2)
9     SR1.hat = mu1.hat / sig1.hat
10    SR2.hat = mu2.hat / sig2.hat
11    SRs = round(c(SR1.hat, SR2.hat), digits)
12    diff = SR1.hat - SR2.hat
13    names(SRs) = c("SR1.hat", "SR2.hat")
14    se = compute.se.Parzen(ret)
15    se.pw = compute.se.Parzen.pw(ret)
16    SEs = round(c(se, se.pw), digits)
17    names(SEs) = c("HAC", "HAC.pw")
18    PV = 2 * pnorm(-abs(diff)/se)
19    PV.pw = 2 * pnorm(-abs(diff)/se.pw)
20    PVs = round(c(PV, PV.pw), digits)
21    names(PVs) = c("HAC", "HAC.pw")
22    list(Sharpe.Ratios = SRs, Difference = round(diff, digits),
23         Standard.Errors = SEs, p.Values = PVs)
24 }
25
```

This function is programmed in R software and this helps to find the *p value* to compare the difference between the Sharpe ratios of the portfolios.

This R code is provided by Lediot and Wolf (2008) and can be found on:

<https://www.econ.uzh.ch/en/people/faculty/wolf/publications.html#9>

Appendix 3: VBA function to compute the Option Strike price for Zero Cost Cylinder

" This function finds the strike of an option with a particular delta

```
Function getStrike(spot, delta, timeToMaturity, baseInterestRate, counterInterestRate, volatility) As Double
Dim K1, K2, K3 As Double
Dim f1, f2, f3 As Double
Dim difference, tolerance As Double
Dim callPut As String
Dim COUNTER
difference = 100
tolerance = 0.0001
COUNTER = 0
If delta > 0 Then
callPut = "C"
ElseIf delta < 0 Then
callPut = "P"
Else
End If
End If
K1 = 0.5 * spot
K3 = 2 * spot
While difference > tolerance And COUNTER < 100

K2 = (K1 + K3) / 2
COUNTER = COUNTER + 1
f1 = optionDelta(spot, K1, volatility, counterInterestRate, baseInterestRate, timeToMaturity, callPut) - delta
f2 = optionDelta(spot, K2, volatility, counterInterestRate, baseInterestRate, timeToMaturity, callPut) - delta
f3 = optionDelta(spot, K3, volatility, counterInterestRate, baseInterestRate, timeToMaturity, callPut) - delta

If Sgn(f1) = Sgn(f2) Then
K1 = K2
ElseIf Sgn(f3) = Sgn(f2) Then
K3 = K2
End If

difference = Abs(f2)

Wend

getStrike = K2
```

End Function

```
Function getStrikeGivenPremium(spot, callPut, timeToMaturity, baseInterestRate, counterInterestRate, volatility, optPremium) As Double
Dim K1, K2, K3 As Double
Dim f1, f2, f3 As Double
Dim difference, tolerance As Double
Dim COUNTER
difference = 100
tolerance = 0.0001
COUNTER = 0

K1 = 0.5 * spot
K3 = 2 * spot

While difference > tolerance And COUNTER < 100

K2 = (K1 + K3) / 2
COUNTER = COUNTER + 1
f1 = optionPrice(spot, K1, volatility, counterInterestRate, baseInterestRate, timeToMaturity, callPut) - optPremium
f2 = optionPrice(spot, K2, volatility, counterInterestRate, baseInterestRate, timeToMaturity, callPut) - optPremium
f3 = optionPrice(spot, K3, volatility, counterInterestRate, baseInterestRate, timeToMaturity, callPut) - optPremium

If Sgn(f1) = Sgn(f2) Then
K1 = K2
ElseIf Sgn(f3) = Sgn(f2) Then
K3 = K2
End If

difference = Abs(f2)

Wend

getStrikeGivenPremium = K2

End Function
```

The getStrike function helps to find the Strike price of the Call Option for a particular delta.

The getStrikeGivenPremium function takes into consideration the premium of the Call Option using the Black Scholes model (Appendix 4) using the Call Option Strike price computed using the getStrike function. Thus, the Strike Price of the Put Option is calculated in such a way that the net cost for buying both the Options is equal to zero.

Both the functions use the method of **Internal Bisection** to find the Strike prices. The function also considers the Risk Reversal rates to find the Strike prices of the Options in Zero Cost Cylinder Strategy. Risk reversal rate is difference between the implied volatilities of the Out of the money Call and Out of the money Put Options. So, a positive risk reversal rate implies that the participants in the market are expecting the rise in the currency and vice versa for the negative rates. Thus, it helps to find the behavior of the participants in the markets.

Appendix 4: VBA function to calculate the Option Premium

Option Explicit

```
Function optionPrice(ByVal spot As Double, ByVal strike As Double _
    , ByVal volatility As Double, ByVal intrate As Double _
    , ByVal divYield As Double, ByVal timeToMaturity As Double _
    , callPut) As Double
```

'This function helps to find the Option Premium

```
Dim d1, d2 As Double
```

```
d1 = (Log(spot / strike) + (intrate - divYield + volatility * volatility * 0.5) * timeToMaturity) / (volatility * Sqr(timeToMaturity))
d2 = d1 - volatility * Sqr(timeToMaturity)
```

```
If callPut = "C" Then
```

```
    optionPrice = spot * Exp(-divYield * timeToMaturity) * normalDist(d1) - strike * Exp(-intrate * timeToMaturity) * normalDist(d2)
```

```
Elseif callPut = "P" Then
```

```
    optionPrice = strike * Exp(-intrate * timeToMaturity) * normalDist(-d2) - spot * Exp(-divYield * timeToMaturity) * normalDist(-d1)
```

```
Else
```

```
End If
```

```
End Function
```

The optionPrice VBA function uses the Black Scholes-Merton pricing formula as stated by Hull (2015, p. 335). It takes into consideration the variables of the Spot price, Strike price, Volatility, Dividend yield, time to maturity to find the premium of the Call Option and the Put Option.