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**Forwards versus Options:
Effectiveness in Hedging Currency Risk in International
Portfolios**

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ABSTRACT

This paper aims to examine effectiveness of currency hedging of forward contracts and options in international portfolio, consisting of assets denominated in Chinese Yuan and Indian Rupee. Instead of applying Markowitz's portfolio optimization, mean-CVaR framework is used in order to deal with non-normality of return of financial assets as well as exchange rates. In this paper, the finding shows that hedging strategies, either with forwards or options yield better performance compared to unhedged strategy. In this research, there is no clear conclusion whether forward contracts or put options outperforms one another. The conclusion is different at different level of strike prices. Forward contract is more effective compared to put option with strike price of 1%, 5% and 10% above spot rate whereas put option with strike price of 15% above spot rate is more effective compared to forwards in term of hedging currency risk in international portfolio.

Keywords: Currency Hedging, International Portfolios Diversification, Currency Forward Contracts, Currency Put Options.

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1. INTRODUCTION

1.1 Background

Since 1990s, international financial integration has increased dramatically. Many individual investors and institutional portfolio managers do not only invest domestically, but also diversify their capital to other foreign countries. It is assumed that international assets have a low correlation, relative to domestic assets. Consequently, international investment is expected to reduce volatility, and help increase diversification. The move toward international investment could be seen in significant growth in annual gross cross-border flows [1], from approximately 5% of world GDP in the mid-1990s to around 20% in 2007 (OECD, 2011).

International portfolio is inevitably exposed to currency risk, as its market value is subject to fluctuation in exchange rate. International investors are at risk of incurring losses, when converting investment return from foreign back into base currencies. Therefore, it is important for financial institutions as well as investors to consider currency hedging as a mean to mitigate currency risk; hence the expected return of the investment can be maintained. The basic principle behind currency hedging is to “convert or exchange the currency while the rate of exchange is favorable, and then make the investment with currency that is native to the country of origin where the investment is based” (Patil, 2012). This approach is adopted to protect the investor against fluctuation in currency exchange rate, and thereby preventing monetary loss.

1.2 Problem Discussion

Forward contracts and options are tools that are commonly used to hedge against currency risk. Though many researches have been studying the effectiveness of forwards and options in currency risk hedging; there is no consensus which tool outperforms one another. The performance of each hedging tool, in terms of currency risk hedging, varies across different papers. Eun and Resnick (1997) as well as Topaloglou, et al. (2007) found that forward-hedged portfolio appeared to outperform optimally-hedged portfolio with put option. On the contrary, Maurer and Valiani (2007) concluded that European put in-the-money option has potential to substitute portfolio that is optimally hedged with forward. In

their paper, it appeared that small investment in European put in-the-money option could yield currency hedging benefit, as much does the optimally forward-hedged portfolio.

In the past years, most of the empirical research in the field of international diversification has focused on investment in assets denominated in currencies of developed countries. Only a few studies have examined currency hedging in emerging markets. For example, Lessard (1973) mainly focused on Latin American countries. Hauser et al, (1994) compared international portfolios invested in developed and emerging markets. Bekaert and Urias (1996) focused in the emerging markets such as in Latin America, Asia, and the Middle East. Moreover, Bugar and Maurer (2002) explored the benefits of investing in emerging European countries such as Hungary.

International portfolios with only assets denominated in currencies of developed countries no longer reflect real-world situation. Therefore, many financial institutions and individual investors are starting to shift their investments from developed regions into emerging markets. Capital flows to emerging economies have surged dramatically after Subprime crisis in 2008. Moreover, less stringent monetary policy in developed countries, particularly in United States makes investment return in this region unattractive. Additionally, significant economic growths as well as higher interest rates make emerging markets more appealing among investors. Capital inflows to emerging economics are expected to increase from \$1,080 billion in 2012, to \$1,118 billion in 2013. The inflows are anticipated to increase even more in 2014, to \$1,150 billion (Institute of International Finance, 2013).

Interestingly, emerging Asia is considered to be attractive investment destination, compared to other emerging markets. Real GDP growth of emerging Asia is estimated to be approximately around 7% in 2013 and 2014, which is higher relative to 3% to 4% growth of the rest of emerging markets. Share of emerging Asia in total private capital flows to emerging markets is forecasted to be average 46% in 2013. Among countries in emerging Asia, China and India appear to be appealing to many investors. Capital inflows to China have increased sharply over the past decade. Chinese inflows account for about 40% of all inflows in 30 major emerging market economies. The total capital inflow for the year 2012 was of \$370.4 billion, and capital inflow is expected to be \$313.1 billion in 2013, and \$312.6 billion in 2014. India capital inflows are also increasing rapidly. India total capital inflow in

the year 2012 was of \$7.6 billion; and expected to be \$21 billion in 2013 (Institute of International Finance, 2013).

Since few literatures in the field of international hedging have been focusing on emerging countries such as Latin America, Hungary, South East Asia, and the Middle East; together with outstanding performance of India and China in global economy, this paper aims to fill a missing gap and take an opportunity to study currency hedging effectiveness of international portfolio that take into account Chinese and Indian market.

1.3 Research Question

‘Which hedging tools, forward or option outperforms one another, in terms of currency hedging in international portfolio, consisting of assets denominated in Chinese Yuan and Indian Rupee?’

1.4 Scope and Delimitation

This paper examines currency-hedging effectiveness in international portfolios from the viewpoint of European investors. The international portfolio consists of equities and government bonds denominated in five different currencies, which are British Pounds, US Dollars, Euro, Indian Rupee, and Chinese Yuan. Among these currencies, British Pounds, US Dollars, Euro are considered to be the currencies of developed countries, while Indian Rupee and Chinese Yuan are accounted to be the currencies of emerging countries. Portfolio performance would be assessed at one-month horizon. The period starts from January 2005 until December 2012.

1.5 Disposition

The structure of this research will be as follows: Section 2 discusses literature review, section 3 gives some necessary theoretical background, section 4 briefly describes the data that is used for the analysis. Whereas section 5 explains methodologies applied to measure hedging effectiveness, section 6 is finding and empirical results. Finally, section 7 provides summary and concluding remarks of this research.

2. LITERATURE REVIEW

Many research papers have been studying the effectiveness of forwards and options in currency risk hedging. Lessard (1973) took the viewpoint of a US-investor and studied the diversification benefits of an investment into Latin American countries, which included Colombia, Chile, Argentina, and Brazil. He applied multivariate analysis to determine diversification benefit in international portfolio, and concluded that investing in Latin America created gains within the portfolio, which is attractive to non-Latin American investors.

Hauser, *et al.*, (1994) compared hedged and unhedged equity portfolios in developed and emerging markets. In his study, Value-at-Risk portfolio optimization framework was implemented. He found that hedging currency risk in emerging markets enhances portfolio performance, but at a cost of substantial increase in risk. Only investor who can tolerate more risk can take advantage of diversifying their portfolio into emerging markets.

Harvey (1995) compared the benefits of investing in emerging markets. His research included six Latin American markets (Argentina, Brazil, Chile, Colombia, Mexico, Venezuela), eight Asian markets (India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Taiwan, Thailand), three European markets (Greece, Portugal, Turkey), and two African markets (Nigeria, Zimbabwe). In his research, he used mean-variance portfolio optimization framework. He concluded that it is possible to lower portfolio risk when participating in emerging markets. This result is due to the correlations of equity returns in emerging market tend to have low correlation with those of developed countries.

Eun and Resnick (1997) implemented two strategies used to hedge against currency exchange risk. First strategy applied forwards contracts; and second strategy used protective put option to mitigate the currency risk exposure. Their research focused on developed markets which included Canada, France, Germany, Japan, Switzerland, UK, and US. They used mean-variance framework to optimize international portfolios, and concluded that the use of forward contracts yield better performance in comparison with the protective put options.

Roon, *et al.* (1999) tested the performance of using forward contracts in terms of hedging currency risk in international stock portfolio from a US investor perspective. The paper

focused only in developed markets within G5 countries, which includes United States, France, Germany, Japan, and United Kingdom. In this paper, regression framework is used to assess hedging performance in three different cases which are mean-variance case, non mean-variance case and case with nontraded risk. The paper concluded that “static hedging with currency forwards does not lead to improvements in portfolio performance for a US investor that holds a stock portfolio from the G5 countries. On the other hand, hedges that are conditional on the current interest rate spread do lead to significant performance improvements” (Roon, *et al* 1999,p.1).

Lien and Tse (2001) studied hedging effectiveness of futures and options in portfolio denominated in three currencies the British Pound, the Deutsche Mark, and the Japanese Yen. In this paper, Lower Partial Moment (LPM) is used in order to evaluate hedging effectiveness of futures contracts and options. The paper concluded that the use of currency future contracts almost always outperforms the use of option in currency hedging. “The only situation in which options outperforms futures is when the individual hedger is optimistic (with a large target return) and not too concerned about larger losses (so that large losses do not impose greater weights than small losses)” (Lien and Tse, 2001, p.13).

Bugar and Maurer (2002) contrasted the benefits from international diversification with futures in a developed stock market, Germany, with those in an emerging market, Hungary. Throughout their paper, mean-variance framework is used to generate three different investment strategies. Different hedging policies are also implemented in this paper in order to observe hedging effectiveness. The study concluded that global investment yields better investment performance compared to domestic investment. It found out that gains from international diversification in the perspective of Hungarian investors are more observable compared to that of German investors. Moreover, the paper suggested that optimally hedged portfolio does not necessarily yield better performance than the fully hedged one.

Maurer and Valiani (2007) explored diversification benefit of forward contracts and European put options for hedging currency risk. The research paper included five developed countries, which are Switzerland, Japan, Germany, US, and UK. Also, it included the mean-lower partial moment (LPM) to determine performance of forward and European put option in mitigating risk in multi-currency portfolio. They found that forward-hedged portfolio appeared to outperform optimally-hedged portfolio with European put option. Only European

put in-the-money option has potential to substitute the portfolio that is optimally hedged with forward. In their paper, it appeared that small investment in European put option could yield currency hedging benefit, as much does the optimally forward-hedged portfolio.

Topaloglou, *et al.* (2007) evaluated performance of forward contracts and currency put options, consisting of assets denominated in British Pound, German Mark, and Japanese Yen. The research paper employed mean-CVaR framework to minimize the excess losses beyond predetermined thresholds, and concluded that international portfolio with forward appeared to be superior than portfolio hedged with currency put options. However, when combining several put options with different strike prices, different expiration, or even long and short positions together, complex put option strategy e.g. Bear Spread strategy [2] yielded a better result compared to forward contracts.

Campbell (2010) considered hedging strategies of stocks and bonds denominated in seven major developed-market currencies which included: US Dollar, Euro, Japanese Yen, Swiss Franc, British Pound, Canadian Dollar and Australian Dollar. In his paper mean-variance portfolio optimization framework was implemented to evaluate the different portfolio strategies. The paper concluded that risk-minimizing currency strategy for a global bond investor is close to a full currency hedge; the optimal position of these seven currencies is to long the US Dollar, Swiss Franc, and Euro; and simultaneously short the remaining currencies.

Despite the fact forward contracts appears to outperform options in many literatures, there is no consensus whether forwards or options outperforms one another. The performance of each hedging tool, in terms of currency risk hedging, varies across different settings. Moreover, only few literatures study about hedging effectiveness in emerging market. For this reason, this paper aims to fill a missing gap and take an opportunity to study currency hedging effectiveness of forwards and options in international portfolio that take into account emerging markets of China and India.

3. THEORETICAL BACKGROUND

3.1 Currency Hedging Tools: Forwards and Options

There are two very common tools used for hedging against currency exchange risk, which include forward contracts and options. A currency forward contract is an agreement that obligates two parties either to buy (long position) or sell (short position) foreign currency at a current spot rate, at a certain specified future date, and at a specified forward exchange rate. On the other hand, a currency options is a contract that gives the right but not the obligation to buy or sell foreign currency at a specific exchange rate at or before a specified date. However, option holders need to pay the premium in any circumstance of fluctuation in exchange rate. There are two different types of options, which are a call and a put option. A call option gives the holder the right to buy foreign currency at a specified rate at a determined date. A put option gives the holder the right to sell foreign currency at a specified rate at a determined date.

Both forwards and options have advantages and disadvantages. Forward contracts help create stability to both ends of the transaction are ensured to receive exact amount of money, regardless of fluctuations in exchange rate in the future. Although forwards limit the losses in the case of unfavorable change in exchange rate, the contracts also limit positive potential gains and extra profits that investors are entitle to get in the event of a favorable movement in exchange rate (Western Union Business Solutions, 2013). Similarly, options also help protect against unfavorable fluctuation in exchange rate. In addition, options have comparative advantage in term of flexibility. The holders could choose to abandon options in the event of favorable movement in exchange rate, and exercise the contracts in the event of unfavorable movement in exchange rate. Thus, options help limit loss up to option premium, but not limit upside gain. Nevertheless, flexibility comes with cost. Option holders are required to pay option premium, which could not be recovered in any circumstance.

Forwards and options could be used differently to hedge against currency risk, depending on the effect of fluctuation in exchange rate on particular agents. For agents who need to buy foreign currencies with local currencies, appreciation in foreign currencies would have negative impact to them. This is because more local currencies are needed in order to afford same amount of foreign currencies. In other words, this type of agent has to pay more when foreign currencies appreciate. In order to hedge against foreign currency appreciation, the

agent would take long position in forward, or buy call option to lock the exchange rate that will be applied when they have to buy foreign currencies in the future.

On the other hand, currency depreciation in foreign currencies tends to have negative effect on agents who need to sell foreign currency in exchange for local currencies. This is because less local currencies would receive out of same amount of foreign currencies when foreign currencies depreciate. To hedge against foreign currency depreciation, this type of agent would take short position in forward, or buy put option to lock the rate they have to sell foreign currencies in exchange for local currencies in the future.

Figure 1: *Currency Hedging*

Currency Appreciation		Currency Depreciation	
Long position in forwards	Long position in foreign currency call options	Short position in forwards	Long position in foreign currency put options

3.2 Downside Risk Measure

In finance theory, risk is defined as loss of investment. There are different kinds of risks in finance industry. However, it appears that symmetric risk is commonly used in finance industry, due to its simplicity. By definition, symmetric risk is described as “a gain that occurs when the move in the underlying asset in one direction is similar to the loss when the underlying asset moves in the opposite direction” (Barron’s Insurance Dictionary, 2013). Nevertheless, symmetric risk is subject to criticism for treating return and loss equally. “Intuitively, it makes more sense to punish the investor or fund manager for low returns, and reward for high returns” (Bourachnikova and Yusupov, 2009).

Due to the criticism, downside risk is introduced in order to capture negative returns. This risk could be calculated with different measures, especially with Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) as following

Value at Risk (VaR)

Value-at-Risk (VaR) is a percentile of a loss distribution. $VaR_{\alpha}(X)$ is defined as a lower α -percentile of the loss (X). In the paper of Sarykalin et al (2008), $VaR_{\alpha}(X)$ is derived mathematically as following,

$$VaR_{\alpha}(X) = \min\{z | F_X(z) \geq \alpha\}; \alpha \in [0, 1]$$

where X is a random variable, which in this case is loss

$$F_X(z) \text{ is cumulative distribution function, } F_X(z) = P\{X \leq z\}$$

Conditional Value at Risk (CVaR)

Conditional Value-at-risk (CVaR) was introduced by Rockafellar and Uryasev (2000). It is often proposed as an alternative percentile measure of risk. CVaR is also known as Expected Shortfall (ES), and usually defined as the expected value of losses exceeding VaR. In the paper of Sarykalin et al (2008), $CVaR_{\alpha}(X)$ is derived mathematically as following

$$CVaR_{\alpha}(X) = \int_{-\infty}^{\infty} z dF_X^{\alpha}(z); \alpha \in [0, 1]$$

$$\text{where } F_X^{\alpha}(z) = \begin{cases} 0, & \text{when } z < VaR_{\alpha}(X), \\ \frac{F_X(z) - \alpha}{1 - \alpha}, & \text{when } z \geq VaR_{\alpha}(X). \end{cases}$$

Based on Acerbi (2002), CVaR can also be equivalently derived as following,

$$CVaR_{\alpha}(X) = \frac{1}{\alpha} \int_0^{\infty} VaR_{\beta}(X) d\beta$$

Comparative Analysis of VaR and CVaR

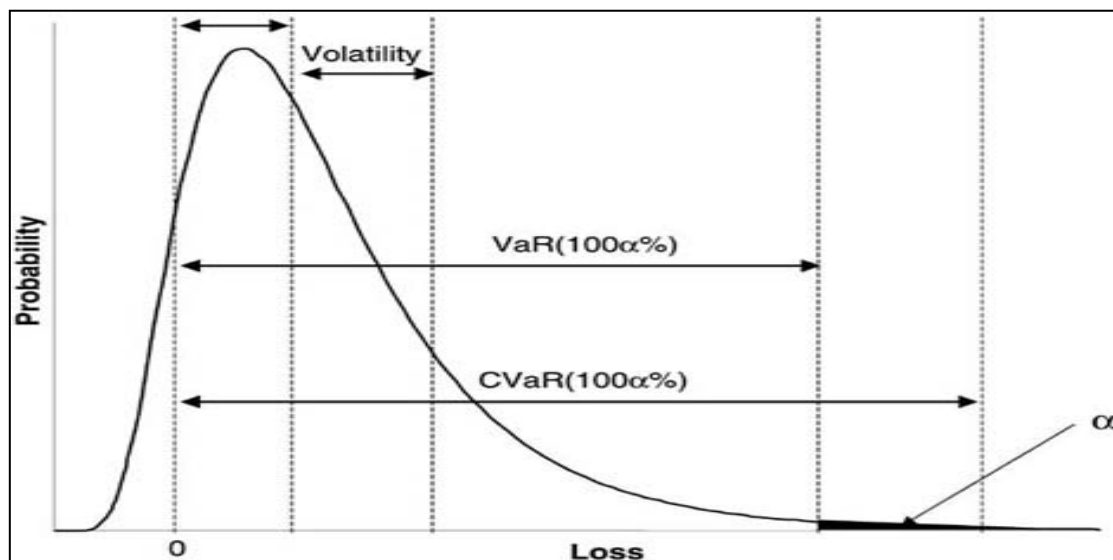
VaR and CVaR are downside risk measures. However, these two measures are different in certain aspects as following

Figure 2: *VaR and CVaR table comparison*

Characteristics	VaR	CVaR
Size of losses	Silent about size of losses	Indicate about size of losses
Coherent risk measure	No	Yes
Portfolio Optimization	Hard	Easy
Stochastic Dominance Order	First-Order Stochastic Dominance	Second-Order Stochastic Dominance

By definition, VaR indicates only how much one could lose with specified confidence level, but is silent about magnitude of the losses if tail events happen. In other words, VaR does not indicate about maximum possible losses. Unlike VaR, CVaR quantifies size of loss given that a tail-event has occurred. The relationship between VaR and CVaR is shown in figure 3. This characteristic makes CVaR superior to VaR in exhibiting a strategy with an asymmetrical risk profile, such as for writing options. It can capture the minimal probability of a substantial loss for such strategy. In contrast, the VaR for this kind of strategy would fail to reflect the potential magnitude of losses (Jorion 2007). It may cause investors to encounter high risk unintentionally.

Figure 3: VaR and CVaR graph comparison



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CVaR has some attractive mathematical characteristics; relative to VaR. CVaR is a coherent risk measure. In contrary, VaR is not a coherent risk measure, because it is not satisfy sub-additive property, meaning that VaR of portfolio may be greater than sum of VaR of individual assets. In other words, VaR does not satisfy risk diversification property.

VaR portfolio optimization is very hard, especially for losses that are not normally distributed. Its non-convex characteristic makes optimization with VaR has multiple local minima. This makes VaR optimization a challenging computational problem. Portfolio optimization with CVaR, on the other hands, is much easier. Because CVaR is a convex function of portfolio positions, it could be expressed by minimization formula, and reduced to

linear programming. This is confirmed by Rockafellar and Uryasev (2000). They showed that when portfolio losses are estimated using a nonparametric method, portfolio risk is more easily optimized by using CVaR than VaR.

VaR and CVaR are also different in term of stochastic dominance order. “VaR is consistent with expected utility maximization only if portfolio can be ranked by first order stochastic dominance; while CVaR is consistent with expected utility maximization if portfolios can be ranked by second order stochastic dominance” (Nilsson, 2013).

3.3 Portfolio Optimization

Markowitz’s Portfolio Optimization

Mean-variance portfolio optimization of Markowitz (1952) indicates that agents optimally select mean-variance efficient portfolios based on tradeoff between mean and variance of portfolio. Based on the theory, efficient portfolio should yield the lowest risk for a given expected return. This model is a cornerstone of modern portfolio theory, and widely used in many financial applications. It is employed in determining optimal asset allocation, measuring gains from international diversification, and evaluating portfolio performance (Alexander et al., 2007).

The classical mean-variance portfolio optimization is formulated as following

$$\text{Minimize} \quad \sum_{i,j=1}^n w_i w_j \sigma_{ij}$$

Subject to

$$\sum_{i=1}^N w_i E(R_i) = R_p$$

$$\sum_{i=1}^N w_i = 1 \text{ where } w_i \geq 0, i = 1, 2, \dots, N$$

where w_i is the optimal weight of portfolio allocated to asset i

$w_i \geq 0$ means short-sales are excluded because we focus on institutional investor

R_i is return of individual assets

R_p is the expected portfolio return

Mean-CVaR Portfolio Optimization

Mean-CVaR portfolio optimization is an extension of classical mean-variance model. In their paper, Rockafellar and Uryasev (2000) defined a substitute function of CVaR as following

$$F_\alpha(x, \zeta) = \zeta + \frac{1}{1-\alpha} E\{[f(x, y) - \zeta]^+\}$$

where $f(x, y)$ is a loss function with decision vector x and vector y of risk factor.

For example, loss function of portfolio with two assets could be written as

$$f(x, y) = -(x_1 y_1 + x_2 y_2)$$

where x_1 and x_2 are weights of the portfolio

y_1 and y_2 are rates of returns of two assets

In this sense, $F_\alpha(x, \zeta)$ optimization would yield same result as CVaR optimization. $F_\alpha(x, \zeta)$ can be used to replace CVaR in optimization as following

$$\text{Minimize} \quad F_\alpha(x, \zeta) = \zeta + \frac{1}{1-\alpha} E\{[f(x, y) - \zeta]^+\}$$

$$\text{Subject to} \quad f(x, y) - \zeta - \eta_k \leq 0$$

$$\eta_k \geq 0, k = 1, 2, \dots, N$$

where ζ is VaR_α

$$\eta_k = [f(x, y) - \zeta]^+$$

Consequently, mean-CVaR portfolio optimization is formulated as following

$$\text{Minimize} \quad F_\alpha(x, \zeta) = \zeta + \frac{1}{1-\alpha} E\{[f(x, y) - \zeta]^+\}$$

$$\text{Subject to} \quad \sum_{i=1}^N w_i E(R_i) = R_p$$

$$\sum_{i=1}^N w_i = 1$$

$$f(x, y) - \zeta - \eta_k \leq 0$$

$$\eta_k \geq 0, k = 1, 2, \dots, N$$

$$w_i \geq 0, i = 1, 2, \dots, N$$

Comparative Analysis of mean-variance and mean-CVaR framework

Figure 4: Mean-Variance and Mean-CVaR framework comparison

Characteristic	Mean-Variance framework	Mean-CVaR framework
Risk measure	Symmetric	Downside
Second Order Stochastic Dominance	No	Yes

Mean-variance and mean-CVaR framework are different in terms of risk measures. Mean-variance model has variance that captures symmetric risk. This model equally penalizes gains and losses, so it fails to capture low probability events, such as default risk (Bengtsson, 2010). On the other hands, mean-CVaR model utilize CVaR to measure downside risk. It can be defined as average of all losses below quintile threshold.

In addition to risk measures, these frameworks also differ in term of stochastic dominance order. “The Markowitz is not consistent with second order stochastic dominance (SSD), since its efficient sets may contain portfolios characterized by a small risk, but also very low return” (Porter and Gaumnitz, 1972). On the other hands, CVaR is consistent with SSD. “In particular, the consistency with the stochastic dominance implies that minimizing the CVaR never conflicts with maximizing the expectation of any risk-averse utility function” (Takano, 2010, p.3).

4. DATA

Equities indices are used as representative of equity market in each country. In this paper, MSCI equities indices, consisting of MSCI EMU E, MSCI USA, MSCI UK, and MSCI INDIA are used as representative of equity market in Europe, United States, United Kingdom and India. In addition, Shanghai Stock Exchange Composite Index is used to represent Chinese equity market. Note that every equity indices are value-weighted of major companies based on market capitalization.

In addition, government bond indices are used as representative of bond markets in each country. In this paper, clean price index of UK benchmark 10-year government bond index, EMU benchmark 10-year government bond index, US benchmark 10-year index, as well as FTSE Chinese government bond index 10+ years are used to represent long-term bond market in United Kingdom, Europe, United States and China. Moreover, total return index of India benchmark 8+ years government bond index is used to represent long-term bond market in India.

As this paper aims to investigate hedging effectiveness in the view of European-based investors, exchange rates and forward rates in term of domestic currency per foreign currency are used as parts of our data. To be more precise, exchange rate and one-month forward exchange rate of Euro per British Pound, Euro per US Dollar, Euro per Chinese Yuan, and Euro per Indian Rupee are used within this research.

In this paper, data of equities and bonds indices returns as well as exchange rates are not normally distributed. Based on table 1, 2 and 3, skewness of equities and bonds indices returns denominated in each currency as well as exchange rates are not equal to zero, indicating that the data is not normally distributed [3]. As equities indices returns have negative skewness, the distribution of equity market is skewed to the left [4]. On the contrary, bond indices returns have positive skewness, meaning that distribution of the bond market is skewed to the right [5]. In addition, exchange rates have both positive and negative skewness. US Dollar has negative skewness indicating left skewed, while British Pound, Chinese Yuan and Indian Rupee have positive skewness indicating right skewed. Moreover, kurtosis for equities and bonds indices returns denominated in each currency as well as exchange rates are not equal to three, implying that the data is not normally distributed [6]. As equities and bonds indices returns have positive excess kurtosis, this indicates that the data of equities and bonds indices returns have Leptokurtic distribution [7]. Non-normality

characteristic of equities and bonds indices returns as well as exchange rates are also confirmed by Jarque-Bera (J/B) test [8]. Based on table 1, 2 and 3, most of the returns of equities and bonds indices as well as exchange rates are statistically significant at 5 percent significant level. Thus, null-hypothesis of normal distribution is rejected.

Table 1: Descriptive Statistics of Equities Indices

Equities Indices Returns	EUROZONE	US	UK	CHINA	INDIA
Mean	0.000586	0.002137	0.001950	0.009793	0.011312
Median	0.010732	0.013122	0.010867	0.014848	0.022258
Maximum	0.125244	0.112848	0.086087	0.199945	0.210252
Minimum	-0.220184	-0.235000	-0.200310	-0.284278	-0.295632
Std. Dev.	0.055146	0.044954	0.043108	0.072182	0.072902
Skewness	-0.890794	-1.758469	-1.376960	-0.572854	-0.897552
Kurtosis	5.208951	10.25887	7.307978	5.088311	6.031038
Jarque-Bera	31.87850	257.5293	103.4817	22.45836	49.12130
Probability	0.000000	0.000000	0.000000	0.000013	0.000000

Table 2: Descriptive Statistics of Bond Indices

Bond Indices Return	EUROZONE	US	UK	CHINA	INDIA
Mean	0.002449	0.002443	0.002773	0.001663	0.003289
Median	0.002201	0.002446	0.001911	-0.000827	0.002076
Maximum	0.048577	0.094240	0.071103	0.066383	0.119930
Minimum	-0.030087	-0.047832	-0.055420	-0.038084	-0.066778
Std. Dev.	0.015207	0.019471	0.017342	0.015791	0.021941
Skewness	0.481814	1.103566	0.596702	1.085573	1.547286
Kurtosis	3.550090	7.771608	5.855998	5.895353	11.06142
Jarque-Bera	4.873408	109.4070	37.92455	51.84206	295.1447
Probability	0.087449	0.000000	0.000000	0.000000	0.000000

Table 3: Descriptive Statistics of Exchange Rates

Exchange rate (per €)	US DOLLAR	BRITISH POUND	CHINESE YUAN	INDIAN RUPEE
Mean	0.748385	1.288953	0.105650	0.016322
Median	0.755663	1.252361	0.103941	0.016192
Maximum	0.848838	1.506925	0.127660	0.019105
Minimum	0.634593	1.086653	0.090735	0.013940
Std. Dev.	0.051247	0.144164	0.009879	0.001436
Skewness	-0.239460	0.252954	0.496467	0.187159
Kurtosis	-0.482993	-1.603737	-0.760459	-1.186994
Jarque-Bera	48.927399	84.907576	59.877581	69.947849
Probability	0.000000	0.000000	0.000000	0.000000

There is no data of currency put option price available on Datastream. Consequently, price of European currency put option [9] is calculated based on option pricing model derived by Biger and Hull (1983) and Garman and Kohlhagen (1983). The formula of European put option price is as following,

$$P_t = -SX_t \exp(-r_f(T-t))N(-d_1) + K \exp(-r(T-t))N(-d_2)$$

where

$$d_1 = \frac{\ln\left(\frac{SX_t}{K}\right) + (r - r_f)(T - t)}{\sigma\sqrt{T - t}} + (1/2)\sigma\sqrt{T - t}$$

$$d_2 = \frac{\ln\left(\frac{SX_t}{K}\right) + (r - r_f)(T - t)}{\sigma\sqrt{T - t}} - (1/2)\sigma\sqrt{T - t}$$

where P_t is price of a European put option that mature at time t

SX_t is spot exchange rate at time t (local currency/foreign currency)

r is risk-free rate in local currencies (Euro)

r_f is risk-free rate in foreign currencies

$T - t$ is time to maturity (1 month)

σ is volatility of return on log of spot rates [10]

K is the strike price

For the purpose of evaluating hedging effectiveness, at-the-money and out-of-the-money put options are disregarded; and only in-the-money put options are focused in this paper. This is because at-the-money and out-of-the-money put options are not going to be lapsed. Investors are going to trade currency in spot market instead of using put options. For this reason, at-the-money and out-of-the-money put options are considered to expose to fluctuation in exchange rates, not different from unhedged strategy. Only in-the-money put options would be focused in this paper.

Note that strike prices of currency put options are not available on DataStream. As a result, assumption about the strike prices needs to be made. Because strike prices are settled at transaction date of options; thus, this paper assumes that strike prices are determined at the beginning of each month. As only in-the-money put options are emphasized in this paper, strike prices of put options are assumed to be higher than spot rate at the beginning of each month by 1%, 5%, 10% and 15%.

5. METHODOLOGIES

5.1 Mean-CVaR Portfolio Optimization Framework

For a long period of time, mean-variance framework has been used to construct the optimal portfolio. In this framework, variance has been used to measure portfolio risk. However, this framework is not applicable for this research for the following reasons described below.

Mean-variance framework is not applicable in the context of currency risk management. It is not efficient in capturing downside risk, which is the main emphasis of this research. As this paper aims to evaluate hedging effectiveness of forwards and put options, it is appropriate to apply other models that better capture unfavorable fluctuation in exchange rate. As a result, this paper opts in to apply mean-CVaR framework, which is more efficient in terms of measuring downside risk.

Moreover, mean-variance framework is based on assumptions of symmetric return distribution, which is inconsistent with return distribution in this paper. According to table 1, 2 and 3 presented in previous section, returns of stock and bond indices as well as exchange rates are not normally distributed. As paper of Cotter (2011) suggests hedgers to use CVaR, instead of traditional variance in the case of asymmetric distribution; thus it is more applicable to apply mean-CVaR model in this scenario.

For this reason, this research use mean-CVaR framework, instead of using traditional Markowitz's framework to perform portfolio optimization. Our goal is to minimize CVaR given the expected returns with probability level of 0.95. Moreover, investment weights are assumed to be equal or more than zero because many of institutions are only allowed to take long position, and are prohibited to conduct short sales. Our framework can be shown as following

$$\begin{aligned} & \text{Minimize} && CVaR_{0.95}(x) \\ & \text{Subject to} && \sum_{i=1}^N w_i E(R_i) = R_p \\ & && \sum_{i=1}^N w_i = 1 \\ & && w_i \geq 0, i = 1, 2, \dots, N \end{aligned}$$

This framework is estimated by using MATLAB, which the code is available in appendix section. By using this software, $VaR_{0.95}(x)$ would be calculated in order to obtain $CVaR_{0.95}(x)$. In MATLAB, $CVaR_{0.95}(x)$ is calculated based on following equation

$$CVaR_{0.95}(x) = VaR_{0.95}(x) + \frac{1}{1-0.95} \int \max\{0, (f(x, y) - VaR_{0.95}(x))\} p(y) dy$$

5.2 Hedging Strategies Implementation

In this paper, there is one unhedged strategy, and two hedging strategies with forwards and options. Since this research only concentrates on European institutional investors, who need to sell foreign currencies in exchange for Euro, only currency depreciation of foreign currencies against domestic currencies (in this case Euro) would be considered to be currency risk in this context. Consequently, this paper only focuses on two currency hedging strategies which are 1.) short position in forward and 2.) long position in put option.

This paper incorporates three different hedging strategies through asset returns (R_i) in portfolio optimization framework as following,

Unhedged strategy

Unhedged strategy refers to the strategy, which does not incorporate currency hedging in international portfolio. This means that the portfolio is fully exposed to fluctuation in exchange rates.

Return of unhedged strategy is derived in the following equation:

$$R_i = R_{i,f} + e_f + R_{i,f} * e_f$$

where $R_{i,f}$ is the rate of return of assets in the currency based in Euro

$$e_f = \frac{SX_{t+1} - SX_t}{SX_t} \text{ represents rate of appreciation or depreciation of foreign currencies}$$

Short position in forwards

This strategy applies forward to hedge against exchange rate risk in international portfolio. By applying short position in forwards, the contract acts as a hedge in the event of depreciation in other foreign currencies against Euro. Basically, short position in forwards locks exchange rate that investors are entitle to sell, or convert total return received from sale

of equities and bonds denominated in foreign currencies to Euro. When short selling forwards, Euro-based investors would not lose their profit, or lose less than they should have if they do not hedge.

Return of hedging with forward contract is derived in the following formula:

$$R_i^{forward} = R_i + h_i \left(\frac{F_{t+1} - SX_{t+1}}{SX_t} \right)$$

where R_i refers to return of unhedged strategy

F_{t+1} refers to forward exchange rate

h_i refers to the hedge ratio [10]; $0 \leq h_i \leq 1$

Long position in put options

This strategy uses European put options to hedge against currency risk in international portfolio. Similar to previous strategy, put options act as a hedge against Euro depreciation. With put option, investors would give the rights to sell profits denominated in foreign currencies in exchange for Euro at specified strike price (K) at future date. Because investors are not obliged to exercise put option at future date, they would choose to exercise put option only in the event of unfavorable fluctuation in exchange rate or Euro depreciation. Nevertheless, flexibility comes with the cost. Investors have to pay premium (P) in any circumstances.

Return of hedging strategy with European put options is written in the following formula:

$$R_i^{put\ option} = R_i + h_i \left(\frac{\max(K - SX_{t+1}, 0) - P}{SX_t} \right)$$

where R_i refers to return of unhedged strategy

K is strike price of put option

P is put option price (calculated by using Black Scholes Model).

h_i refers to the hedge ratio; $0 \leq h_i \leq 1$

5.3 Hedge Ratio

Hedging refers to reducing exposure of currency risk when investing in international portfolios. By definition, “the conventional optimal hedge ratio is the percent of non-domestic currency exposure that when converted back to domestic currency exposure minimizes total portfolio volatility, it can also be defined in terms of maximizing return” (Knapp, 2009).

However, the extent of optimal hedging is still questionable. Unitary hedge ratio or full hedge does not necessarily yield optimal performance. From theoretical point of view, “the unitary hedge ratio is the optimal one only if the exchange rate returns and local returns are uncorrelated and the forward exchange premium is an unbiased predictor of the future exchange rate returns” (Bugar and Maurer, 2002). Yet, this is unlikely to happen in practice. Each hedging assets tend to have different optimal hedge ratios.

For this reason, this paper assumes four different hedge ratios of 0.25, 0.5, 0.75 and 1.00 (unitary hedge ratio). Within these four hedge ratios, the one that yields highest Conditional Sharpe Ratio (CSR), and at the same time gives the lowest Conditional Value-at-Risk (CVaR) would be said to be the closest to optimal hedge ratio.

5.4 Performance Measure

After obtaining efficient frontier from mean-CVaR framework, minimum-risk portfolio (MRP) would be used as a criterion to select optimal portfolio for each hedging strategies. MRP refers to the criterion that selects “the portfolio that gives the minimum level of risk, in terms of shortfall expectation” (Maurer and Valiani, 2007)

By definition, hedging effectiveness is defined as “the extent to which hedging an investment actually reduces risk” (Ferlex Financial Dictionary, 2012). As forward contracts and put options are used to hedge against currency risk of international portfolio, risk-adjusted return would be used as a benchmark to evaluate hedging effectiveness.

Since this paper applies mean-CVaR framework, Conditional Sharpe ratio (CSR) is used instead of traditional Sharpe ratio to obtain risk-adjusted returns. CSR can be defined as following

$$\text{Conditional Sharpe Ratio (CSR)} = \frac{R_p - R_f}{CVaR\alpha}$$

In this research, CSR is implemented to international portfolios with different hedging strategies. Then, CSR of each strategy is compared in order to measure hedging effectiveness. Hedging strategy with the highest CSR can be considered the most effective strategy to hedge currency risk in international portfolio with asset denominated in currencies of emerging countries.

6. FINDINGS AND EMPEIRICAL RESULTS

6.1 Optimal Hedge Ratio of forwards and put options

In this paper, it is found that hedge ratio of 1.00 is optimal hedge ratio for forward contracts among other hedge ratio of 0.25, 0.50 and 0.75. An optimal hedge ratio of 1.00 means that it is optimal for investors to fully hedge with forward contract against currency risk. Based on table 4, international portfolio with forward with hedge ratio of 1.00 yields highest CSR of 16.08% relative to other international portfolio. In addition, international portfolio with forward with hedge ratio of 1.00 gives the lowest CVaR of 1.72% compared to other forward-hedged portfolio.

Table4: Forward Hedged Strategy

Forwards Hedged Strategy				
Hedge Ratio	<i>Hi=0.25</i>	<i>Hi=0.50</i>	<i>Hi=0.75</i>	<i>Hi=1.00</i>
Portfolio Return	0.26%	0.27%	0.28%	0.39%
Excess Return	0.14%	0.15%	0.17%	0.28%
Portfolio CvaR	1.77%	1.76%	1.74%	1.72%
CSR	8.19%	8.74%	9.48%	16.08%

Similarly, it is found that hedge ratio of 1.00 is optimal for put options for every strike price of 1%, 5%, 10% and 15% above spot rate. An optimal ratio of 1.00 means that it is optimal for investor to fully hedge with put option against currency risk. Based on table 5, international portfolios hedged with different put options with 1.00 hedge ratio yield highest CSR as well as lowest portfolio risk compared to other hedge ratio of 0.25, 0.50 and 0.75. For portfolio with put option with strike price 15% above the spot rate, it yields highest CSR of 21.52% and lowest CVaR of 1.52%. For portfolio with put option with strike price 10% above the spot rate, it yields highest CSR of 15.86% and lowest CVaR of 1.60%. For portfolio with put option with strike price 5% above the spot rate, it yields highest CSR of 10.97% and lowest CVaR of 1.69%. For portfolio with put option with strike price 1% above the spot rate, it yields highest CSR of 9.26% and lowest CVaR of 1.75%.

Table 5: Option Hedged Strategy

15% Strike Price Option Hedged Strategy				
Hedge Ratio	<i>Hi=0.25</i>	<i>Hi=0.50</i>	<i>Hi=0.75</i>	<i>Hi=1.00</i>
Portfolio Return	0.28%	0.33%	0.39%	0.44%
Excess Return	0.16%	0.22%	0.27%	0.33%
Portfolio CvaR	1.71%	1.65%	1.58%	1.52%
CSR	9.59%	13.21%	17.24%	21.52%
10% Strike Price Option Hedged Strategy				
Hedge Ratio	<i>Hi=0.25</i>	<i>Hi=0.50</i>	<i>Hi=0.75</i>	<i>Hi=1.00</i>
Portfolio Return	0.26%	0.31%	0.33%	0.37%
Excess Return	0.15%	0.20%	0.22%	0.25%
Portfolio CvaR	1.73%	1.69%	1.65%	1.60%
CSR	8.69%	11.70%	13.20%	15.86%
5% Strike Price Option Hedged Strategy				
Hedge Ratio	<i>Hi=0.25</i>	<i>Hi=0.50</i>	<i>Hi=0.75</i>	<i>Hi=1.00</i>
Portfolio Return	0.25%	0.28%	0.29%	0.30%
Excess Return	0.13%	0.16%	0.18%	0.19%
Portfolio CvaR	1.75%	1.73%	1.71%	1.69%
CSR	7.65%	9.40%	10.62%	10.97%
1% Strike Price Option Hedged Strategy				
Hedge Ratio	<i>Hi=0.25</i>	<i>Hi=0.50</i>	<i>Hi=0.75</i>	<i>Hi=1.00</i>
Portfolio Return	0.24%	0.26%	0.27%	0.27%
Excess Return	0.12%	0.15%	0.16%	0.16%
Portfolio CvaR	1.77%	1.76%	1.75%	1.75%
CSR	7.05%	8.40%	8.89%	9.26%

As the result shows that it is optimal to use forward contracts and put options to fully hedge against currency risk; thus from now on, portfolios hedged with forward and put options with hedge ratio of 1.00 will be further utilized in the analysis in the following sections.

6.2 Portfolio composition of each hedging strategies

Each hedging strategy yields a different portfolio composition. Investment weight of unhedged strategy is relatively high in Europe and UK markets. With unhedged strategy, almost half of capital is allocated to European bond market. Moreover, 15.97% share of capital goes to European stock market, and 25.61% share of capital goes to UK bond market. There is not any significant investment weight in emerging market. Only 1.80% of capital is allocated to Chinese equity market, and 5.37% of capital is allocated to Chinese bond market. There is no investment in India market at all. In unhedged strategy, high investment weights in Europe in both markets are expected, since international portfolio is fully exposed to currency risk. Investors especially the risk-averse ones, would invest mostly in the domestic market to avoid exchange rate risk exposure. Thus, approximately 65% of total capital is allocated to stock and bond markets in Europe.

Table6: Portfolio Weight

Portfolio Weight	Stock markets					Bond markets				
	Europé	US	UK	China	India	Europé	US	UK	China	India
Unhedged Strategy	15.97%	2.10%	0.00%	1.80%	0.00%	49.15%	0.00%	25.61%	5.37%	0.00%
Forward (Hi = 1)	5.61%	0.01%	4.96%	5.95%	0.00%	57.63%	0.00%	1.48%	24.36%	0.00%
Put Option with Strike Price 15% (Hi = 1)	13.91%	3.56%	0.00%	0.79%	0.00%	47.00%	5.70%	26.08%	2.95%	0.00%
Put Option with Strike Price 10% (Hi = 1)	13.95%	3.89%	0.00%	0.51%	0.00%	46.30%	5.58%	26.85%	2.93%	0.00%
Put Option with Strike Price 5% (Hi = 1)	14.52%	2.79%	0.00%	0.76%	0.00%	46.28%	5.81%	25.77%	4.07%	0.00%
Put Option with Strike Price 1% (Hi = 1)	16.44%	0.00%	0.00%	1.85%	0.00%	46.52%	0.00%	23.52%	11.67%	0.00%

Investment weight of forward-hedged strategy tends to be different from unhedged strategy. Comparing with unhedged strategy, investment weights of international portfolio with forward contracts are diversified away from Western markets to emerging markets, especially Chinese market. Based on table 3, investment weight in European market decreases from 65.12% to 63.24%, investment weight in UK market significant declines from 25.61% to 6.44%, and investment weight in US market decreases from 2.01% to 0.01%. On the contrary, investment weight in Chinese financial market increases from 7.17% to 30.31%. With forward contracts, 24.36% of capital is allocated to Chinese bond market and 5.95% of capital is allocated to Chinese equity market.

Unlike forward-hedged strategy, option-hedged strategy resembles that of unhedged strategy. Only small investment diversification away from local market could be realized. Compared to unhedged strategy, investment weights in European bond market with put options with different strike prices of 1%, 5%, 10% and 5% above spot rate reduce from 49.15% to 46.52%, 46.28%, 46.30% and 47% respectively. Investment weights in European equity market with put options with different strike prices of 5%, 10% and 5% above spot rate decrease from 15.97% to 14.52%, 13.95% and 13.91% compared to unhedged strategy. Moreover, more capitals shift away from emerging region to developed markets as the strike price increase from 1% to 15% above spot rate. Based on table 6, investment weight in Chinese bond market of option-hedged strategy with strike price 1%, 5%, 10% and 15% above spot rate decrease from 11.67%, 4.07%, 2.93% and 2.95% respectively. On the contrary, investment weight in US stock market of option-hedged strategy with strike price 1%, 5%, 10% and 15% above spot rate increase from 0.00% to 2.97%, 3.89% and 3.56% respectively. Investment weight in US bond market of option-hedged strategy with strike price 1%, 5%, 10% and 15% above spot rate increase from 0.00% to 5.81%, 5.58%, 5.70% respectively. Investment weight in UK bond market of option-hedged strategy with strike price 1%, 5%, 10% and 15% above spot rate increase from 23.52% to 25.77%, 26.85% and 26.08% respectively.

6.3 Hedging effectiveness

The results confirm that hedging strategies, either with forwards or put options yield better performance compared to unhedged strategy. Portfolios with forwards and put options have higher Conditional Sharpe Ratio (CSR) than that of unhedged strategy. Comparing to unhedged strategy, hedging strategies help reduce portfolio risk, and increase portfolio return at the same time. From table 7, hedging with forward increases portfolio return from 0.23% to 0.39%; whereas lower portfolio risk from 1.77% to 1.72%. Hedging with put options with strike price of 1%, 5%, 10% and 15% above spot rate increase portfolio return from 0.23% to 0.27%, 0.30%, 0.37% and 0.44% while reduce portfolio risk from 1.77% to 1.75%, 1.69%, 1.60% and 1.52% respectively.

Table7: Hedging Effectiveness

	Unhedged	Hedged with Forward	Hedged with Option (S = 1%)	Hedged with Option (S = 5%)	Hedged with Option (S = 10%)	Hedged with Option (S = 15%)
Portfolio Return	0.23%	0.39%	0.27%	0.30%	0.37%	0.44%
Excess Return	0.12%	0.28%	0.16%	0.19%	0.25%	0.33%
Portfolio CvaR	1.77%	1.72%	1.75%	1.69%	1.60%	1.52%
CSR	6.64%	16.08%	9.26%	10.97%	15.86%	21.52%

In this paper, there is not clear conclusion whether forwards and put options outperforms one another. The conclusion is different across different levels of strike price of put options. In this paper, forward-hedged strategy is more effective in term of hedging compared to options-hedged strategy with strike price of 1%, 5% and 10% above spot rate. Based on table 7, portfolio with forwards has CSR of 16.08% which is significantly higher than CSR of 9.26% and 10.97% of portfolio with put options with strike price 1% and 5% above spot rate. This is because forwards introduce higher magnitude increase in portfolio return as well as relatively equal magnitude of decrease in portfolio risk compared to portfolio with put options with strike price of 1% and 5% above spot rate. In table 7, hedging with forward increases portfolio return by 70%; whereas hedging with put options with strike price of 1% and 5% above spot rate increase portfolio return by 17% and 30%. In addition, hedging with forward decreases portfolio CVaR by 2.8%; while hedging with put options with strike price of 1% and 5% above spot rate decreases portfolio risk by 1.1% and 4.5% respectively. Moreover, portfolio hedged with put option with strike price of 10% above spot rate yields relatively high CSR as that of forwards. However, the CSR of portfolio with put option with strike

price of 10% above spot rate is slightly lower than CSR of portfolio hedged with forward contracts of 16.08%. Though portfolio hedged with put options with strike price of 10% above spot rate introduces higher magnitude of reduction in portfolio risk of 9.6%, compared to portfolio hedged with forwards; yet magnitude of increase in portfolio returns of 60% is not as significant as 70% of that of portfolio hedged with forwards. Consequently, portfolio hedged with forwards slightly outperforms portfolio hedged with put options with strike price of 10% above spot rate.

On the contrary, option-hedged strategy with strike price of 15% above spot rate outperforms forward-hedged strategy. Unlike other portfolio with put options, portfolio hedged with put options with strike price of 15% above spot rate yields higher CSR of 21.52% compared to portfolio hedged with forwards with CSR of 16.08%. This is because put options with strike price of 15% above spot rate introduce higher magnitude increase in portfolio return as well as higher magnitude decrease in portfolio risk. According to table 7, hedging with put options with strike price of 15% increases portfolio return by 91% whereas hedging with forwards increases portfolio return by 70%. In addition, hedging with put options with strike price of 15% above spot rate reduce portfolio risk by 14% while hedging with forward decrease portfolio risk by 2.8%.

Moreover, forwards is more effective in term of hedging with Chinese Yuan rather than British Pound and US Dollar. Based on table 7, investment weight in Chinese financial market increases from 7.17% to 30.31%; while investment weight in in UK market significant declines from 25.61% to 6.44%, and investment weight in US market decreases from 2.01% to 0.01%. This is because short position in forward yields relatively higher payoff when foreign currency depreciate against local currency. As Chinese government try to intervene very hard to prevent their currency to appreciate against Western currencies, Chinese Yuan tends to depreciate against Western currencies, including Euro. Consequently, forwards is more effective in term of hedging fluctuation in Chinese Yuan rather than British Pound and US Dollar.

Unlike short selling forward contracts, taking long position in put options is more effective in term of hedging fluctuation in US Dollar and British pound rather than Chinese Yuan. Based on table 7, investment weight in US market of option-hedged strategy with strike price 5%, 10% and 15% above spot rate increase from 2.10% to 8.60%, 9.47% and 9.26% respectively. Investment weight in UK market of option-hedged strategy with strike price 5%, 10% and

15% above spot rate increase from 25.61% to 25.77%, 26.85% and 26.08% respectively. This is because long position in put options allows investors to take advantage of convexity when market is volatile. If exchange rate moves against investors, then convexity help ensure that investors lose at decreasing rate. On the other hands, if exchange rate moves in favor investors, then convexity help ensure that investors gain money at increasing rate (Labuszewski, 2013). As US Dollar and British Pound have relatively higher volatility compared to Chinese Yuan, purchasing put option tends to be more effective in term of hedging British Pound relative to Chinese Yuan. Based on table 3, US Dollar has standard deviation of 0.051247, British Pound has standard deviation of 0.144164, and Chinese Yuan has standard deviation of 0.009879.

Nevertheless, levels of strike price play important role in determining hedging effectiveness of put options. The higher the strike price set above spot rate, the higher the portfolio CSR. From table 7, portfolios with put options with strike price of 1%, 5%, 10% and 15% above spot rate have CSR of 9.26%, 10.97%, 15.86% and 21.52% respectively. This is because higher put option strike prices ensure higher protection against currency risk. With higher strike price (K), investors are entitled to receive higher payoff ($K - SX$) to cover increasing premium (P).

7. LIMITATIONS

This paper has two main limitations. One limitation is that option prices calculated by a theoretical formula fails to take into account positive or negative shocks in daily market, which plays significant role in option prices. This is because the formula assumes risk-free rates and volatilities are constant, contrast to the reality that risk-free and volatility fluctuates according to the conditions of the market. Moreover, the model assumes option prices are continuous and that large changes such as those occur after M&A announcement do not occur (Yeow Khoo, 2006). Consequently, option prices which are calculated with formula can be overpriced or underpriced compared to real option prices available in the market.

Moreover, this paper is only applicable for high risk-averse investor with relative low risk tolerance. As this research is dealing with hedging that aims to mitigate currency risk, only risk-averse agent would be considered to be relevant. Moreover, minimum risk portfolio (MRP) is used as a criterion to select portfolio, instead of traditional tangency portfolio (TP). Though TP is relevant to risk-averse; yet the extent of risk tolerance is relatively higher compared to MRP. TP takes into account risk-return tradeoff when selecting optimal portfolio. It picks portfolio with lowest risk for given return. Unlike TP, MRP selects portfolio with lowest risk regardless of expected return. Consequently, this paper should be relevant to high risk-averse agents such as traditional mutual funds and pension funds, not agents with low risk aversion such as hedge funds.

8. SUMMARY AND CONCLUDING REMARKS

This paper measures currency hedging effectiveness of two hedging tools which are forward contracts and put options in international portfolio from the viewpoint of European institutional investors. The international portfolio consists of equities and government bonds denominated in five different currencies, including British Pounds, US Dollars, Euro, Indian Rupee, and Chinese Yuan. Mean-CVaR framework is applied to conduct portfolio optimization, and Conditional Sharpe Ratio (CSR) is used to evaluate currency hedging effectiveness of forwards and put options.

In this research, there is no clear conclusion whether forward contracts or put options outperforms one another. The conclusion is different at different level of strike prices. Forward contract is more effective compared to put option with strike price of 1%, 5% and 10% above spot rate whereas put option with strike price of 15% above spot rate is more effective compared to forwards in term of hedging currency risk in international portfolio. Moreover, forward is found to be relatively more effective in term of hedging against fluctuation in Chinese Yuan; while put option is found to be relatively more effective in term of hedging against fluctuation in British Pound and US Dollar. Lastly, levels of strike price play important role in determining hedging effectiveness of put options. The higher the strike price set above spot rate, the more effective in term of currency hedging.

This finding has implication for international investors, especially Euro-based investors to select financial tools to hedge against currency risk. There is no definite conclusion whether investors should either choose forward contracts or put options. The selection between forward contracts and put options depends on affordability and investment objective of each investor. Forwards would be recommended for investors with relatively low affordability because forward contracts do not require premium upfront. On the other hands, put options would be recommended for investors with relatively high affordability. This is because investors are required to pay relatively high premium for put option to provide better protection against currency risk compared to forward contracts. In this paper, investors have to pay relatively high premium to substitute forward contracts with in-the money options with strike price of 15% above the spot rate. Otherwise, they would be better of hedging with forward contracts, rather than using put options.

Based on investment objective, forward would be suggested to investors who intend to diversify their investment to emerging market particularly China. This is because Chinese

Yuan tends to depreciate against currencies of developed nations due to government intervention. Moreover, hedging against Chinese Yuan fluctuation with put options would not be beneficial to investors. As Chinese government adopts managed exchange rate policy; exchange rate is only allowed to fluctuate within small band. This indicates that Chinese Yuan tends to have relatively low volatility, so investors can not take advantage from convexity characteristic of put options due to relatively volatility. On the contrary, put options would be suggested to investors who aim to invest in financial markets of United States and United Kingdom. Unlike China, these countries do not put strict control on exchange rate and allow their currencies to float in the market. With floating exchange rate policy, US Dollar and British Pound tend to have relatively high volatility compared to Chinese Yuan. Consequently, hedging US Dollar and British Pound with put options would be recommended to investors because they are allowed to benefit from convexity.

Nevertheless, this recommendation is drawn from specific scenario in this paper. Introduction of changes in certain variables may lead to alteration in the finding. Thus, further researches are encouraged in order to have more reliable recommendation in term of currency hedging in the future. The researches could be developed in different areas. For example, the research could be conducted in different time periods. Changing time periods would introduce different characteristic in exchange rate that may lead to changes in investment recommendations. In addition, different portfolio selections could be used to replace minimum-risk portfolio (MRP) in order to reflect different types of investors. Introduction of new hedging tools such as currency swap or even hedging strategies with combination of options could also be applied in order to evaluate currency hedging effectiveness. By doing so, valuable recommendations could be generated that would be beneficial for international investors in the future.

NOTES

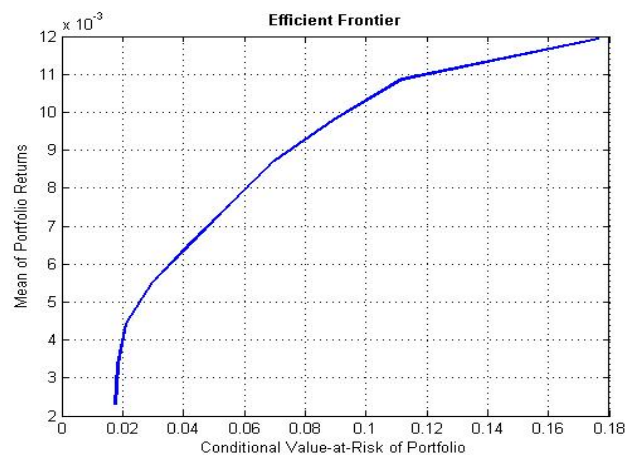
- (1) Annual gross cross-border flows are measured by the acquisition of assets abroad. These assets include equity and debt securities, cross-border lending and deposits, and foreign direct investment or FDI. (OECD, 2011).
- (2) Bear Spread strategy is applied in a situation of downturn market. “It involves buying an at-the-money put option and selling an out-of-the-money put option that has a lower strike price” (Clarke and Clarke, 2012)
- (3) Requirement for a distribution to be considered normally distributed is that skewness value has to be zero.
- (4) Skewed to the left means that left tail is longer relative to the right tail.
- (5) Skewed to the right means that the right tail is longer relative to the left tail
- (6) Requirement for a distribution to be considered normally distributed is that the kurtosis must have a value of three or the excess kurtosis must be close to zero.
- (7) An excess kurtosis that has a positive value is called a leptokurtic distribution. These distributions have higher peaks than normal. Leptokurtic distributions also have thick tails on both sides.
- (8) The J/B tests whether the data have the skewness and kurtosis requirements that match a normal distribution. The null hypothesis of the test is skewness and excess kurtosis equal to zero implying a normal distribution; while the alternative hypothesis is having a non-normal distribution.
- (9) Options can be divided into American options and European options. American options can be exercised at any point in time until the option reaches its maturity date, while European options can only be exercised only on the expiration date.
- (10) To calculate monthly volatility, standard deviation of the daily log spot rates is calculated. Then, monthly volatility is estimated by taking average of daily volatility. Because there are 2,085 daily observations and 96 months; as a result, this paper assigns 22-day trading window in order to estimate monthly volatility.

APPENDIX

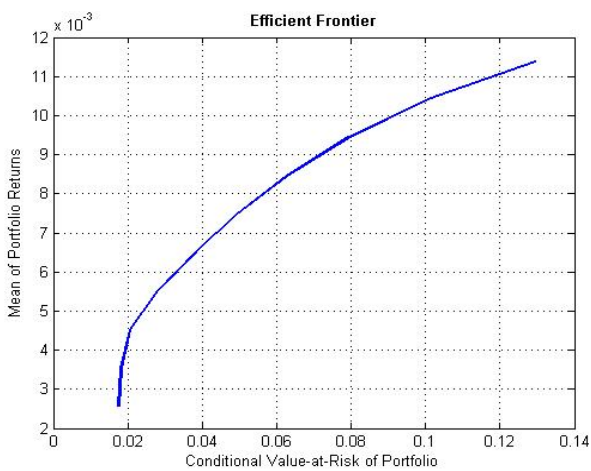
1. CVaR Framework in MATLAB Code:

```
p = PortfolioCVaR;  
  
p = p.setScenarios(AssetScenarios);  
  
p = p.setDefaultConstraints;  
  
p = p.setProbabilityLevel(0.95);  
  
[lb, ub, isbounded] = p.estimateBounds;  
  
pwgt = p.estimateFrontier
```

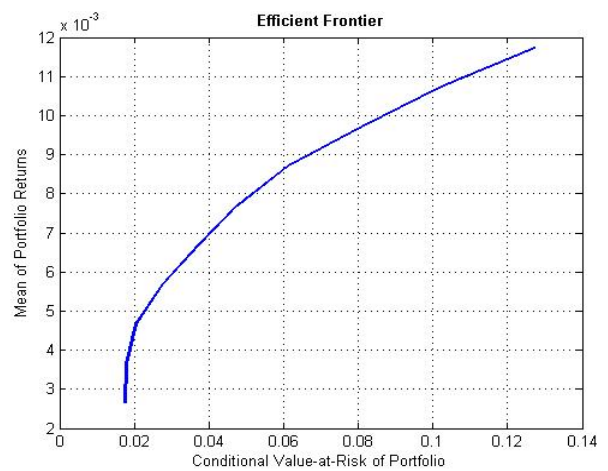
2. Portfolio Efficient Frontier Graphs for the Three Strategies:



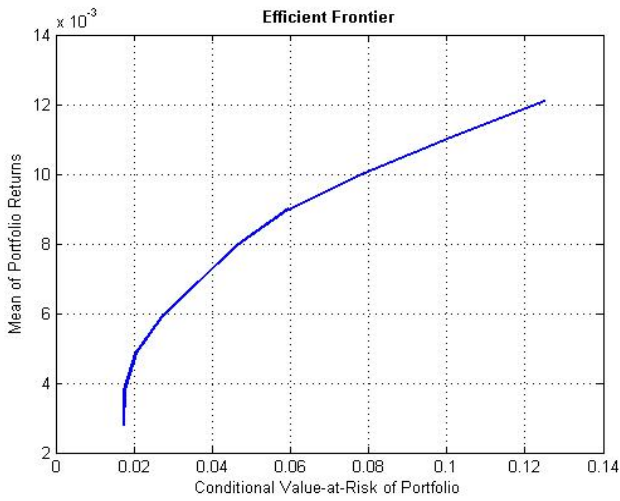
Unhedged Strategy



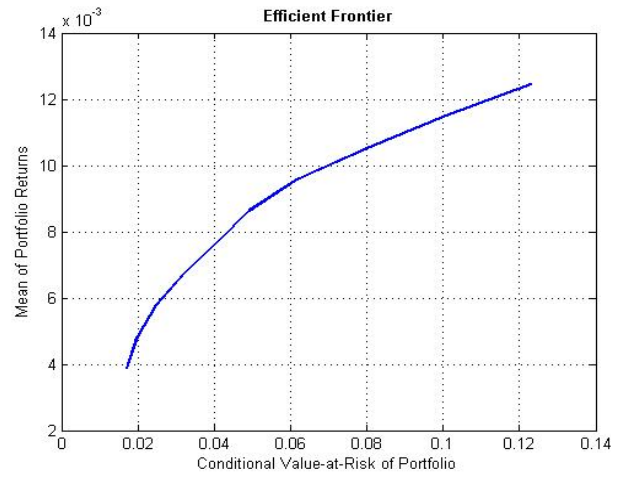
Forward Strategy Ho=0.25



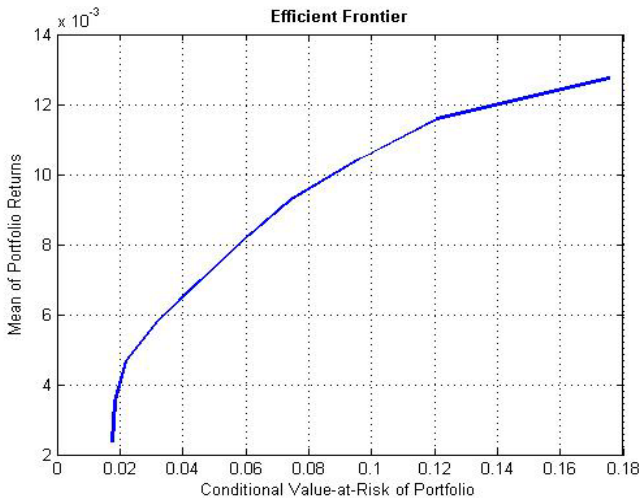
Forward Strategy Ho=0.50



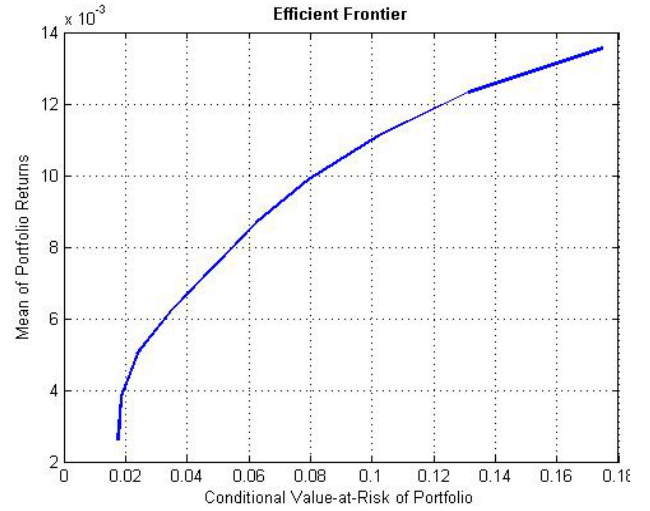
Forward Strategy $H_0=0.75$



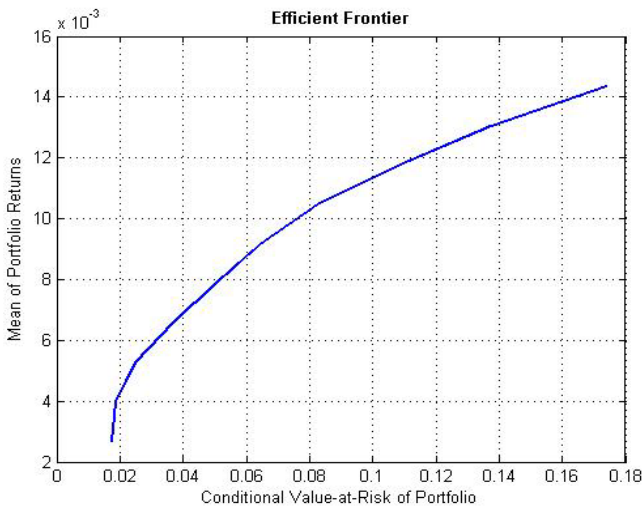
Forward Strategy $H_0=1.00$



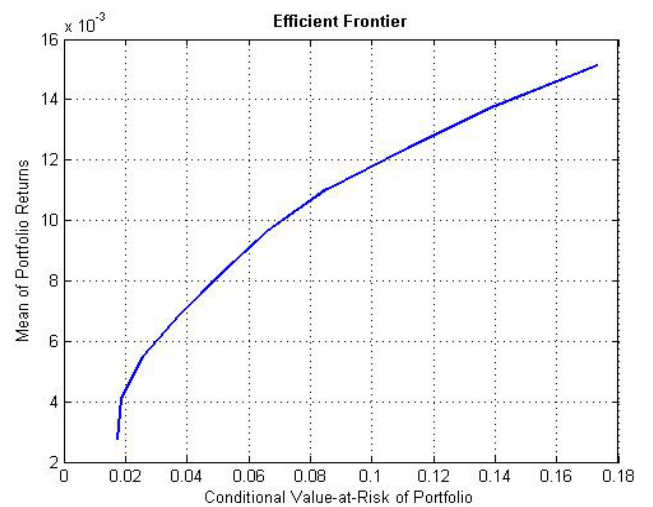
Options Strategy Strike Price 1% $H_0=0.25$



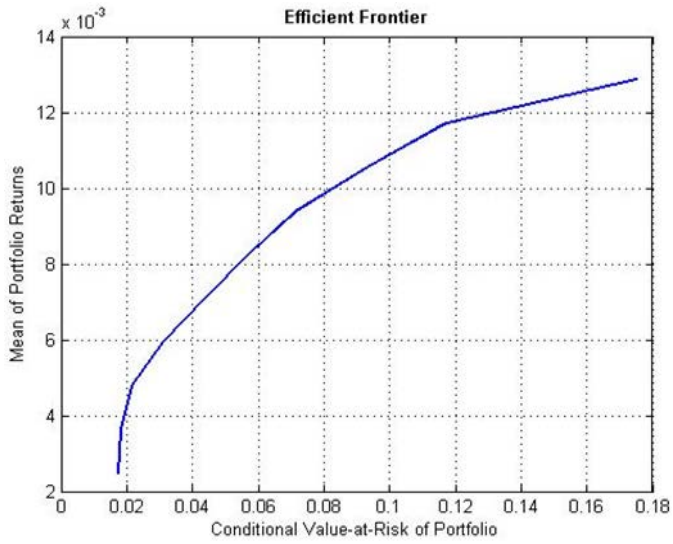
Options Strategy Strike Price 1% $H_0=0.50$



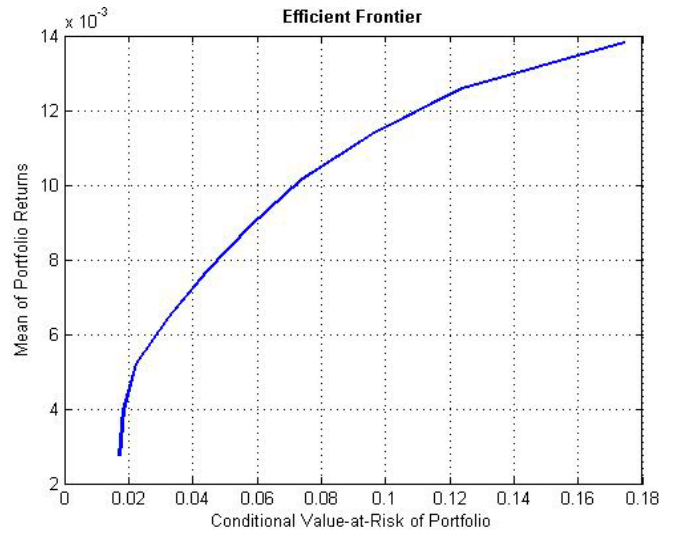
Options Strategy Strike Price 1% $H_0=0.75$



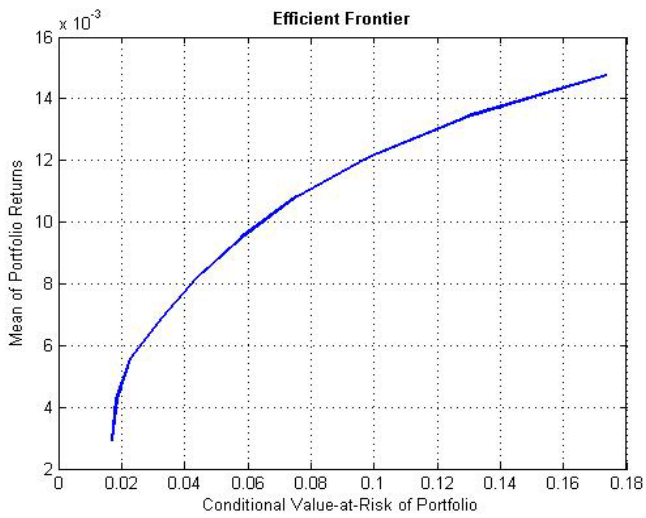
Options Strategy Strike Price 1% $H_0=1.00$



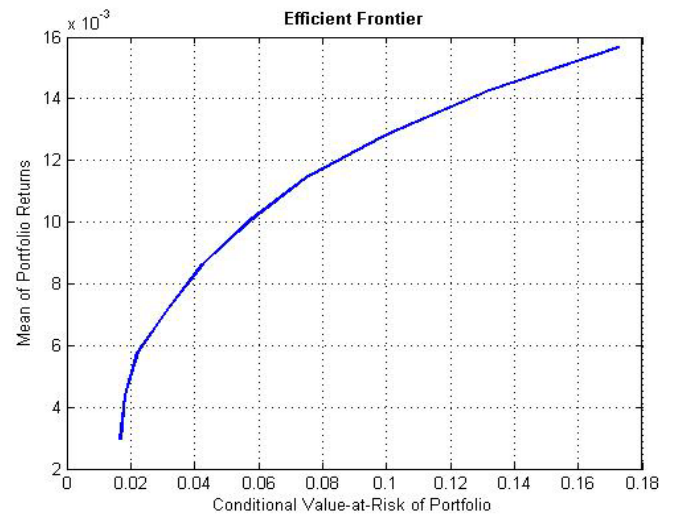
Options Strategy Strike Price 5% $H_o=0.25$



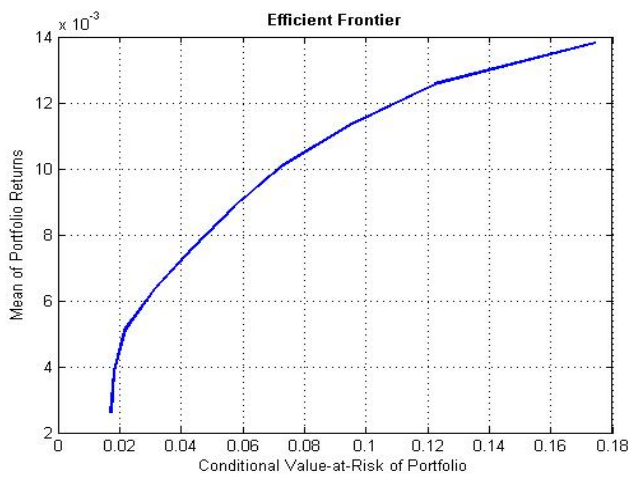
Options Strategy Strike Price 5% $H_o=0.50$



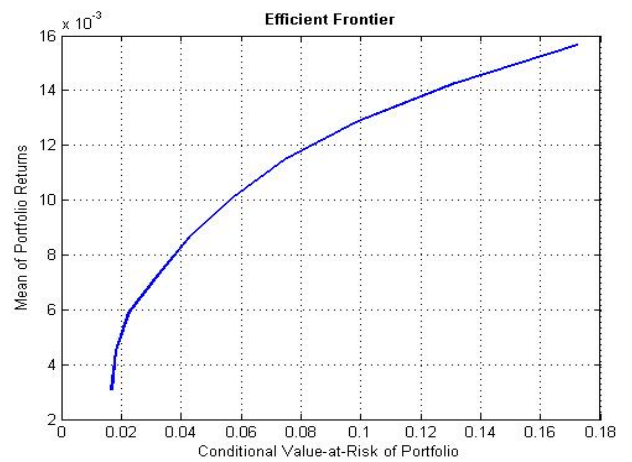
Options Strategy Strike Price 5% $H_o=0.75$



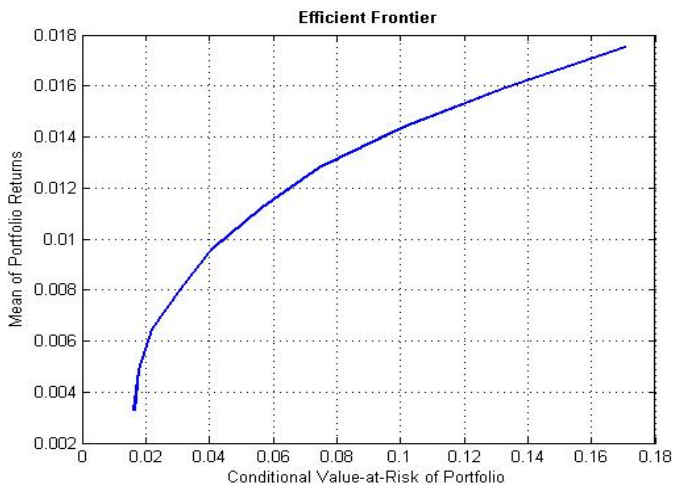
Options Strategy Strike Price 5% $H_o=1.00$



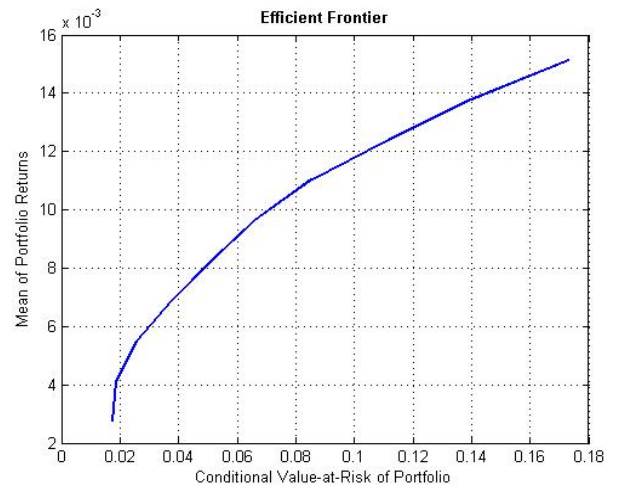
Options Strategy Strike Price 10% $H_o=0.25$



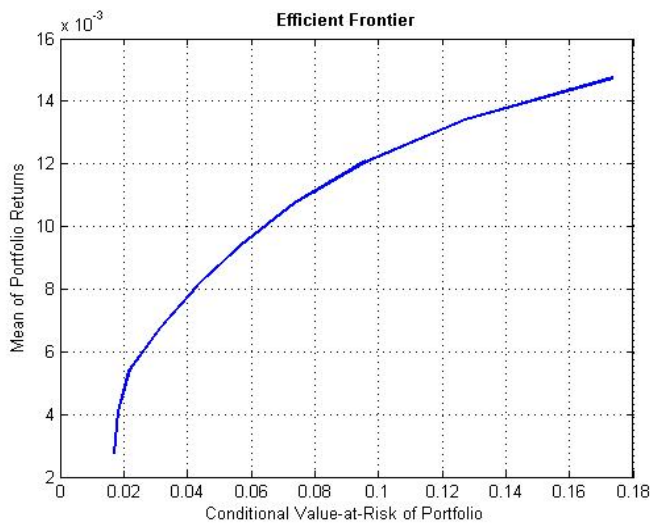
Options Strategy Strike Price 10% $H_o=0.50$



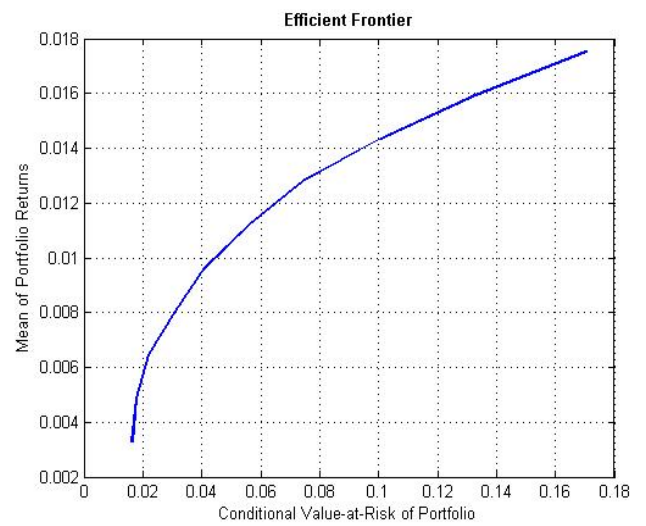
Options Strategy Strike Price 10% $H_0=0.75$



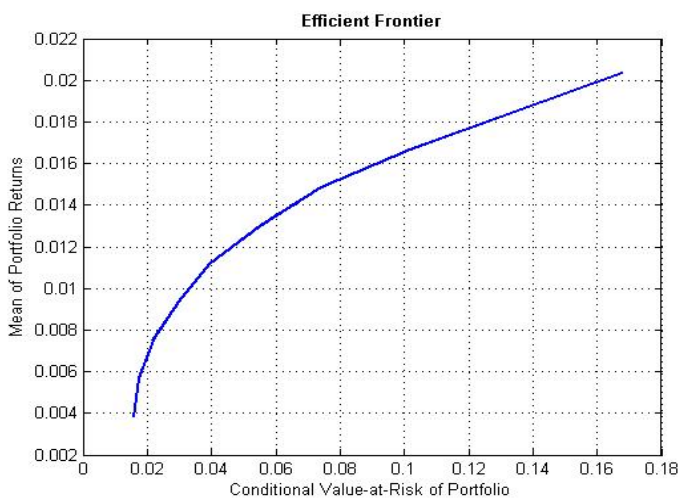
Options Strategy Strike Price 10% $H_0=1.00$



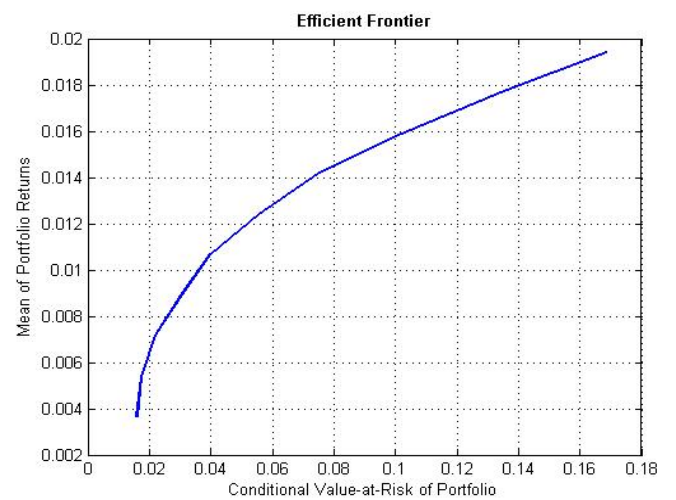
Options Strategy Strike Price 15% $H_0=0.25$



Options Strategy Strike Price 15% $H_0=0.50$



Options Strategy Strike Price 15% $H_0=0.75$



Options Strategy Strike Price 15% $H_0=1.00$

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