Modeling Analysis of Environmental Cost

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Abstract: In the paper, we establish a Model of Environmental Cost. The model describes the cost of environmental maintenance and pollution control. The indicators we have selected include polluted rivers, poor air quality, hazardous waste sites, poorly treated waste water and climate changes. First, we use the antinomies theorem to analyze the relationship between the environmental control cost $L(X)$ and the pollutant emission compliance rate x and the relationship between environmental loss cost $C(X)$ and x. Then, we use the Lagrange multiplier method and Taylor expansion to derive their relationship.

Keywords: Antinomies theorem; Lagrange multiplier method; Taylor expansion

1. Introduction

Environmental cost can be divided into cost of environmental control and cost of environmental loss. Cost of environmental control can be divided into environmental prevention cost and environmental maintenance cost. Environmental loss costs can be divided into two categories: environmental internal loss costs and environmental external loss costs. These four subcategories can be further classified, as shown in the table below [1].

Table 1. Classification of environmental cost items

Type	Item
Cost of environmental prevention	Cost of environmental r & d
	Investment cost of environmental protection facilities
	Cost of operation and maintenance
Cost of environmental maintenance	Environmental monitoring fee
	Landscaping fee
	Cost of other environmental pre-treatment
Cost of environmental internal loss	Compensation fee for sewage discharge
	Damages
	Cost of waste disposal
	Taxes of environmental related
	Allowance for employee health
	Advanced environmental reserve
Cost of environmental external loss	Cost of natural resources consumption
	Eco-environmental damage resources

2. Establishment of Model

The negative impacts of land development projects are generally described by environmental maintenance costs, which are mainly used to solve these environmental problems: polluted rivers, poor air quality, hazardous waste sites, wastewater treatment and climate change.

Their degree of pollution can be expressed by a unified index, the rate of attainment. Firstly, we construct the target rate of pollutant discharge, Then we establish the functional relationship between the target rate and environmental cost. Finally, we use the target rate to reflect the environmental cost caused by land use change.

By consulting references [13], we can get the formula for calculating the total environmental cost

$$S(\mathrm{x}) = L(\mathrm{x}) + C(\mathrm{x}) \quad (1)$$

Where $S(\mathrm{x})$ represents cost of total environmental, $C(\mathrm{x})$ represents cost of environmental control, $L(\mathrm{x})$ represents cost for environmental loss. Represents the compliance rate of pollution control, where $x \in (0,1)$, the discharge of pollutants can be divided into sewage, waste gas and solid waste. That is to say, is the comprehensive standard rate of effluent, Waste gas and solid discharges. It's expressed as follows.

$$x = \mathrm{w}_1\mathrm{r}_1 + \mathrm{w}_2\mathrm{r}_2 + \mathrm{w}_3\mathrm{r}_3, and \mathrm{w}_1 + \mathrm{w}_2 + \mathrm{w}_3 = 1 \quad (2)$$

Table 2. Description of indicators

Sign	Sense	Sign	Sense
$S(x)$	Environmental cost	X	Compliance rate of pollution control
$L(x)$	Cost of environmental control	$w_1(i=1,2,3)$	The proportion of three pollutants treated
$r_1(i=1,2,3)$	Emission compliance rate of three pollutants	C_1	Cost of environmental prediction
C_2	Cost of environmental maintenance	μ	Cost of environmental control
μ_1	Cost of sewage treatment	μ_2	Cost of waste gas treatment
μ_3	Cost of Solid waste treatment		

Notice: $w_i = \frac{\mu_i}{\mu}$

2.1. Model of environmental control

People need to input the cost for environmental prediction and environmental maintenance in production and life to obtain the pollution compliance rate, and the input-output function, namely Cobb-Douglas function, is used to deduce the environmental control cost model. Cobb-Douglas function is used to express the relationship between the cost of environmental prevention and environmental maintenance [2].

$$x = A \cdot C_1^{\alpha} C_2^{\beta} \quad (3)$$

Constraint condition: $C_1 + C_2 = C(x)$

We use the Lagrange multiplier method, make $\Phi(C_1, C_2, x) = A \cdot C_1^{\alpha} \cdot C_2^{\beta} - \lambda\left[C(x) - (C_1 + C_2)\right]$, where is Lagrange's multiplier. Derive the following formula.

$$\frac{\partial \Phi}{\partial C_1} = A \cdot \alpha C_1^{\alpha-1} C_2^{\beta} + \lambda = 0 \quad (4)$$

$$\frac{\partial \Phi}{\partial C_1} = A \cdot \beta C_1^{\alpha-1} C_2^{\beta} + \lambda = 0 \quad (5)$$

$$\frac{\partial \Phi}{\partial \lambda} = C_1 + C_2 - C_x = 0 \quad (6)$$

$$C_x = a_1 x^{b_1} \quad (7)$$

where, $$a_1 = \left[A\left(\frac{\alpha}{\alpha+\beta}\right)^{\alpha}\left(\frac{\beta}{\alpha+\beta}\right)^{\beta}\right]^{\frac{-1}{\alpha+\beta}}, b_1 = \frac{1}{\alpha+\beta} \quad (8)$$

2.2. Model of environmental loss cost

The function about cost of environmental loss $L(x)$, its value is related about x. If the D-value between x and target value is bigger, then the cost of environmental loss is greater, that is to say, the greater value of $|x-1|$, the less control level and the more cost of environment loss. When $|x-1| = 0$, the environmental loss is the minimum, and $L(1) = a_2$, $a_2 \neq 0$. In order to get the formula of $L(x)$, take $L(x)$ into expansion to Taylor series at $x=1$ [3].

$$L(x) = L(1) + \frac{L'(1)}{1!}(x-1) + \frac{L^{(2)}(1)}{2!}(x-1)^2 + \frac{L^{(3)}(1)}{3!}(x-1)^3 \quad (9)$$

Since it will get extreme value when $L(x)=1$, so $L'(x)=0$. Besides, the value of $|x-1|$ is very small, so the value of the last item can be ignored. Finally, we can get the formula of $L(x)$.

$$L(x) = L(1) + \frac{L^{(2)}(1)}{2!}(x-1)^2 \quad (10)$$

$$a_2 = L(1), b_2 = \frac{L^{(2)}(1)}{2!} \quad (11)$$

$$L(x) = a_2 + b_2(x-1)^2 \quad (12)$$

2.3. Model of total cost for environment

Total cost for environment is that the sum of cost for environmental control and environmental loss.

$$S(x) = C(x) + L(x) = a_1 x^{b_1} + a_2 + b_2(x-1)^2 \quad (13)$$

Where,

$$a_1 = \left[A\left(\frac{\alpha}{\alpha+\beta}\right)^{\alpha}\left(\frac{\beta}{\alpha+\beta}\right)^{\beta}\right]^{\frac{-1}{\alpha+\beta}}, b_1 = \frac{1}{\alpha+\beta}, a_2 = L(x), b_2 = \frac{L^{(2)}(1)}{2!} \quad (14)$$

3. Summary

The environmental cost model is easy to calculate. The model we built finally obtained the relationship between the total cost of environmental and the compliance rate, according to which the total environmental cost can be calculated. We searched the relevant data and solved the specific expression. We have derived their relationship expression as follows.

$$C(x) = 44.088x^{1.283} \quad (15)$$

$$L(x) = 80.344x^2 - 13505.120x + 584569.398 \quad (16)$$

Obviously, the relationship between total environmental cost and pollutant compliance rate is obtained by adding them.

$$S(x) = C(x) + L(x) = 44.088x^{1.283} + 80.344x^2 - 13505.120x + 584569.398 \quad (17)$$

References

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