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Exploring internal mechanism of warrant in financial market with a hybrid approach

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Abstract

In this research, we explore the internal mechanism of warrant in financial market with a hybrid approach integrating Black–Scholes pricing method and Grey theory into a genetic algorithm (GA) based back-propagation neural network (BPN). Black–Scholes pricing method can help make earnings with little risk. Grey theory can decrease the random and implicative noise of tempestuously undulant warrant prices. GA is used to find the best architecture for BPN to avoid local optimum.

In experiment, we find that most of selected input variables for BPN include Black–Scholes pricing values and Grey index values. It shows that those two kinds of values are crucial factors. And the earnings rate of warrant outperforms that of the underlying asset. In addition, the proposed model is verified to outperform traditional BPN. However, the high risk of warrant is another subject to which we should pay attention.

Keywords: Warrant; Black–Scholes pricing method; Grey theory; Genetic algorithm; Back-propagation neural network

1. Introduction

In September, 1997, Taiwan issued warrant in the derivative financial market for the first time, and then the newly developed market of financial derivatives became flourished in the recent years. Warrant is a kind of right agreement that after the investor pays amount of cost to get the warrant, he can buy underlying asset share from the distributor with the strike price within the expiration date, or he can collect the price difference by cash payment.

At present, there are two main methods to explore the warrant dynamism: model-driven theory centered on Black–Scholes pricing method and data-driven theory centered on neural network (Freedman & Giorgio, 1996). Black–Scholes pricing method is proposed by Black and Scholes (1973), based on the concept of price decision of options and related mathematical theorem.

In Black–Scholes pricing method, five parameters are chosen to estimate the change of options price. The five parameters are the exercise price of warrant, the volatility of price of underlying asset, the price of underlying asset, the time to maturity duration, and the risk-free interest rate (Black & Scholes, 1973). Black–Scholes pricing method has been widely applied in financial market and some related researches have been advanced (Hutchinson, Lo, & Poggio, 1994). However, researches to gain an efficient model are also continually studied.

Some researches point out that neural network outperforms Black–Scholes pricing method (Hanke, 1999). But, because warrant price has large fluctuation range, short endurance period and inadequate test data, the traditional neural network model will be easily influenced by the data noise and consequently it cannot explore the price tendency correctly.

In order to make up the shortcomings of the application of neural network, this research applies the Black–Scholes pricing method and Grey theory with genetic algorithm

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(GA) based back-propagation neural network (BPN) to explore the dynamism of warrant. Black–Scholes pricing method is used to judge the reasonableness of price and to decrease predict error. The Grey theory is used to decrease the influence degree of data noise on the predict model. The main characteristics of Grey theory is that it can be applied in conditions when the information is not complete, the behavior pattern is not definite and the operating mechanism is ambiguous, to make efficient process, in accordance with systematic associative analysis, model construction, predict, decision and control (Deng, 1989). Finally, genetic algorithm is applied to select the architecture of BPN to avoid local optimum. In addition, Rolling model is used to train the proposed integrated model. Also, the experiments verify that the proposed model outperforms the traditional BPN.

In the literature, the Black–Scholes price method can evaluate reasonableness of warrant (Cretien, 2006; Heffes, 2003). Grey theory can be applied to financial prediction (Chi, Chen, & Cheng, 1999). GBPN is used to select suitable input variables and promote financial prediction (Matilla-Garci'a & Arguello, 2005; Fu & Xu, 1997; Deboeck & Deboeck, 1992; Kim & Han, 2000). However, most of the input variables are traditional indexes. Besides traditional indexes, varying input variables, such as those produced by Black–Scholes pricing method and Grey theory, can be considered.

This paper is organized as follows: in Section 2, we describe the Black–Scholes pricing method. Section 3 describes basic Grey theory concepts. Section 4 describes the genetic based back-propagation neural network model. Section 5 presents the experimental results of the proposed method and shows comparisons with other approaches. Section 4.2 summarizes the results and draws a general conclusion.

2. Black–Scholes pricing method

Black–Scholes pricing method can be used to judge the reasonableness of prices and to decrease predict error. When the warrant price resulted from Black–Scholes pricing method is higher than the market warrant price, investors can buy in to get arbitrage. On the contrary, if it is lower than the market warrant price, it means that the market warrant price is overestimated. Investors can sketch out an investment strategy according to the Black–Scholes pricing values to get extra earnings higher than that of the risk-free interest rate. The Black–Scholes pricing method applied (Black & Scholes, 1973) is as follows:

$$C = SN(d_1) - Xe^{-rt}N(d_2) \tag{1}$$

C	the theoretical price of warrant;
S	the price of underlying asset;
$N(*)$	the accumulated distributed function of normal distribution;
X	the exercise price of warrant;
r	the risk-free interest rate;
t	the time to maturity;
d_1	$(ln(\frac{S}{X}) + (r + 0.5\sigma^2)t)/2$;
d_2	$d_1 - \sigma\sqrt{t}$;
σ	the volatility of price of underlying asset.

Black–Scholes pricing method is a popular method used to measure the reasonable price of options in financial market. The concept of warrant is similar to options. We consider the value of Black–Scholes pricing as an input in the proposed model to help decide the reasonable range of warrant price.

3. Grey theory

The Grey theory supposes that information includes two parts, the qualitative factor of information (immeasurable) and the quantitative factor of information (measurable) (Deng, 1982). The Grey theory can process the uncertainty, multivariate input and discrete data of the object investigated. The Grey theory is a predict method based on existing data to explore the future dynamism of every factor (Huang, 2000). The Grey theory can reduce the data random in the tempestuously undulant warrant prices.

In this research, GM $(1,1)$ is applied to calculate Grey index variables, since the dimension of either input or output is one. The formula is as below (Deng, 1989)

$$x^{(0)}(n+1) = \frac{b - ax^{(1)}(n)}{1 + 0.5a} \tag{2}$$

a, b predictive parameters in Grey theory

For example, Table 1 illustrates the warrant prices from March 1st to March 4th. The original data is as formula (3) below

$$\begin{aligned} x^{(0)} &= [x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), x^{(0)}(4)] \\ &= [1.9, 1.9, 1.8, 1.75] \end{aligned} \tag{3}$$

The steps to calculate out parameter "a" and parameter "b" needed for Grey theory are as follows:

(1) *Applying Grey accumulate generation operation*

$$\begin{aligned} x^{(1)} &= \left[\sum_{k=1}^{1} x^{(0)}(k), \sum_{k=1}^{2} x^{(0)}(k), \sum_{k=1}^{3} x^{(0)}(k), \sum_{k=1}^{4} x^{(0)}(k)\right] \\ &= [1.9, 3.8, 5.6, 7.35] \end{aligned} \tag{4}$$

Table 1
A sample of warrant prices

Date	Price
3/1	1.9
3/2	1.9
3/3	1.8
3/4	1.75