Applied Mathematical Sciences, Vol. 8, 2014, no. 110, 5469 - 5476
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ams.2014.47595

Hedging Against Foreign Exchange Risk of Peso-Dollar Rates Using Futures

Jonathan B. Mamplata, Rome Augusta Joyce R. Lo and Maria Amiella E. Reyes

Institute of Mathematical Sciences and Physics
University of the Philippines Los Baños
College, Laguna, Philippines

Abstract

Transactions involving foreign exchange trading are very popular to investors particularly to multinational companies and other large corporations. This kind of transaction includes risk due to great fluctuation in currency exchange rates. Thus, this paper used currency futures contract with a maturity of six months to hedge risk resulting from the fluctuations on the peso-dollar (Philippine peso - US Dollar) exchange rates. The Cox Ingersoll-Ross (CIR) model was utilized to forecast 182-day Philippine and US Treasury Bill (T-bill) rates for January to June 2012. Maximum Likelihood Estimation (MLE) was applied in estimating the parameters of the CIR model. The computed T-Bills were used to forecast the price of the futures contract. To help the investors decide in making such transaction, optimal hedge ratio (OHR) was also calculated using the time series model GARCH (1,1).

Mathematics Subject Classification: 62P05, 91G70

Keywords: futures, CIR model, maximum likelihood estimation, optimal hedge ratio

1 Introduction

Nowadays, different multinational companies are engaged with foreign exchange trading which include currency risk. For example, a Philippine based company has a contract from which you will receive a certain amount of dollar after six months. So, you plan to sell US Dollar and buy Philippine Peso. In order to eliminate the risk involves in currency trading, futures contract as a hedging technique can be utilized.

Risk is the probability that an investments actual return may be different from the expected outcome [5]. This includes the consequence of losing some or all of the original investment. In order for the investor to minimize his uncertainty, different hedging strategies are employed. Hedging is a method used to protect the underlying asset against the fluctuation of prices by using derivatives such as forwards, futures, options, swaps, and money markets. Derivatives or financial instruments are used to construct a hedge which aims to balance the possible losses in an investment.

Among other financial instruments, futures contract is more widely used because of its low transaction cost. Futures contract is an agreement between two parties to buy or sell an asset at a certain future time for a specific price. Furthermore, this contract is classified according to what underlying asset is involved in the trading transaction. Examples are the currencies which are most commonly traded in the market. These currencies are traded using Foreign Exchange trading which engage in buying one currency and selling another through a broker or dealer. Currency futures are contracts traded on an organized market protecting an investor from the risk of foreign exchange rates. It is a fnancial instrument which agrees to buy or sell specifed currencies at a particular time in the future. This derivative is involved in an open and effcient trading [9].

In order to minimize the risk, an investor must not only be concerned with the hedging technique he will apply but also with the size of the contract he will hedge. Optimal hedge ratio (OHR) is defined as the proportion of a position on the spot market that should be covered by an opposite position on a futures market [8]. It is simply the comparison of the size of the futures contract purchased to the value of the underlying asset being hedged. Furthermore, according to [3], full hedging is not always the best approach so computation of hedge ratio is essential. It is an important tool used by investors to identify and minimize risk.

2 Preliminary Notes

Derivatives have two categories which are Forward-type contracts and Option-type contracts. A forward-type contract, which comprises forwards, and swaps, is an agreement to buy or sell the underlying asset at a certain future time for a certain price. On the other hand, options give the holder the right but not the obligation to buy or sell the underlying asset by a certain date for a specific price.

Definition 2.1 *A futures contract is a derivative which agrees to buy or sell an underlying commodity on a specifc price on some future date. This type of derivative is an exchange-traded contract having a particular delivery date, location, and procedure.*

Pricing of futures via arbitrage is

$$F = S_0 e^{(r_d - r_f)t} \tag{1}$$

where:

$F =$ price of the currency futures contract

$S =$ spot Peso-Dollar exchange rates

$r_d =$ US T-bill rates ate time t

$r_f =$ Philippine T-bill rate at time t

$t=$ time to maturity in months

Definition 2.2 *The Cox-Ingersoll-Ross model for short-term interest rate is defined by*

$$dr_t = \alpha(\mu - r_t)dt + \sigma\sqrt{r}\, dW_t; \quad r_0 > 0 \tag{2}$$

where:

$r_t =$ *interest rate at time t*

$\alpha =$ *spee of adjustment or mean of reversion*

$\mu =$ *long run mean of the short term interest rate*

$\sigma =$ *volatility*

$W_t =$ *standard Brownian motion*

This is used to model the behavior of the interest rate in general.

The general equation for ARIMA(p, d, q) of the time series $\{X_1, X_2, X_3, ...\}$ is defined by

$$\Phi(B)(1 - B)^d X_t = \Theta(B)\epsilon_t \tag{3}$$

with

$$\Phi(B) = 1 + \theta_1 B + \theta_2 B^2 + \cdots + \theta_p B^p \tag{4}$$

and

$$\Theta(B) = 1 - \phi_1 B - \phi_2 B^2 - \cdots - \phi_q B^q \tag{5}$$

The general form of the GARCH(p, q) is given by,

$$\sigma^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \sigma_{t-1}^2 + \sum_{j=1}^{q} \beta_j \epsilon_{t-1}^2 \tag{6}$$

where:

$\sigma_t^2 =$ forecast of the next period variance

$\sigma_{t-1}^2 =$ past sequence variance forecast

$\epsilon_{t-1}^2 =$ past realization of the variance itself

with

$$\sum_{i=1}^{p} \alpha_i + \sum_{j=1}^{q} \beta_j < 1 \tag{7}$$

$$\alpha_0 \geq 0, \alpha_i > 0, i = 1, 2, ..., p \quad \beta_j > 0, j = 1, 2, ..., q \quad p \geq 0, \quad q > 0$$

Optimal hedge ratio is defined as the ratio of covariance of the spot and futures return prices and variance of the futures return prices. This is the ratio that will help the investors to minimize risk. The OHR, β_j^*, is

$$\beta_j^* = \frac{\sigma_{s,f,t}}{\sigma_{f,t}^2} \tag{8}$$

3 Results and Discussion

Table 1 shows the obtained rates for the missing values for the year 2007 to 2011 Philippine T-Bill rates. Different set of CIR model parameters were computed for each month having missing values.

Month	rate
June (2007)	0.0393
February (2008)	0.0467
March (2008)	0.0469
April (2008)	0.0473
May (2008)	0.0475
June (2008)	0.0479
August (2008)	0.0648
December (2008)	0.0672

Table 1: Gap filling of the missing values for 2007-2011 Philippine T-bill rates

The obtained estimated parameters for the CIR model for the Philippine T-Bill rates, σ, α, μ, were 0.0635, 0.0124, and 0.0282 respectively. On the other hand, the estimated value for the σ, α, μ, for the US T-bill rates were 0.0740, 0.1141, and 0.0007 respectively.

Month	Philippines	United States
January	0.0185	0.0006
February	0.0192	0.0008
March	0.0196	0.0009
April	0.0218	0.0013
May	0.0236	0.0013
June	0.0244	0.0014

Table 2: Forecasted monthly interest rates from Jan 2012 - June 2012.

The estimated parameters obtained with the same program used in gap filling were substituted and the values on the table above were the rates produced.

Prices of the futures contract for January 2012 to June 2012 was forecasted using the forecasted T-bill rates for the same months of 2012. The obtained values are the agreed exchange rates on time to maturity of the futures contract which is specifically six month after the trading transaction was made. This simulated result is beneficial for an investor since this can serve as a basis for a decision to purchase or not the said futures contract. Furthermore, with this kind of information, an investor can perceive it will be profitable to engage in such transaction.

Table 3 below shows the summary of results for the optimal hedge ratio of the investment. These values tell us that 60.02% of the investment is protected from risk while 39.98% remain exposed if the maturity date of our contract is on the first day of June. Whereas 91.32% of the investment is protected from risk on June 4, 91.32% on June 5, and so on.

Time	OHR
1-Jun	0.600166084
4-Jun	0.934961833
5-Jun	0.913220733
6-Jun	0.80220746
7-Jun	0.937705765
8-Jun	0.563063715
11-Jun	0.789269647
13-Jun	0.641143521
14-Jun	0.617785977
15-Jun	0.918743668
18-Jun	0.62509815
19-Jun	0.708328996
20-Jun	0.899811324
21-Jun	0.609815592
22-Jun	0.959170115
25-Jun	0.862222704
26-Jun	0.72027306
27-Jun	0.85009963

Table 3: OHR of the investment on its maturity date.

4 Conclusions

This paper made use of the Cox Ingersoll Ross (CIR) model in forecasting the Philippine and US T-bill rates for January 2012 to June 2012. Gap filling with the use of similar interest rate model was applied to fill in the missing values in the data. The computed parameters, σ, α, μ, for the Philippine T-Bill rates were 0.0635, 0.0124, and 0.0282 respectively whereas 0.0740, 0.1141, and 0.0007 were the obtained values for the US T-Bill rates.

These parameters were used in forecasting T-Bill rates which were then applied in determining the price of the futures contract. 1000 simulations of these T-Bills rates were done to come up with the computation of 1000 futures prices from January 2012 to June 2012. The forecasts of the Peso-Dollar exchange rates range from 42.28669 to 44.93537. As mentioned before, financial markets fluctuate tremendously as a result of political disorders, economic crises, wars or natural disasters. Thus, it can be seen that the computed futures prices differ only by one to two pesos since Philippine economy is more stable today.

Moreover, the 1000 simulated futures prices were then compared to futures prices which used the Philippine and US T-Bill rate long run mean, μ, as the interest rate for January 2012 to June 2012 for each respective country. It was discovered that the 0.39 probability of the simulated futures prices which is less than the computed futures prices using the long run mean ranges from 0.9160 to 1.

On the other hand, the endeavor to examine if GARCH-type model is appropriate in describing the return series of the predicted futures prices and using it to compute for the optimal hedge ratio of the Peso-Dollar exchange rates was done statistically and empirically. The dataset was first tested by various statistical testing methods to see if GARCH modeling was applicable. These include the Ljung-Box-Pierce Q-Test and Engles ARCH Test to test whether the dataset change with respect to time. It was followed by diagnostic checking where overfitting of the model was done to determine which model best fitted the dataset. After model fitting of the data set was done, the parameters were estimated and the best model used is GARCH(1,1). Finally, the conditional variance of the data set were forecasted and used in the computation of OHR.

In addition, the computed parameters of GARCH (1,1) model were used to compute for the conditional covariances of the spot and futures returns which was also needed in the computation of OHR.

The result of the OHR for the maturity of the futures contract lies between the interval [0.563063715, 0.959170115]. This means that the percentage of your investment which is protected from risk lies on that interval only. These are the computed ratio that will minimize your risk.

References

[1] Bodie, Kane, and Marcus. *Investments (Fifth Edition).* The McGraw-Hill Companies, Inc., 2003

[2] T. Bollerslev, *Generalized Autoregressive Conditional Heteroscedasticity,* Journal of Econometrics, 31, 301-327, 1986.

[3] L.H. Ederington, L.H., *The Hedging Performance of the New Futures Markets,* Journal of Finance, 34, 157-170, 1979.

[4] R.F. Engle, *Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation,* Econometrica, 50, 987-1008, 1982.

[5] S. Gandhi, *Hedging Foreign Exchange Risk- Isnt it also a risk?,* The Chartered Accountant, 260-264, 2006.

[6] N.A. Khan, *Forecasting Value-at-Risk by Using GARCH Models,* University of Karachi, 2007.

[7] B. Kumar, P. Singh and A. Pandey, *Hedging Effectiveness of Constant and Time Varying Hedge Ratio in Indian Stock and Commodity Futures Markets,* Indian Instititute of Management Ahmedabad, Research and Publication, 2008.

[8] A.M. Parhizgari and P. Chunhachinda, *Time-Varying Optimal Hedge Ratios of Foreign Currency Futures,* Finance India, 10, 325-332, 1996.

[9] D. Plaza, *The Role of Currency Futures in Risk Management: Currency Futures and Risk Management,* GRIN Verlag, 2011.

[10] I. Ramlall, *Striving for the Optimal Hedge Ratio,* University of Technology, Mauritius, 2006.

Received: August 7, 2014