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Retraction

Retracted: Optimal Pricing Model of Environmental Quality Index Futures from the Perspective of Green Finance

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] J. Che, S. Zhou, R. Shan, H. Jia, and Z. Liu, "Optimal Pricing Model of Environmental Quality Index Futures from the Perspective of Green Finance," *International Transactions on Electrical Energy Systems*, vol. 2022, Article ID 6951040, 8 pages, 2022.

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Research Article

Optimal Pricing Model of Environmental Quality Index Futures from the Perspective of Green Finance

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In order to establish the optimal price of low-carbon products and set the optimal target carbon emissions in the production cycle so as to maximize profits, this paper proposes the optimal pricing model of environmental quality index futures from the perspective of green finance. This paper mainly studies the optimal pricing and carbon emission strategy of low-carbon products of a single enterprise under the carbon trading system based on the quota system. When enterprises join the carbon trading system, how to optimally determine their target carbon emissions in the production cycle and the optimal price of their low-carbon products in order to maximize their own profits, based on the carbon emission quotas freely allocated by the government in the face of exogenous carbon trading prices and different consumer preferences for low-carbon products in the market, is discussed in detail. The experimental results show that the low marginal cost of emission reduction will urge enterprises to implement low-emission strategies as much as possible, and the marginal cost of a specific size will enable enterprises to implement low-carbon policies with low emissions, and the optimal emissions will decline with the increase of carbon prices. However, from the perspective of 50–300 carbon trading prices, the profits generated are less than those of the minimum emission strategy, and the difference between the two is generally one order of magnitude. Therefore, if the internal conditions permit and the external carbon trading price is reasonable, enterprises should reduce carbon emissions as much as possible. The properties obtained from the model analysis and the numerical conclusions given in the example part reflect the relationship between the enterprise product pricing, the marginal cost of emission reduction, and the target emission decision-making and draw some valuable information for the enterprise and the government decision-making.

1. Introduction

International carbon futures trading originated from the spot trading of carbon emission rights. In 2003, the Chicago Climate Exchange (CCX) was established. Based on "quota and trade," it became the world's first legally binding greenhouse gas emission registration, voluntary emission reduction, and trading platform based on international rules [1, 2]. In 2005, the EU established the EU Emissions Trading System (EUETS), which has become the largest total carbon emission control and trading system in the world. Since then, the European Climate Exchange (ECX), the French electricity exchange, the BlueNext trading market, the European energy exchange (EEX), the Italian electricity exchange (IPEX), and the UK emission rights exchange under the EU Emission Rights Trading System have been gradually established. Driven by the government's policy of low-carbon economic transformation and the promotion of relevant financial institutions, the carbon spot trading market has developed rapidly, and the trading volume is rising day by day.

In April 2005, the European Climate Exchange launched the first EU carbon emission quota (EUA) futures and operated on the electronic futures trading platform of the London International Petroleum Exchange (IPE). The Chicago Climate Exchange, the European Climate Exchange, and the European energy exchange (EEX) have successively launched certified emission reduction (CER) futures contracts. Once the carbon futures contract was launched, it was sought after by many investors, and the trading volume increased rapidly. At present, the main carbon futures products in the global carbon finance market include the European Climate Exchange carbon finance contract (ECXCFI), emission index futures (EUAFutures), certified emission reduction futures (CERFutures), and the Chicago Climate Exchange carbon trading financial futures (CCXCFIFutures) [3]. Figure 1 shows the organizational structure of the green industry fund.

2. Literature Review

In response to this research problem, Lee et al. took the carbon emission trading pilot as the background, considered that when there was dual pressure of emission reduction policy and low-carbon demand, they introduced the manufacturer's carbon emission per unit product decision variables, and analyzed the manufacturer's optimal pricing and optimal emissions by constructing the manufacturer's simplified decision model [4]. Wu et al. studied the optimal pricing and carbon emission strategy of low-carbon products for a single enterprise under the carbon trading system based on the quota system. In the carbon trading environment, the government allocates a certain carbon emission quota to enterprises for free. Facing the carbon trading price given by the carbon trading market and the different preferences of consumers on the low-carbon degree of products in the product market, it provides solutions on how to optimally determine the target carbon emissions within the production cycle of enterprises and the optimal price of low-carbon products produced so as to maximize their own profits [5]. CSS et al. pointed out in their research on the establishment of an emission rights market in China that carbon taxation, a Pigou mean, and carbon emission rights trading, a Coase mean, are based on internalizing the external effects of environmental problems and combining policy intervention with market mechanisms to affect enterprises' emission and pollution control behavior. However, carbon tax mostly relies on government intervention, while carbon emission rights trading focuses on using market mechanisms to solve environmental problems [6]. Pan et al. pointed out that the carbon tax is levied on the carbon content of energy consumption products, which is conducive to the realization of carbon emission reduction. However, the carbon tax will have an impact on the competitiveness, distribution, and environment of enterprises' products, so some enterprises are reluctant to adopt it [7]. Yu et al. found that if the marginal emission reduction cost (MAC) and marginal loss and other cost and benefit functions of enterprises can be clearly defined, carbon trading and carbon tax can achieve the optimal goal of carbon emission reduction through appropriate pricing [8]. Yang et al. found that when other conditions remain unchanged, the optimal environmental economic means can be selected by comparing the size of the marginal management cost and marginal transaction cost. When the degree of marketization is low, the carbon tax means are more appropriate [9].

The problem we need to solve is how to set the optimal low-carbon product price and set the optimal target carbon emissions in the production cycle in the face of the established carbon emission allocation quota and customers with different low-carbon preferences in the market so as to maximize profits. Enterprises need to balance the following issues: reducing emissions will gain carbon trading benefits and will positively affect the market demand for products due to better low-carbon performance, but at this time, enterprises will bear higher emission reduction input costs. On the contrary, if the enterprise relaxes the control on emission reduction, the cost will be relatively reduced, but on the one hand, it may not get the carbon trading income. On the other hand, it will have an adverse impact on product sales due to poor environmental performance and a negative corporate image [10]. In this paper, carbon emissions are directly taken as decision variables. The main reasons for this assumption are (1) it can clearly reflect the relationship between enterprise emissions, the trading market, the carbon quota, and the government's low-carbon policy; (2) as an indicator or task, emissions have a very intuitive guiding significance in the actual production process. We think this assumption is also reasonable from the perspective of enterprise production because carbon emissions mainly come from energy consumption. Enterprises can change the energy input structure or use efficiency to reduce carbon emissions under the condition of ensuring a certain output. For example, some agricultural product production enterprises' CDM projects change the power access from thermal power to wind power or biogas power generation, which will not affect the final production. Another example is the energy-saving projects related to cement production.

3. Research Methods

3.1. Symbol Description. The symbols used in this article are explained one by one:

p: Low carbon product market pricing, as a decision variable;

e_c The total carbon emission in the production cycle of the enterprise, which is a decision variable;

$D(p, e_c)$: The market demand of the final product, which is the function of the above two decision variables, and the demand will decrease with the increase of price or carbon emission;

e_l: Minimum possible carbon emission, i.e., the minimum emission that the enterprise can achieve within its production cycle with all efforts;

e_m: Maximum carbon emission refers to the total carbon emission generated during the production cycle of an enterprise without any emission reduction technology;

p_0: The market price of general products, an exogenous variable, is the market-accepted price of similar but nonlow-carbon products;

c_0: Marginal production cost without emission reduction technology input;

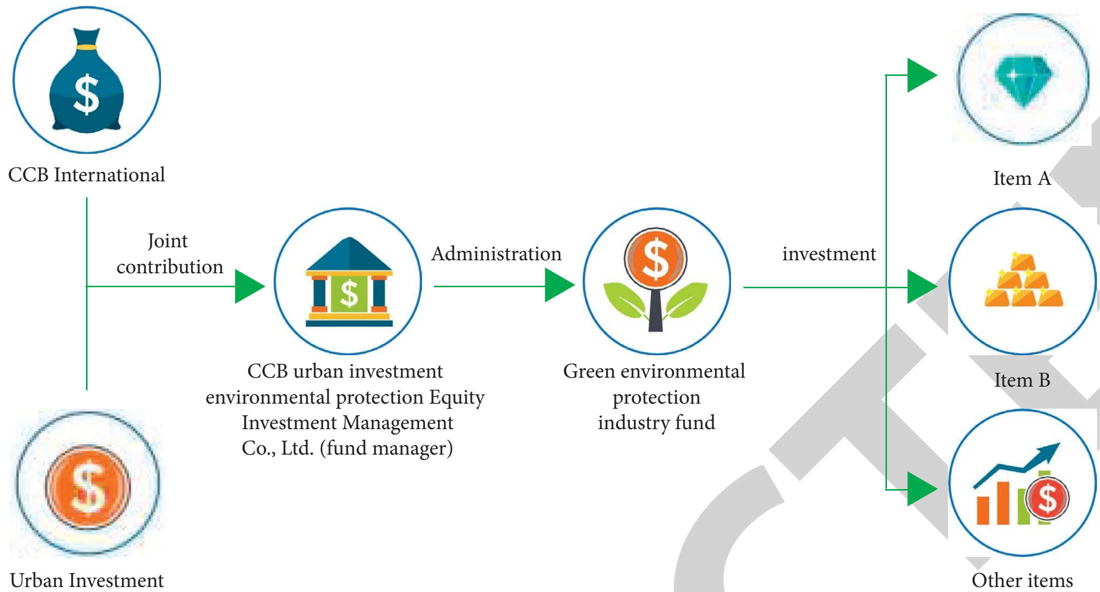

FIGURE 1: Organizational structure of the green industry fund.

$c_d(e_c)$: Low carbon input cost, set as the convex increasing function of the enterprise's target carbon emissions;

β: Emission reduction coefficient;

$\overline{e}$: The carbon emission limit for specific enterprises shall be allocated by the government free of charge;

ε: Carbon trading price;

δ: Low carbon preference of consumers;

t: Government subsidy coefficient for low-carbon products;

M: The total market capacity of the same type of low-carbon products and general products of the enterprise.

3.2. Enterprise Decision. After the carbon emission quota is known, the enterprise must make the optimal target carbon emission and product pricing decisions before the start of its production cycle to maximize its profits after the production cycle. The objective function is as follows:

$$\max_{p,e_c} \Pi = D(p, e_c)(p - c_0) - c_d(e_c) + \varepsilon(\overline{e} - e_c), \quad \text{s.L. } e_l \le e_c \le e_m, \tag{1}$$

where if $\overline{e} - e_c$ is positive, it means that the enterprise can sell the carbon quota, and if it is negative, it means that the enterprise should purchase the quota from the outside; c_d will use the classic AJ model for reference and set the emission reduction cost as the quadratic form $c_d = \beta(e_m - e_c)^2$. Compared with previous models, the differences and innovations of this paper are as follows:

(1) The construction of this model takes carbon emissions as the cornerstone and adds the positive and negative benefits generated by the carbon trading process to the profits;

(2) Considering the government subsidy to the market rather than the low-carbon subsidy to enterprises because the government policy orientation in this paper focuses on the market rather than administrative means, and a corresponding part of the profits of enterprises will come from carbon trading rather than the subsidy amount.

The subsidy to the market is to stimulate consumption and improve citizens' awareness of environmental protection [11].

3.3. Product Demand. Suppose that consumers' cognition of low-carbon products (or environmental satisfaction) in the market obeys the uniform distribution on $[\overline{\delta}, \underline{\delta}]$. $\overline{\delta}$ means that for consumers who will buy any low-carbon products, $\underline{\delta}$ is a customer who has no low-carbon awareness and is only willing to buy general products. Set the government subsidy amount for consumers to purchase low-carbon products as $t(e_m - e_c)$, which indicates that the low-carbon degree is based on the maximum carbon emission of enterprises. The government can adjust the subsidy coefficient t to change the subsidy amount, which is an exogenous variable [12, 13]. Here, for the convenience of analysis, we assume that consumers' information on the carbon emissions of enterprises is complete. At the same time, in practice, e_m and e_c are generally large, so t should be a small number in reality. For consumers, whether they buy low-carbon products of the enterprise depends on whether their consumption utility is less than that of purchasing similar to nonlow-carbon products. Considering such marginal customers, their low-carbon awareness is δ, and they hold an "indifferent" attitude towards whether to buy low-carbon products, that is, for them, the utility of buying two types of products is the same, i.e., $p - p_0 = k(\delta - \underline{\delta}) + t(e_m - e_c)$, where k is a normal number, indicating the utility coefficient of consumers' low-carbon awareness.

The following equation is obtained:

$$\delta = \frac{p - p_0 - t(e_m - e_c) + k\underline{\delta}}{k}. \tag{2}$$

Meanwhile, the market demand for such low-carbon products is as follows:

$$D(p, e_c) = M\int_{\delta}^{\overline{\delta}} \frac{1}{\overline{\delta} - \underline{\delta}} \mathrm{d}x = M\left(1 + \frac{t(e_m - e_c) + p_0 - p}{k(\overline{\delta} - \underline{\delta})}\right). \tag{3}$$

3.4. Optimal Pricing. Considering that the enterprise makes the pricing decision first, for a given EC, there is the following formula:

$$\max_{p} \Pi = M\left(1 + \frac{p_0 + t(e_m - e_c) - p}{k(\overline{\delta} - \underline{\delta})}\right)(p - c) - \beta(e_m - e_c)^2 + \varepsilon(\overline{e} - e_c). \tag{4}$$

The optimal solution obtained from formula (4) F.O.C is as follows:

$$p^* = \frac{1}{2}\left(c + p_0 + t(e_m - e_c) + k(\overline{\delta} - \underline{\delta})\right). \tag{5}$$

The following conclusions can be drawn:

Conclusion 1. The higher the government subsidy, the higher the product pricing of enterprises. This can be directly observed from equation (5). Therefore, government subsidies to consumers can indirectly help enterprises that implement low-carbon production to make profits.

Conclusion 2. Under the same target emission level, the greater the maximum carbon emissions of enterprises, the higher the product price. Obviously, the larger e_m shows the characteristics of higher energy consumption in the industry [14]. The difference between e_c and EC essentially reflects the efforts of enterprises to reduce emissions.

Conclusion 3. The higher the target carbon emissions, the lower the product price. From equation (5), it can be seen that without considering the emission reduction cost and other factors, the increase in carbon emissions will affect consumers' preference for environmental protection products through $\overline{e} - e_c$ [15]. When the emissions increase, some customers with strong environmental awareness will not choose such products, and the market demand will decline. At this time, enterprises will have to reduce the product price.

Conclusion 4. The stronger the consumers' awareness of low-carbon δ, the higher the price of low-carbon products. This conclusion is not only tenable in the model but also logical in practice because the improvement of low-carbon awareness will bring more sales.

3.5. Optimal Carbon Emissions. Substitute (5) into (4) to obtain

$$\max_{0 \leqslant e_c \leqslant e_m} \Pi = M\left(1 + \frac{p_0 + t(e_m - e_c) - 1/2\left(c + p_0 + t(e_m - e_c) + k(\overline{\delta} - \underline{\delta})\right)}{k(\overline{\delta} - \underline{\delta})}\right)\left(\frac{1}{2}\left(c + p_0 + t(e_m - e_c) + k(\overline{\delta} - \underline{\delta})\right) - c\right) - \beta(e_m - e_c)2 + \varepsilon(\overline{e} - e_c) \tag{6}$$

Formula (6)

$$\max_{0 \leqslant e_c \leqslant e_m} \Pi\& = \varepsilon(\overline{e} - e_c) - \beta(e_m - e_c)^2 + \frac{M\left(c - p_0 + te_c - te_m - h\overline{\delta} + h\underline{\delta}\right)^2}{4k(\overline{\delta} - \underline{\delta})}.$$

Find the second derivative of e_c for (6) and obtain the following equation:

$$\frac{\partial^2 \Pi}{\partial e_c^2} = \frac{\mathrm{Mt}^2}{2k(\overline{\delta} - \underline{\delta})} - 2\beta. \tag{7}$$

When looking for the optimal carbon emission e_c^*, we take $\mathrm{Mt}^2/4k(\overline{\delta} - \underline{\delta})$ as the threshold and discuss it in three cases according to the marginal cost of emission reduction of different sizes.

Case 1. $\beta = \mathrm{Mt}^2/4k(\overline{\delta} - \underline{\delta})$

At this time, the profit function has a linear relationship with the decision variable e_c. The following properties can be obtained:

Property 1. When $\beta = \mathrm{Mt}^2/4k(\overline{\delta} - \underline{\delta})$, the lowest emission will be the best choice for the enterprise.

3.5.1. Nature 1: Certification. Finding the first-order partial derivative of e_c for π_{e_c} yields $\partial\Pi/\partial e_c = \mathrm{Mt}((c - p_0) - k(\overline{\delta} - \delta))/2k(\overline{\delta} - \underline{\delta}) - \varepsilon \leqslant 0$, (6) is a monotonic nonincreasing function of e_c. Obviously, when $e_c = e_l$, the profit reaches the maximum. The certificate is completed.

The following conclusions are drawn:

Conclusion 5. When the marginal cost of enterprise emission reduction is equal to a certain value, the larger the carbon emission, the smaller the profit. Property 1 illustrates this problem, and at this time, the enterprise should reduce emissions as much as possible [16].

4. Result Analysis

The established model and its related properties and conclusions are analyzed with examples. For different marginal costs and carbon prices, we discuss the optimal decision under specific examples according to the basic properties of the objective function. The specific values are set as follows:

$$\begin{aligned} &M = 500, e_m = 250, e_l = 100, t = 0.2, k = 0.1, \overline{\delta} = 10, \\ &\underline{\delta} = 0, c = 10 p_0 = 20, \varepsilon = 50, \overline{e} = 200 \end{aligned} \quad (8)$$

4.1. Linear Objective Function. At this time, $\beta = \mathrm{Mt}^2/4k(\overline{\delta} - \underline{\delta})$ and $\partial\Pi/\partial e_c = \mathrm{Mt}((c - p_0) - k(\overline{\delta} - \delta))/2k(\overline{\delta} - \underline{\delta}) - \varepsilon \leq 0$ are used to analyze the impact of target emissions on profits, as shown in Figures 2 and 3.

As can be seen from Figure 2, when the target emissions increase, the profits decrease rapidly. It is obvious from Figure 3 that the increase in carbon trading prices will improve the overall profit level. Figure 4 analyzes the sensitivity of profit to the carbon price. As stated in conclusion 6, higher prices will increase the absolute value of the slope of profits to emissions, that is, when the carbon price is higher, the profits of enterprises will decline faster with the increase of emissions. At this time, if enterprises loosen the control of emissions, on the one hand, they will encounter lower market demand; on the other hand, they will bear the opportunity cost of carbon trading [17].

4.2. Nonlinear Objective Function. Combining the carbon price and the marginal cost of emission reduction, we analyze it based on inference 4.

Known by

when $\mathrm{Mt}^2/4k(\overline{\delta} - \underline{\delta}) = 5 < \beta \leqslant k\mathrm{Mt}(\overline{\delta} - \underline{\delta}) + 2k\varepsilon(\overline{\delta} - \underline{\delta}) - \mathrm{Mt}(te_l - te_m - p_0 + c)/4k(e_m - e_l)(\overline{\delta} - \underline{\delta}) = 6.26$, the change of profit to marginal cost is analyzed in Figure 5. It is found that when other conditions remain unchanged, the profit will rapidly decline with the increase of emission reduction marginal cost.

When $\beta \geq k\mathrm{Mt}(\overline{\delta} - \underline{\delta}) + 2k\varepsilon(\overline{\delta} - \underline{\delta}) - \mathrm{Mt}(te_l - te_m - p_0 + c)/4k(e_m - e_l)(\overline{\delta} - \underline{\delta}) = 6.26$, we analyze the impact of the marginal cost of emission reduction on the optimal carbon emission, and Figure 6 is obtained. The results show that when the marginal cost of emission reduction increases, the decision-maker will increase the target carbon emissions, and the graph is concave to β and takes the maximum emission of 250 as the limit value. This shows that the positive impact of the marginal cost of emission reduction on carbon emissions is limited by the capacity of enterprises.

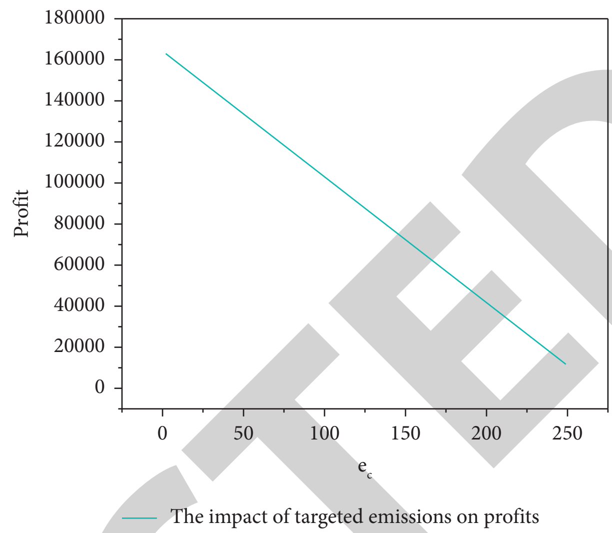

Figure 2: $\varepsilon = 50, \overline{e} = 200, e_c \in [0, 250]$.

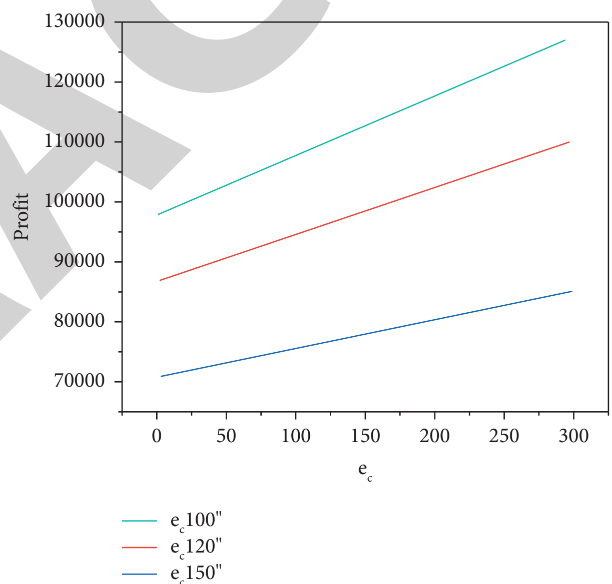

Figure 3: $\varepsilon \in [0, 300], \overline{e} = 200, e_c = 100$.

Figure 6 analyzes the impact of the corresponding optimal emissions on profits when $\beta \in [6.3, 20]$. Compared with Figure 4, it is found that when the emission reduction cost is large, the overall profit level decreases significantly, and the impact of cost on profit is also different. The former is linear in a limited range, whereas the latter is nonlinear, and its influence degree varies from large to small [18].

Figure 7 analyzes the sensitivity of profit to carbon price under the concave function ($\beta = 6.3$). From the change

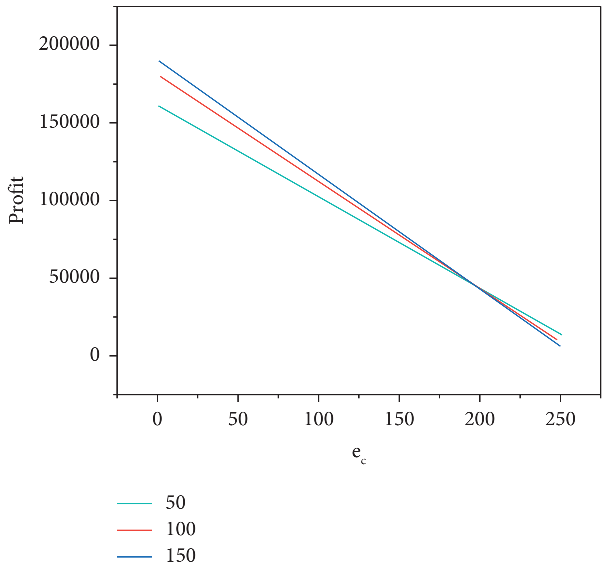

Figure 4: $\varepsilon = 50, 100, 150, e_c \in [0, 250]$.

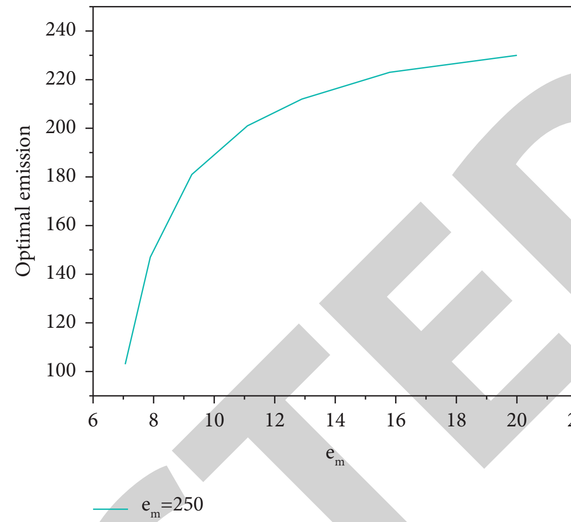

Figure 6: $\beta \in [6.3, 20]$.

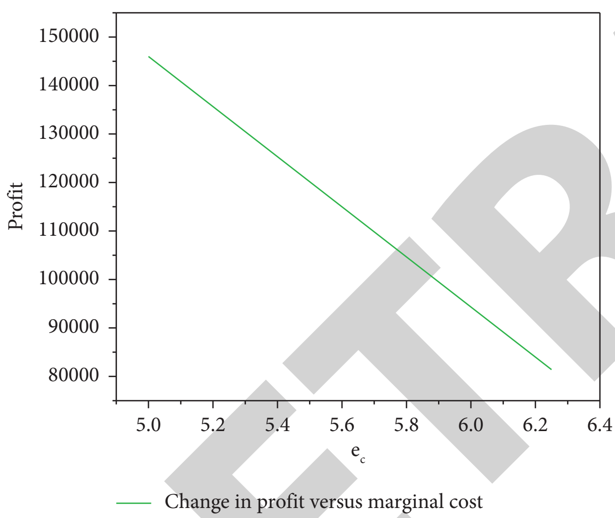

Figure 5: $e_c = 0, \beta \in [5, 6.3]$.

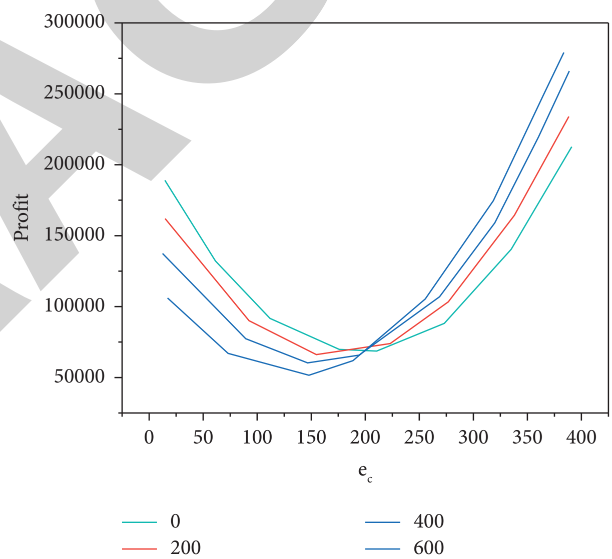

Figure 7: $e_c = [0, 400], \varepsilon = 0, 200, 400, 600$.

track of the stable point, a higher carbon price will enable enterprises to obtain the global optimal profit with less emissions. At the same time, if enterprises expand emissions, their profits will decline faster [19, 20]. When $e_c = 200$, the enterprise profits under the four carbon prices are the same, and beyond this point, the enterprise profits under the higher carbon prices will be lower [21].

The low marginal cost of emission reduction will urge enterprises to implement low emission strategies as much as possible. The marginal cost of a specific size will enable enterprises to implement low-carbon policies with low emissions, and the optimal emissions will decline with the increase in carbon prices. However, from the perspective of 50–300 carbon trading prices, the profits generated are less than those of the minimum emission strategy, and the difference between the two is generally one order of magnitude. Therefore, if the internal conditions permit and the external carbon trading price is reasonable, the enterprise should reduce carbon emissions as much as possible [22].

5. Conclusion

This paper discusses how enterprises make the optimal price of low-carbon products and emission reduction strategies under the carbon trading system.

In terms of carbon emission decision-making, we first analyze different decisions based on linear, concave, and convex objective functions according to the size of enterprise marginal cost and obtain some valuable information combined with numerical examples. For example, when there is a linear relationship between corporate profits and carbon emissions, profits will decrease with the increase of carbon emissions, and this trend will intensify with the rise in the carbon trading prices. Under the nonlinear function, when the price of carbon trading market rises, the larger marginal cost of emission reduction will lead to lower optimal target emissions. When the marginal cost of emission reduction is within a certain range, enterprises will try their best to reduce carbon emissions. In addition, when the carbon price is higher, lower carbon emissions will enable enterprises to obtain higher profits, and at this time, the opportunity cost of increasing emissions will be greater. In general, the overall profit level of a convex function (lower marginal cost of emission reduction) is larger than that of a concave function.

Based on the above discussion, we further analyzed the carbon trading price and obtained some valuable information for enterprises and government decision-making. For example, for enterprises, if their marginal cost of emission reduction is low in the carbon trading environment, they should try to reduce their carbon emissions in the production cycle. In particular, when the carbon price rises, emission reduction becomes a top priority for enterprises because there will be a large profit space in the trading market at this time. As far as the government is concerned, it should try to increase the carbon price if its capacity permits, such as through administrative intervention, so as to stimulate the enthusiasm of enterprises to voluntarily reduce emissions. If the local government does not have the ability to affect the carbon price, it should appropriately adjust the subsidies for low-carbon products to indirectly change the cost structure of enterprises and encourage enterprises to implement emission reduction.

The limitation of this paper is that carbon emissions can indeed be measured, and the production environment indicators of consumers and enterprises can also be obtained through some of the ways described in this paper, but the marginal price of consumers' willingness to pay for low-carbon products is a difficult value to measure. The value of different consumers is different and should change over time, but the description of low-carbon awareness in this paper is more abstract. Second, this paper assumes that the carbon emission quota for a certain enterprise is an exogenous variable, but in practice, if the enterprise or group is large, its industrial energy consumption level will affect the government's formulation of carbon trading quota.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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