

An Evaluation of Binomial Model with Implied Volatility in Pricing Warrant

Khairu Azlan Abd Aziz^a, Wan Mohd Yaseer Mohd Abduh^b, Mohd Fazril Izhar Mohd Idris^a, Rizauddin Saian^a

^a*Department of Mathematical Sciences and Statistics, Universiti Teknologi Mara (Perlis), Arau 02600, Malaysia*

^b*Department of Finance, Universiti Teknologi Mara (Perlis), Arau 02600, Malaysia*

ABSTRACT

There are various models that can be applied in pricing warrant. In this study, the Binomial model with implied volatility was chosen to calculate the warrant price. The price of warrant obtained from the model will be compared with the actual price to check the accuracy and consistency of the warrant price. Several companies which issues warrant will be randomly selected from Bursa Malaysia list. Information on underlying shares and warrants were collected from UiTM data stream start on January 2016 until May 2017. Parameters like exercise price or strike price, interest rate, maturity date and volatility are involves in pricing warrant. This study also discussed on moneyness which determines either the mother shares of the warrant are in-the-money, at-the-money or out-the-money.

Keywords: *Warrant, binomial model, implied volatility, price, moneyness.*

1. Introduction

A warrant is an instrument which provides not the obligations, but the right to the investor to buy or sell the underlying asset at a certain price on or before expiration date (Zhang et al. 2009). Strike price also known as exercise price is the price at which the underlying security can be bought or sold. When the investors exercise a warrant, they are actually buy an underlying shares from the company.

There are two types of warrants which are put and call warrants. Put warrant is a type of security that gives holder the right but not the obligation to sell a given amount of the underlying asset at a predetermined exercise price on or before a maturity date. Meanwhile, call warrant gives holder the right to buy a given amount of the underlying asset at a predetermined exercise price on or before maturity date. Due to that difference, to capitalize on downward share price movement, a bearish investor may buy a put warrant, while to profit from upward share price movements, a bullish investor may buy a call warrant.

According to Londani (2011) there are two styles of warrants which are European warrants and American warrants. When people talk about the 'style' of a warrant it is referring to when the warrant can be exercised. For European warrants, the holders can only exercised the warrant on the maturity date while American warrants allows the holders to exercised at any time on or before the expiration date. For an issuer of warrants, the European style is more simple than American style because only at the maturity date of the warrant exercise transaction will occurs.

Warrants are in many ways alike to options, but there are a few dissimilarities to differentiate them. Unlike option, warrant is dilutive and it has much longer periods between issues and expiration. In addition, warrants are typically issued by the company itself, while options are written by other investors that are also known as market-makers.

In 1990, warrant was introduced in Malaysia and it has gained popularity. In finance, warrants can be trades through brokers which handle every transaction over the counter. A warrant can acts as a hedging tool. The principles of hedging are objectively simple and it is considered as an advanced investing strategy. Warrants can be used to insure your investments against a recession just like an insurance policy where you protect your property such as a house or a car.

Warrant can be used as a tools of hedging. The price movement of the underlying shares can highly influence the position of the investment either profitable or losses. Thus, the losses on the underlying share is offset by the gain on the warrant as a hedge. The fluctuating of the underlying share price up and down also allow traders to exploit arbitrage opportunities. Arbitrage is like buying an underlying share in a market and then exercise it in another market with higher price to gain profit. This is considered as a risk free profit for the arbitrageurs. The oppurtunity of the arbitrage is happened when the issuer or seller mispriced the warrant either undervalued or overvalued. Pricing the warrant is not an easy task because the pattern or

movement of the warrant price is nonlinear. Thus, the players of this investment need to possess the knowledge in finance and mathematics to obtain a fair price of warrant.

2. METHODOLOGY

In this section, the process and methodology of this paper is presented. The variables needed for pricing call warrants are time to maturity (Δt), exercise price or strike price (K), stock price (S), actual warrant price and risk free rate (r). According to Sanjay and Vijayakumar (2008), there exist a relationship between implied volatility and moneyness of option which is known as volatility smile. Implied volatility (σ) formula is shown below:

$$C(S, T) = SN(d_1) - Ke^{-r(T-t)}N(d_2) \quad (1)$$

$$f(\sigma) = SN(d_1) - Ke^{-r(T-t)}N(d_2) - C = 0. \quad (2)$$

Then, differentiate Newton's method to find the volatility,

$$\sigma_{n+1} = \sigma_n - \frac{[SN(d_1) - Ke^{-r(T-t)}N(d_2) - C]}{S \left(\frac{1}{\sqrt{2\pi}} \right) e^{\frac{d_1^2}{2}} \sqrt{T-t}}, \quad (3)$$

where,

$$d_1 = \frac{\ln \frac{S}{K} + \left(r + \frac{\sigma^2}{2} \right) (T-t)}{\sigma \sqrt{T-t}}, \quad (4)$$

$$d_2 = d_1 - \sigma \sqrt{T-t}. \quad (5)$$

Michailidis and Mattas (2007) used binomial method in pricing the option. The main point for the study is to show that the binomial method can be applied in calculating the price of option. Since there are many similarities between warrant and option, thus we can also use the pricing method of option to price warrant (Zeng and Zhang 2011). During the process of binomial model, stock price can be either jump up or down with given probability p and (1-p) where $p \in [0,1]$. Let u and d be the jump up and down factors respectively.

$$A = \frac{1}{2} (e^{-r\Delta t} + e^{r\Delta t + \sigma^2 \Delta t}) \quad (6)$$

$$u = A + \sqrt{A^2 - 1} \quad (7)$$

$$d = \frac{1}{u} \quad (8)$$

$$p = \frac{e^{r\Delta t} - d}{u - d} \quad (9)$$

where

u = share price up

d = share price down

p = probability of price up

q = probability of price down

The binomial tree model for market share price shows as the following (Benniga and Weiner, 1997):

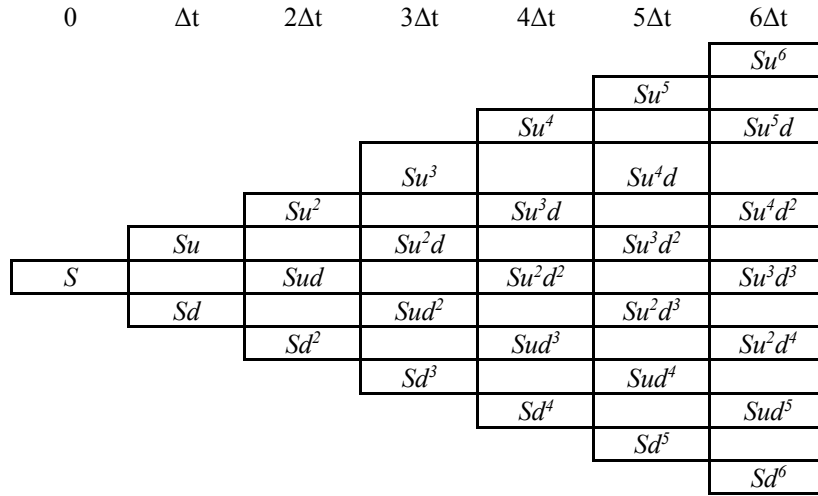


Fig. 1 Binomial tree model to calculate maximum payoffs

In this stage, the values of warrant payoffs are calculated at expiration date for each node. Once underlying share price is constructed, the maximum warrant payoffs at maturity date Δt are calculated. The formula of call warrant payoffs is shown as below:

$$V = \max(S - X, 0) \quad (10)$$

The price of warrant can be calculated by using backward induction algorithm. The European style of warrant is considered to apply this backward method. The formula are shown as below:

$$C = \max\left(e^{-r\Delta t} (pVu + (1-p)Vd, \max(S - X, 0))\right) \quad (11)$$

Where Vu = warrant value at node going up and Vd = warrant value at node going down.

There are three type of moneyness which are known as in-the-money, at-the-money and out-the-money (Abd Aziz et al, 2015). Then the equation that will be used to calculate the moneyness (M) of the underlying share is

$$M = \frac{S - Xe^{-r\Delta t}}{Xe^{-r\Delta t}} \quad (12)$$

In order to get the price of put warrant (P), put call parity can be apply after obtained the call warrant. The formula to find the put warrant is

$$P = C + Xe^{-rt} - S \quad (13)$$

We can know the valuation of the warrant by evaluating its relative pricing error. From that, we are able to identify either the warrant is undervalued or overvalued compared to the actual market price of warrant. It can be measure by using the formula below:

$$D = \frac{C_A - C_M}{C_A} \quad (14)$$

where

C_M = model call warrant,
 C_A = actual call warrant.

The mean squared error (MSE) is defined as follows:

$$MSE = \frac{1}{n} \sum (C_A - C_M)^2 \quad (15)$$

3. RESULTS AND DISCUSSIONS

In pricing the warrants, implied volatility was calculated first since it cannot directly gained from the market information. There are many different measures of implied volatility which can use some or all open, low, high, or close of underlying share price. The calculation of the implied volatility based on close price of underlying share is presented in Fig. 2 below using equation (3).

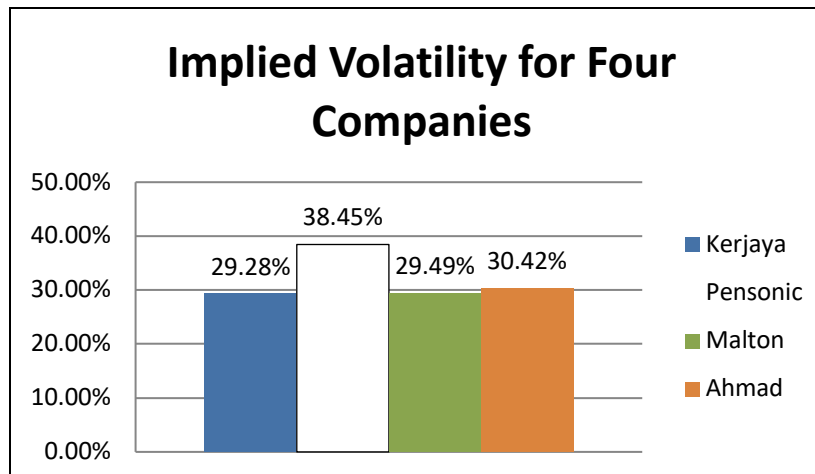


Fig. 2 Graph of Implied Volatility

There are many companies in Malaysia trade warrant. Companies that trade warrant are listed in Bursa Malaysia Board. For this project, we have chosen randomly 4 companies trade warrant to evaluate the consistency of the binomial model in pricing warrant. The warrant prices of randomly selected companies obtained from equation (11) are tabulated in table below.

Table 1. Summary for Kerjaya Prospek Group Berhad Warrant

Date	Underlying Share Price (MYR)	Actual Warrant Price (MYR)	Model Warrant Price (MYR)	Model Put-Call Parity (MYR)	Exercise Price (MYR)	Error
1/3/2016	1.63	0.67	0.76	0.11	1	-0.09
1/6/2016	1.97	1.28	1.08	0.10	1	0.20
1/9/2016	2.33	1.39	1.43	0.08	1	-0.04
1/12/2016	2.27	1.35	1.37	0.09	1	-0.02
1/3/2017	3.14	2.23	2.23	0.08	1	0.00
1/6/2017	3.75	2.78	1.88	0.08	1	0.90

Table 2. Summary for Pensonic Holding Berhad Warrant

Date	Underlying Share Price (MYR)	Actual Warrant Price (MYR)	Model Warrant Price (MYR)	Model Put-Call Parity (MYR)	Exercise Price (MYR)	Error
1/3/2016	0.60	0.19	0.20	0.14	0.55	-0.01
1/6/2016	0.63	0.25	0.23	0.22	0.55	0.02
1/9/2016	0.70	0.26	0.28	0.28	0.55	-0.02
1/12/2016	0.65	0.23	0.24	0.24	0.55	-0.01
1/3/2017	0.65	0.25	0.24	0.24	0.55	0.01
1/6/2017	0.61	0.23	0.21	0.16	0.55	0.02

Table 3. Summary for Malton Berhad Warrant

Date	Underlying Share Price (MYR)	Actual Warrant Price (MYR)	Model Warrant Price (MYR)	Model Put-Call Parity (MYR)	Exercise Price (MYR)	Error
1/3/2016	0.74	0.17	0.10	0.35	1	0.07
1/6/2016	0.66	0.14	0.07	0.37	1	0.07
1/9/2016	0.64	0.10	0.05	0.40	1	0.05
1/12/2016	1.50	0.23	0.13	0.32	1	0.10
1/3/2017	1.21	0.75	0.64	0.13	1	0.11
1/6/2017	0.68	0.43	0.41	0.18	1	0.02

Table 4. Summary for Ahmad Zaki Resources Berhad Warrant

Date	Underlying Share Price (MYR)	Actual Warrant Price (MYR)	Model Warrant Price (MYR)	Model Put-Call Parity (MYR)	Exercise Price (MYR)	Error
1/3/2016	0.64	0.21	0.22	0.10	0.52	-0.01
1/6/2016	0.74	0.37	0.31	0.08	0.52	0.06
1/9/2016	0.64	0.28	0.22	0.10	0.52	0.06
1/12/2016	0.63	0.25	0.22	0.10	0.52	0.03
1/3/2017	1.11	0.63	0.65	0.05	0.52	-0.02
1/6/2017	1.13	0.58	0.67	0.05	0.52	-0.09

The graph in figures below showing the comparison between actual call warrant price and model call warrant price using binomial model for four randomly selected companies trade warrant.

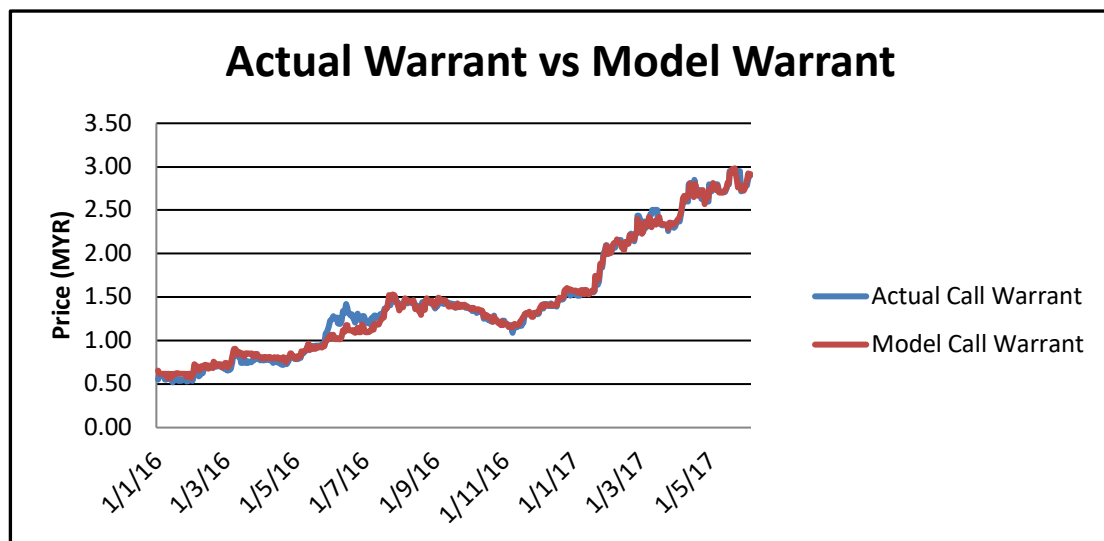


Fig. 3 Actual versus Model for Kerjaya Prospek Group Berhad

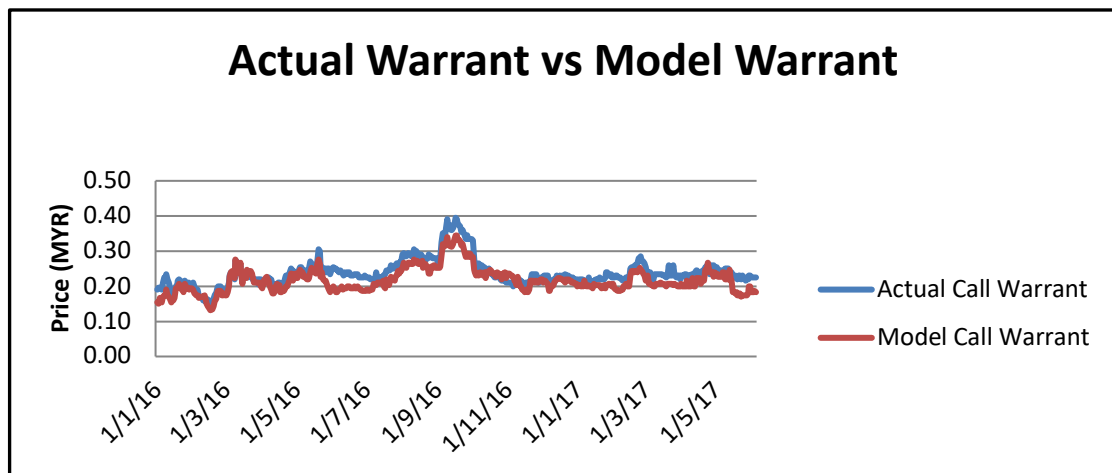


Fig. 4 Actual versus Model for Pensonic Holding Berhad

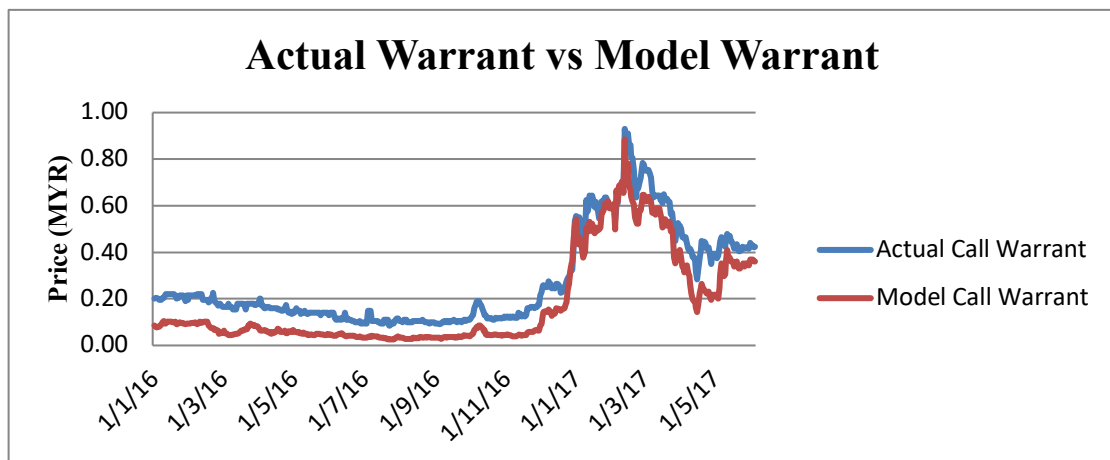


Fig. 5 Actual versus Model for Malton Berhad

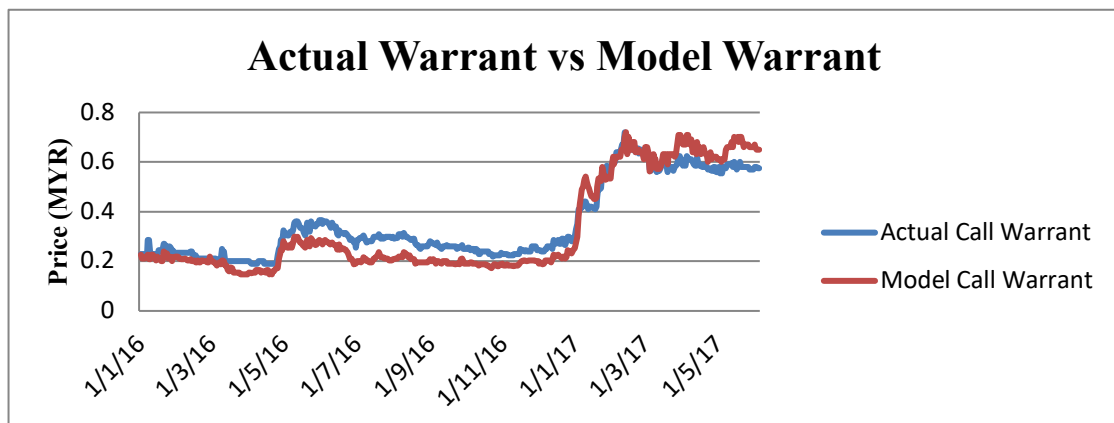


Fig. 6 Actual versus Model for Ahmad Zaki Recourses Berhad

From the graph above, we can see that there exist a gap between actual price of warrant and model price. Despite there are some different on price, but the gap is not too much and still follow the pattern of the actual price. In addition, the pattern of graph for the mother share and its warrant also showed a similar movement. Furthermore, we can identify which warrant is undervalued or overvalued based on two prices from the graph. The valuation and MSE of four warrants using equation (14) and (15) can be referred in Table 5 below:

Table 5. Summary of Valuation for four companies

Company	MSE Value (%)	Valuation
KerjayaProspek	0.41 %	-0.0053 (undervalued)
Pensonic Holding	0.074 %	0.0877 (overvalued)
Malton	0.98 %	0.4817 (overvalued)
Ahmad Zaki Resources	0.32 %	0.1150 (overvalued)

Moneyiness is the concept that showed the performance of the companies and their relationship between the underlying share price and the exercise price. It will determine the condition of the underlying share whether good or not. The warrant is called in-the-money when the price of underlying share is higher than exercise price while the warrant is out-of-the-money when the price of underlying share is lower than the exercise price. For at-the-money, the price of underlying share is exactly the same to the exercise price. Based on Table 6, it shown that all of the companies are in-the-money.

Table 6. Result summary of Moneyiness for four companies

Company	Moneyiness
KerjayaProspek	1.4080 (in-the-money)
Pensonic Holding	0.3510 (in-the-money)
Malton	0.17852 (in-the-money)
Ahmad Zaki Resources	0.5380 (in-the-money)

4. CONCLUSION

Binomial model is one of the method that can be used to price warrant although it was develop to price the option. The findings of this study has shown that the warrant price from binomial model is close and follow the pattern of the actual price. From the previous research done by Abd Aziz et al (2015) , warrant was priced by using Black Scholes model which is one of the pricing model for option. The result shown a consistent pattern of the price movement between model and actual price. Segara and Sagara (2007) also claim that the basic characteristics of a warrant are similar to the options and obligation of issuing corporation for each share. Thus, the model for attaining option price can also be utilized to obtain the price of warrant since the characteristics are somewhat similar. However, a further research need to be conduct in order to improve the accuracy of the price.

REFERENCES

- Abd Aziz, K.A., MohdIdris, M. F. I., Saian, R. and Wan Daud, W. S., 2015. "Adaptation of warrant price with Black Scholes model and historical volatility", AIP Conference Proceedings, 1660(090042), p. 1. doi: 10.1063/1.4915886.
- Benninga, S. and Weiner, Z., 1997. "The binomial option pricing model", *Mathematica Education and Research* 6, p. 27.
- Londani, M., 2011. "Numerical methods for mathematical models on warrant pricing", *Int.Statistical Inst.: Proc. 58th World Statistical Congress*, Dublin, p. 6249.
- Michailidis,A., and Mattas,K., 2007. "Using real options theory to irrigation dam investment analysis: An application of binomial option pricing model", *Water Resources Management* 21, p. 1717.
- Sanjay, S. and Vijayakumar, N., 2008. "Determinants of implied volatility function on the nifty index options market: Evidence from India", *Asian Academy of Management Journal of Accounting and Finance* 4, p. 45.
- Segara, L., and Sagara, R., 2007. "Intraday trading patterns in equity warrants and equity options markets: Australian evidence", *Australian Accounting, Business and Finance Journal* 1, p. 42.
- Zhang, W. G., Xiao, W. L., and He, C. X., 2009. "Equity warrants pricing model under fractional Brownian motion and an empirical study", *Expert Systems with Applications* 36, p. 3056.
- Zeng,S. and Zhang,S., 2011. "Real option literature review", *Scientific Research iBusiness* 3, p. 43.