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Research on the Protection of Vulnerable Groups in Water Pollution Conflicts Based on Binomial Tree Pricing Model

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Abstract

The interests of vulnerable groups can't be guaranteed due to their weaker capacity and the limited interests demand channels during the water pollution conflicts. The interest protection for the vulnerable people in the water pollution conflicts has attracted attentions of the international scholars. The paper tries to construct the market mechanism which can make the vulnerable people to involve in the emission trading. The vulnerable people can buy American put option in the emission trading market. When the price of the emission runs below the contract price, the vulnerable people can get the benefit through executing the option. When the price of the emission runs above the contract price, the vulnerable people can give up the right. The binomial tree option pricing model can help the vulnerable people to make a decision through the analysis of the worth of the American put option.

Keywords

Vulnerable Groups, Water Pollution Conflicts, Emission Trading, American Put Option, Binomial Tree Option Pricing Model

1. Introduction

Water pollution often causes damages to people's health and wealth. The vulnerable groups should be paid attention due to their weaker capacity and the locked interests demand channels during the water pollution conflicts. When the interests of the vulnerable groups are violated, they are more inclined to adopt an extreme way to protect their interests. However, it will cause conflicts among up-down river districts and have negative ef-

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fects on economy development and social stability of the region. In recent years, the water pollution conflicts always happen in China. There are nearly 1700 water pollution accidents every year. The vulnerable groups are the most victims in water pollution conflicts and their interests can't be guaranteed because of weaker capacity.

The international scholars have paid attention to the interest protection of the vulnerable groups in water pollution conflicts. Zhou Jichang (Zhou, 2009) [1] proposed that the victims of China's rural water pollution are in large quantities and wide distribution. Wang Hao *et al.* proposed that the vulnerable group protection should be considered in water management (Wang *et al.*, 2006) [2]. A. P. Barnes *et al.* outlined the results of a recent study to understand farmer activities and attitudes towards Nitrate Vulnerable Zone regulations in Scotland (Barnes *et al.*, 2009) [3]. Environmental pollution that renders waters along the coastline and beaches unsatisfactory for use by the general public has become a global health problem (Clark *et al.*, 2003). [4] Chen Yanping and Wu Fengping analyzed the causes of the conflicts and built an evolutionary game model to eliminate the conflicts (Chen and Wu, 2010) [5]. Azizullah Azizullah discussed a detailed layout of drinking water quality in Pakistan with special emphasis on major pollutants, sources of pollution and the consequent health problems (Azizullah *et al.*, 2011) [6]. Shen Dajun focused on the unjust issues existed in water management of China and provided the ways to avoid the unjust issues (Shen, 2005) [7]. Xu and Guo proposed countermeasures for solving water disputes, including integrated management of the river basin, enhancement of legal and regulatory system construction, introduction of market mechanism, and application of new theories about water right and water market to solve water disputes (Xu and Guo, 2007) [8]. Hiromitsu Sakai *et al.* researched the response patterns of the sensor to the river water quality and pollution (Sakai *et al.*, 2000) [9]. Dong and Li proposed that the demand for water resource is great with the rapid growing of population and expanding industries, and there is an obvious water conflict in the basin (Dong and Li, 2006) [10].

The present research shows that the interest protection of vulnerable groups in water pollution conflicts has attracted the international scholars' attention. To protect the interests of the vulnerable groups, the scholars propose that the government should establish the system of dialogue and negotiation or compensate the vulnerable groups for their loss. As the vulnerable groups are of lower status and have no negotiating power, the protection can't achieve the results. So as to protect the basin environment and promote sustainable development, compensating and protecting vulnerable groups is one of effective means of solving environmental problems and promoting sustainable development. The paper proposes that the vulnerable groups can engage the emission trading market to protect their interest autonomously. The vulnerable peoples can buy the American put option of emission in the emission trading market. When the emission trading price runs below the contract price, the vulnerable people can get the benefits through executing the option. When the emission trading price runs above the contract price, the vulnerable people can give up the right.

The remainder of this paper is organized as follows. In section 2, the concept of emission trading and the assumptions of the model are briefly presented. Section 3 introduces the binomial tree model to protect the interest of vulnerable groups. The application of the model in Tai Basin is introduced in Section 4. Section5 concludes this work.

2. Assumptions

The emission trading was introduced by Dales in 1968. The government decides the maximum pollution emissions of the region according to the state of the environment and then divides the Pollution Emissions into sections. Through emission trading, the pollutant in the river basin can be decreased and controlled; the losses of the vulnerable group in water pollution can also be decreased.

In the emission trading market, the increase of the emission trading price will make the polluters pay more for money to discharge pollutants, the polluters may try to develop new technologies or reduce emissions. If the price of the pollution emission decreases, it will make more polluters be able to buy the pollution emission. This will increase the pollutants in the river and cause damage to the vulnerable groups in the water pollution. In this condition, the paper try to introduce the American put option to vulnerable groups to protect their interest through the emission trading market. The vulnerable groups can buy the emission American put option, if the price of the pollution emission decreases, the vulnerable groups can get the benefit through exercising the option. If the price of the pollution emission increases, the vulnerable groups can abandon the option. Although they lose the premium, the pollutants are controlled.

The emission trading price is moving during the certain period of the option. Through the binomial tree option

pricing model, the period of the option can be divided into several sections, the moving of the price and the value of the option can be analyzed to help the vulnerable groups to make decisions to protect their interest.

The assumptions of the model are as the following:

1) The prices of the pollution emission move according to geometric Brownian motion;

2) The risk neutral pricing theory;

3) The potential for arbitrage means cannot be earned in emission trading;

4) The emission trading and the price move is consecutive;

5) There are no cash flows during the period of the option;

6) Short-selling is permitted in emission trading market.

The model notations are as the following:

S: The present price of the pollution emission;

T: The agreed time of the emission American put option;

X_T: The contract price of the pollution;

σ: The volatility of the price of the pollution emission;

r: The risk free rate.

3. Model

Assume that the vulnerable groups buy an emission American put option in the present time ($t = 0$). The agreed time of the option is T. We can divide the T into some small Δt. Assume that the present value of the emission is S_0. S_1 is the value of the option in t_1 ($t_1 = \Delta t$). If the the vulnerable groups want to assess the value of the option in t_1, the move of S_1 can be summarized as the following two states:

$$\begin{cases} S_1 = S^u = uS_0 > S_0 \\ S_1 = S^d = dS_0 < S_0 \end{cases} \tag{1}$$

We consider u ($u > 1$) as increased factor; it means the emission trading price is comparatively increased. We consider d ($d < 1$) as increased factor; it means the emission trading price is comparatively increased. The probabilities of increasing and decreasing are p, $1-p$. The move of the price can be described as **Figure 1**.

If the vulnerable groups want to assess the value of the option in t_2, the move of S_2 can be summarized as the following:

$$t_1 = \Delta t \begin{cases} S_1 = S^u = uS_0 > S_0 \\ S_1 = S^d = dS_0 < S_0 \end{cases} \tag{2}$$

$$t_2 = 2\Delta t \begin{cases} S_2 = S^{uu} = u^2 S_0 \\ S_2 = S^{ud} = udS_0 \\ S_2 = S^{du} = udS_0 \\ S_2 = S^{dd} = d^2 S_0 \end{cases} \tag{3}$$

In the present time ($t = 0$), the emission trading price is S_0. In the time t_1, the emission trading price has two possibilities: uS_0, dS_0. In the time t_1, the emission trading price has three possibilities: $u^2 S_0$, udS_0, $d^2 S_0$. In the time $t_i = i\Delta t$, the emission trading price has ($i + 1$) possibilities, they are:

$$u^j d^{i-j} S_0 \quad j = 0, 1, 2, \cdots, i \tag{4}$$
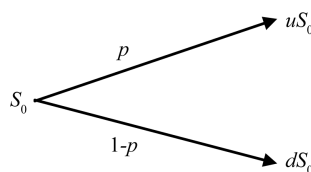
Figure 1. The change of the emission trading price within Δt time.

At the end of the interval Δt, the expectation of the emission is $e^{\Delta t} S_0$. We can get that:

$$e^{\Delta t} S_0 = puS_0 + (1-p) dS_0 \tag{5}$$

$$e^{\Delta t} = pu + (1-p) d \tag{6}$$

The variance of the emission trading price in Δt is $S_0^2 \sigma^2 \Delta t$, we can get:

$$\sigma^2 \Delta t S^2 = pu^2 S_0^2 + (1-p) d^2 S_0^2 - \left[pu + (1-p) d \right]^2 S_0^2 \tag{7}$$

$$\sigma^2 \Delta t = pu^2 + (1-p) d^2 - \left[pu + (1-p) d \right]^2 \tag{8}$$

As $= 1/d$, from Equation (5) and (6), we can get:

$$p = \frac{a-d}{u-d} \tag{9}$$

$$u = e^{\sigma\sqrt{\Delta t}} \tag{10}$$

$$d = e^{-\sigma\sqrt{\Delta t}} \tag{11}$$

where $a = e^{r\Delta t}$ and Δt is very small.

The analysis of the binomial tree option pricing model is begun from the end time T. As in time T, the value of the option is $\max\left\{ (X - S_T), O \right\}$. The vulnerable groups can get the value in time $(T-\Delta t)$ through discounting the value of the option of time T at the risk-free rate of interest r. In the same way, if we want to get the value in time $(T-2\Delta t)$, we can discount the value of the option of time $(T-\Delta t)$ at the risk-free rate of interest r. And by this analogy, we can analyze the value of the option at intervals.

The government can subsidize the option premium to vulnerable groups to encourage them to join the emission trading market. The vulnerable groups can buy the emission American put option to protect their interest.

Through the binomial tree option pricing model, the vulnerable groups can analyze the value of the option.

4. Application

Emission trading was carried out in Tai Basin by the State Environment Protection Administration at 2008. The platform of Emission trading was gradually achieved. To protect the vulnerable groups in Tai Basin, the government can help them with the premium to encourage the vulnerable groups to engage the marketplace.

In the emission trading market, the vulnerable groups buy the American put option. The duration of the agreement is one year, the emission trading price is 1000$, the executive price is 950$. The volatility of the emission trading price is 20%. The risk free rate is 10%. From the above, we can get that:

$$S_0 = 1000, \ X = 950, \ r = 0,1, \ \sigma = 0.2, \ T = 1.$$

Suppose that the vulnerable groups want to assess the value of the option twice a month. We can divide the duration into six equal intervals.

$$\text{So, } \Delta t = 1.1667, \ \sqrt{\Delta t} = 0.4083.$$

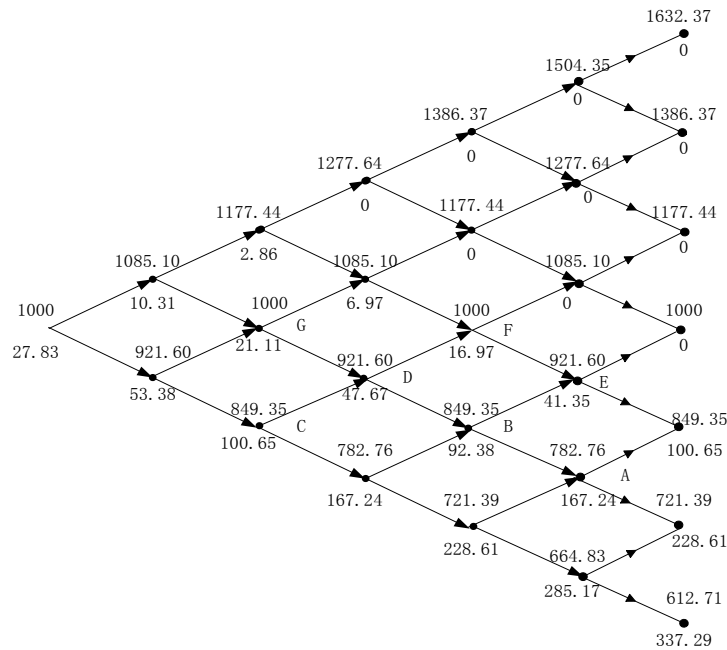According Equation (9)-(11), we can get as the following:

$$u = 1.0851, \ d = 0.9216, \ a = 1.0168,$$

$$p = 0.5826, \ 1 - p = 0.4177.$$

According to the binomial tree option pricing model, we can construct the binomial tree as **Figure 2**. There are two numbers in every node. The above number stands for the emission trading price, the below number stands for the value of the option.

At time $i\Delta t$, the emission trading price is $u^j d^{i-j} S_0$ at the node j. For example, at the node E ($i = 5, j = 2$), the emission trading price is $1.0851^2 \times 0.9216^3 \times 1000 = 921.60$.

We can get the value of the nodes of the penultimate column through that of the last column. Suppose that the option is not performed, and this means the value of the option is the present value of the expected value. For example, the value of the option at the node F is: $(0.5823 \times 0 + 0.4177 \times 100.65) \times e^{-0.1 \times 0.1667} = 41.35\$$. The

Figure 2. The analysis of the change about the emission price and the option price.

value of the option at the node *A* is: $(0.5823 \times 100.65 + 0.4177 \times 228.61) \times e^{-0.1 \times 0.1667} = 151.56\$$.

The vulnerable groups can make decisions through the binomial tree option pricing model. For example, the value of the option will be 0 at the node *F* if the vulnerable groups performed the option. So the best choice is to wait. The value of the option at the node *F* is 10.88\$. On the contrary, the choice at the node *A* is performing the option. Because the value of the option will be 167.24\$ ($950 - 782.76 = 167.24 > 151.56$) at the node *A* if the vulnerable groups performed the option.

However, performing the option is not always the best choice. For example, the value of the option will be 29.4\$ at the node F if the vulnerable groups performed the option. However, if the vulnerable groups choose to hold the option rather than perform, the value will be 47.67\$ ($(0.5823 \times 16.97 + 0.4177 \times 92.38) \times e^{-0.1 \times 0.1667} = 47.67\$$).

From the above, we can know that the vulnerable groups can make decisions through the binomial tree option pricing model. They can choose to perform or hold the option to protect their interest.

5. Conclusion

The paper tries to construct the market mechanism which can make the vulnerable people involved in the emission trading. The vulnerable people can buy the emission American put option in the emission trading market. When the price of the emission runs below the contract price, the vulnerable people can get the benefit through executing the option. When the price of the emission runs above the contract price, the vulnerable people can give up the right. The binomial tree option pricing model can help the vulnerable people to make decision through the analysis of the worth of the American put option.

Acknowledgements

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