Indian J.Sci.Res. 17 (1): 308-313, 2017

ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

COMPARATIVE ANALYSIS OF BLACK-SCHOLES MODEL AND TRINOMIAL MODEL IN US DOLLAR TO RUPIAH FOR HEDGING IN 2008

BANDY CIPTA NUR RAMADHAN[a1] AND RIKO HENDRAWAN[b]

[ab]Master of Management Program, Telkom University

ABSTRACT

In this paper, we will analyze comparison of two option pricing models to protect value of exchange rates when high volatility condition. According to economists, We compare Black-Scholes and Trinomial model for predicting future value for a contract. We used Average Mean Square Error to find the best model. The results are known that Trinomial model is better used in a period of one month,with error 0.37% for call and put. For two months, Trinomial model have best error than Black-Scholes, it have 0.53% for call and put. For three month Black-Scholes model is better used, where this model gets an error value of less than 0.68% for call and put than Trinomial Model.

KEYWORDS: Black-Scholes, Exchange Rate, Option Derivative, Trinomial.

The government policy of the Republic of Indonesia, that always depends on the fluctuation of the US Dollar (USD), raises concerns of the economic actors in the future trading activities. According to the practitioners in Indonesia, it cannot be denied that the rupiah plays an important role in the Indonesian economy, both in terms of fundamentals and sentiments. The concern of Indonesian people is always focused on the risk of a sharp depreciation of rupiah. This happens because the past depreciation of the rupiah is associated with the economy crisis. The depreciation of rupiah will certainly disrupt economic activity for businesses and it will have a bad effect on Indonesia's economic climate. Facing the uncertainty of the US economic policy, Bank Indonesia (the Central Bank of Indonesia) will continue to deepen financial market by issuing derivative and hedging products. Therefore, the further study on hedging is needed by applying the use of option derivative instrument against the exchange of currencies between USD and IDR. It is done to minimalize the risks that can happen in the future.

LITERATURE REVIEW

Chesney & Scott mention that for some decades in the past the markets of currency options have grown up in America, Europe, and other parts of the world [1]. This is because the market can be the strategy in hedging and minimalizing risks, in which it is difficult for the early markets (forward and future market) to minimalize a risk. Most of the option pricing models used in the currency option market are designed with the type of European style, where the execution can only be executed at maturity only. Furthermore, according to Yuen & Yang option pricing has been a topic area that the researchers and practitioners pay attention to [2].

Since Black-Scholes [3] has been introduced and become the basic foundation in an option pricing model, many researchers then develop the model to be even better, namely Lee at al. [4], Ivancevic [5], Sheraz & Preda [6], and Çetin et al. [7]. There are also researchers who make the Black-Scholes model only to compare with other models, for instance: Hendrawan [8], and Chesney & Scott [1]. Then there are also researchers who just try to change the object of the research, generally the use of the Black-Scholes is used on stock prices, but Klein [9], the researcher, tries with different object, namely the credit risk.

Then, the Trinomial Model makes researchers acquainted with option pricing more diverse. The Trinomial Model is used by early researchers as their main method, then it is developed by Tian [10], (Xiaoping et al. [11], Yuen & Yang [2], Ma & Zhu [12], Braouezec [13]. There are also researchers applying this method, and then only changing their research object, such as Krishnaswamy & Rathinaswamy who change their object into the outsourcing offshore contract [14], Ahn & Song who want to compare with other model to see how much the computational cost is spent [15], Derman et al. who just want to see the behavior of volatility itself [16].

Each research must have similarity and difference with the previous researches, ,to maintain the authenticity of this research, the researcher will reveal similarities, differences, and positions of current researcher with the previous researchers. The similarity with the previous researches on the Black-Scholes Model is that this study applies the Black-Scholes model as one of the main models, but the difference is that the researcher does not develop this model as the previous researchers did. Then, the current study on the Trinomial Model has similarity with the previous researches, in

[1]Corresponding author

which this study uses the Trinomial model as one of the main models, but the difference is that the researcher does not add or develop the Trinomial model with others. The current researcher's position is as one who compares the accuracy of the two models, that is the Black-Scholes and the Trinomial Model. Then, the object of the study used is the exchange rate of USD against IDR.

CURRENCY OPTION MARKET

Currency option is a contract for the right to purchase or the right to sell a currency at a certain exchange rate on a predetermined date. In the currency option, the buyer is entitled to pay a premium to the seller, the amount of the premium depends on the number of contracts purchased by buyers in the over-the-counter (OTC) market. At the end of 1982, according to [17] exchanges in Amsterdam, Montreal, and Philadelphia were first applied to the trade with the standardization of foreign currency options. Since then, the option contracts are offered on the Chicaho Mercentile Exchange and the Chicago Board Option Exchange. Exchange options in the United States are regulated by Securities and Exchange Commission, the options can be sold or purchased via a broker for a commission. The currency option is also one of ways for corporations, individuals, or financial institutions to hedge the exchange rate movement.

According to [18], the currency option provides an alternative method of hedging that does not only minimize risk and ensure an unnatural movement of an exchange rate, but also can make a profit as a result of the movement of the market. Here is the Table 1 showing the position of the currency option; it can be applied to formal trade (exchange traded} or nonformal trade / Over The Counter (OTC).

Table 1: Market Area Currency Derivatives

	Exchange Traded	OTC
Currency futures	√	
Currency options	√	√
Currency swaps		√

Black-Scholes Model

In the early of 1970s Fisher Black, Myron Scholes, and Robert Merton produced a big breakthrough in the process of pricing of stock options. Later on it is known as the Black-Scholes Model (or the Black-Scholes, Merton Model), over time this model plays an important role in the world of the option price trading and hedging. This model is very important to keep growing in the model development and to be successful in the financial engineering in the last 30 years [3].

According to [19], this model has some assumptions in usage, for example this model can only use the European style, the volatility and the risk-free interest rate have a constant value until the term of agreement is completed/ due, the return of an option price will also follow a normal distribution, this makes the Black-Scholes Model represented as continuous data.

According to [8], the Black-Scholes formula equation formula for call options is as follows :

$$C=SN(d1)-e^{(-R_f T)} XN(d2) \qquad (1)$$

While the formula for the put option is as follows:

$$P=Xe^{(-R_f T)} N(-d2)-SN(-d1) \qquad (2)$$

Where :

$$d1=(\ln((S/X)+(R_f-\sigma^2/2))/(\sigma\sqrt{T}))T \qquad (3)$$

$$d2=d1-\sigma\sqrt{T} \qquad (4)$$

Information :

S = Spot Price

X = Execution Price

T = Time Maturity

Rf = Risk Free Rate / BI Rate

σ = Variance of exchange rate

N{.}= Normal distribution cumulative.

Trinomial Model

According to [20], a very popular and useful technique to use on the pricing of an option is a binomial tree. In addition to the binomial tree, the trinomial tree is one the alternatives and the development of binomial tree.

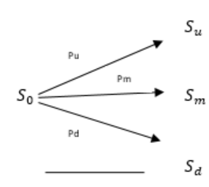

Figure 1: Trinomial Model with 1 step

Like the Binomial tree, the Trinomial tree is represented by discrete data, it can be seen in Figure 1 where each price calculation is followed by an opportunity/ a probability value. The trinomial tree will then allow the prediction of exchange rate in an up, fixed, and descending position. While the Binomial model only allows the position of the exchange rate up and down. The Trinomial tree was first popularized by Phelim Boyle in 1986, where he developed the Binomial model into the Trinomial. The operational variables of Boyle's Trinomial model are the current price, execution price, volatility, due date/ maturity, lamda, and the number of steps. [21] mention in their research that Boyle applies the parameter of λ with value more than one.

Seeing from Figure 1, Trinomial Model can be explained as follows:

$$S(t+\Delta T) = \begin{cases} S(t)u \text{ with the probability } pu \\ S(t)m \text{ with the probability pm} \\ S(t)d \text{ with the probability } pd \end{cases}$$

Based on the theory above, according to [14] the following is the trinomial formula:

C= (Cu * Pu + Cm*Pm + Cd*Pd) / (1+r) (5)

Where :

m = 1

u = e^(λσ√Δt)

d =1/u

μ =r- σ^2/2

λ =1.22474

pu =1/(2λ^2)+ (μ√Δt)/2λσ

pd = 1/(2λ^2)- (μ√Δt)/2λσ

pm = 1* pu* pd

Note:

r = free risk interest rate /BI Rate

σ = exchange rate variance

pu= probability if rising

pm= probability if fixed

pd = probability if falling

m = value of each movement if fixed

u = value of each movement if rising

d = value of each movement if falling

Test of Average Percent Mean-Squared Error

To test and analyze the Trinomial and Black-Scholes model, the researchers apply the analysis of Average Percent Mean-Square Error (AMSE). This analysis is also used by [8] and [22] to test the comparison of two models. The following is the equation used in AMSE:

$$\mathrm{AMSE} = \frac{1}{N}\sum_{t=1}^{N}\left(\frac{APt-SPt}{APt}\right)^2 \quad (6)$$

Where :

APt = Actual exchange rate value

SPt = Exchange rate value of calculation model

N = Number of experiments performed

COMPARISON RESULTS

Comparison Results of Trinomial Model and Black-Scholes Model for 1 Month

Here is the table of AMSE calculation results for call and put on the two models which are observed, where X = execution price, P = spot price, BS = Black-Scholes Model, TR = Trinomial model, and AMSE = Average Percent Mean Square Error.

Table 2: Result both model for 1 month

NO	AMSE						Note
	X<P		X=P		X>P		
	BS	TR	BS	TR	BS	TR	
1	0.35%	0.32%	0.36%	0.34%	0.37%	0.36%	CALL
2	0.33%	0.32%	0.34%	0.33%	0.36%	0.35%	PUT

In the Table 2, it is found out that if the condition of execution price is smaller that spot price, the prediction of the Trinomial Model for call and put has the smallest error, that is 0.32% for call and 0.32 for put. When the condition is equal with the spot price, the prediction of Trinomial Model has also the smallest error, that is 0.34% for both call and put. Then, when the condition of the execution price is higher rather than the spot price, the prediction of the Trinomial model has also the smallest error, namely 0.36% for call, and 0.35% for put.

Comparison Results of the Trinomial Model and the Black-Scholes Model for 2 Months

The following table presents the results of AMSE calculation for call and put on both models that have been studied, where X = execution price, P = spot price, BS = Black-Scholes Model, TR = Trinomial model, and AMSE = Average Percent Mean Square Error.

Here is the table of AMSE calculation results for call and put on the two observed models.

Table 3: Result both model for 2 month

NO	AMSE						Note
	X<P		X=P		X>P		
	BS	TR	BS	TR	BS	TR	
1	0.53%	0.51%	0.54%	0.52%	0.54%	0.53%	CALL
2	0.51%	0.51%	0.51%	0.51%	0.52%	0.51%	PUT

In the Table 3, it can be seen if the condition of the execution price is smaller than the spot price, the prediction of the Trinomial model for call has the smallest error, that is 0.51%, while for put of the two models has the same error, that is 0.51%. When the condition of the execution price is as same as the spot price, the prediction of the Trinomial model has the smallest error for call, that is 0.52%; otherwise, for put both models have the same error, 0.51%. Then when the condition of the execution price is higher than the spot price, the prediction of the Trinomial model has the smallest error for call and put respectively, that is 0.53% and 0.35%.

Comparison Results of the Trinomial Model and the Black-Scholes Model for 3 Months

The following table presents the results of AMSE calculation for call and put on both models that have been studied, where X = execution price, P = spot price, BS = Black-Scholesmodel, TR = Trinomialmodel, and AMSE = Average Percent Mean Square Error.

Here is the table of AMSE calculation results for call and put on the two observed models.

Table 4: Result both model for 3 month

NO	AMSE						Note
	X<P		X=P		X>P		
	BS	TR	BS	TR	BS	TR	
1	0.66%	0.66%	0.66%	0.66%	0.66%	0.66%	CALL
2	0.71%	0.72%	0.68%	0.70%	0.66%	0.68%	PUT

In the Table 4, it can be seen that if the condition of the execution price is smaller than the spot price, the prediction of the Black-Scholes and Trinomial model has the same error for call, that is 0.66%, while for put the Black-Scholes model has the smallest error, that is 0.71%. When the condition of the execution price is as same as the spot price, the prediction of both models has the same error for call, that is 0.66%, while for put the Black-Scholes model has the smallest error, that is 0.68%. Then when the condition of the execution price is higher than the spot price, the prediction of both models has the same error for call that is 0.66%, while for put the Black-Scholes model has the smallest error, that is 0.66%

SUMMARY AND CONCLUSION

In this study, it can be concluded that firstly, in one-month agreement, the Trinomial model is better compared with the Black-Scholes model for call and put. This is because the Trinomial model has the smallest error for all three mentioned simulations. For call and put within a period of one and two months, the best condition of the Trinomial model is when the condition of the execution price is lower rather than the spot price, because it has the smallest error value compared with the condition of execution price that is equal to or higher than the spot price. While for a period of three months, the best condition for put is when the execution price is higher than the spot price. Secondly, in the two-month agreement, the Trinomial model is better than the Black-Scholes model for call and put. It is because the Trinomial model has the smallest error for all three mentioned call simulations. The best condition is if an agreement within two months tends to be the condition in which the execution price is lower than the spot price. However, the overall error value obtained when making a two-month agreement is greater than that during a one-month agreement. Thirdly, in a three-month agreement, the Black-Scholes model is better than the Trinomial model for put. This is because the Black-Scholes model has the smallest error for all three mentioned simulations. While for call, two models have the same error. Then, the execution price which is higher than the spot price has the smallest error value if it is compared with the condition when the execution price is equal to or lower than the spot price, this is inversely proportional to the one-month and two-month agreement where the lower the execution price than the spot price is, the smaller the obtained error value is.

The suggestions from the results of this study are for practitioners, firstly, if it wants to make an option agreement in the year of the economy crisis, the use of the Trinomial model tends to be better for a period of one and two months. However, it is highly recommended to use the option in just a month, the goal is to avoid the values that will deviate in the future. This is proved from the results of testing and analysis discussed above. Secondly, when it wants to sell or purchase an option derivative in the year of economy crisis, and to use the Black-Scholes or Trinomial model to determine the future value, it is advisable to enter into an agreement with the condition of the execution price that is lower than the spot price, it has been discussed above, in which the execution price that is lower than the spot price has a small deviation value to protect the owned asset value. Thirdly, for a period of three months in the year of the economy crisis, it is advisable to use the Black-Scholes model to predict the future value, and also advisable that the execution price is higher than spot price. This is because in the study that has been performed, the AMSE statistical test has obtained the smaller error value when the execution price is higher than the spot price compared with the other two conditions.

Suggestions for the next researchers, firstly, it is done another comparative study of optional models, such as Binomial, Monte Carlo, Garch, Black-Scholes that are modified or other model development of the United States Dollar exchange against Rupiah, then it is compared with the results of this study as the reference material from the next researchers. Secondly, it is done the study of American-type option with models that can be used in the type of American options, for example the modified Black-Scholes model, the Trinomial model, and other models. Thirdly, in the next study, the researchers could try another measuring instruments to compare the two option pricing models, with the measuring tools of price Absolute Error, Root Mean Square Error, or others that can compare both models to deviant values.

REFERENCES

M. Chesney and L. Scott, "Pricing European Currency Options: A Comparison of the Modified Black-Scholes Model and a Random Variance Model," J. Financ. Quant. Anal., vol. 24, no. 3, pp. 267–284, Sep. 1989.

F. L. Yuen and H. Yang, "Option pricing with regime switching by trinomial tree method," J. Comput. Appl. Math., vol. 233, no. 8, pp. 1821–1833, Feb. 2010.

F. Black and M. Scholes, "The Pricing of Options and Corporate Liabilities," J. Polit. Econ., vol. 81, no. 3, pp. 637–54, 1973.

C.-F. Lee, G.-H. Tzeng, and S.-Y. Wang, "A new application of fuzzy set theory to the Black–Scholes option pricing model," Expert Syst. Appl., vol. 29, no. 2, pp. 330–342, Aug. 2005.

V. G. Ivancevic, "Adaptive-Wave Alternative for the Black-Scholes Option Pricing Model," Cogn. Comput., vol. 2, no. 1, pp. 17–30, Mar. 2010.

M. Sheraz and V. Preda, "Implied Volatility in Black-scholes Model with Garch Volatility," Procedia Econ. Finance, vol. 8, pp. 658–663, Jan. 2014.

U. Çetin, R. Jarrow, P. Protter, and M. Warachka, "Pricing Options in an Extended Black Scholes Economy with Illiquidity: Theory and Empirical Evidence," Rev. Financ. Stud., vol. 19, no. 2, pp. 493–529, Jul. 2006.

R. Hendrawan, "Perbandingan Model Opsi Black-Scholes dan Model Opsi GARCH di Bursa Efek Indonesia," J. Keuang. Dan Perbank., vol. 14, pp. 13–23, Jan. 2010.

P. Klein, "Pricing Black-Scholes options with correlated credit risk," J. Bank. Finance, vol. 20, no. 7, pp. 1211–1229, Aug. 1996.

Y. S. Tian, "A trinomial option pricing model dependent on skewness and kurtosis," Int. Rev. Econ. Finance, vol. 7, no. 3, pp. 315–330, Jan. 1998.

H. Xiaoping, G. Jiafeng, D. Tao, C. Lihua, and C. Jie, "Pricing Options Based on Trinomial Markov Tree," Discrete Dyn. Nat. Soc., vol. 2014, p. e624360, Jul. 2014.

J. Ma and T. Zhu, "Convergence rates of trinomial tree methods for option pricing under regime-switching models," Appl. Math. Lett., vol. 39, pp. 13–18, Jan. 2015.

Y. Braouezec, "How fundamental is the one-period trinomial model to European option pricing bounds. A new methodological approach," Finance Res. Lett., Nov. 2016.

C. R. Krishnaswamy and R. S. Rathinasamy, "Offshore Outsourcing Contracts: Real Options Analysis Using Trinomial Option Pricing Model," Glob. Bus. FINANCE Rev., vol. 20, no. 1, pp. 15–24, Jun. 2015.

J. Ahn and M. Song, "Convergence of the trinomial tree method for pricing European/American options," Appl. Math. Comput., vol. 189, no. 1, pp. 575–582, Jun. 2007.

E. Derman, I. Kani, and N. Chriss, "Implied Trinomial Tress of the Volatility Smile," http://dx.doi.org/10.3905/jod.1996.407952, 22-Feb-2009. [Online]. Available: http://www.iijournals.com/doi/abs/10.3905/jod.1996.407952?journalCode=jod. [Accessed: 30-Mar-2017].

J. Madura, International Corporate Financial. Mason: Thompson South-Western, 2008.

F. Taylor, Mastering derivatives Markets: a step-by-step guide to the products, applications and risks. Great Britain: Pearson Education, 2007.

R. W. Kolb, Futures, Options, and Swaps, Third. Malden, Massachusetts: Blackwell Publishers Ltd, 1999.

J. Hull, Option, Future, and Other Derivatives Securities. New Jersey: Pearson, 2009.

J. H. Chan, M. Joshi, R. Tang, and C. Yang, “Trinomial or Binomial : Accelarating American Put Option Price on Trees,” J. Futur. Mark., vol. 29, Jan. 2008.

T. Harikumar, M. E. de Boyrie, and S. J. Pak, “Evaluation of Black-Scholes and GARCH Models Using Currency Call Options Data,” Rev. Quant. Finance Account., vol. 23, no. 4, pp. 299–312, Dec. 2004.