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Analysis on Transaction Cost Control Model of Sewage Disposal Right Based on Environmental Protection

Zhiqin Xie[a]*, Hui Xue[a], Yuchen Xie[b]

[a] Department of accounting ,Shijiazhuang posts and telecommunications technical college, Shijiazhuang 050031, China
[b] CAC CPA limited liability partnership, Tianjin 300042, China
x1141038008@126.com

Pollution-discharge right trading system is developed as a new method for control environmental pollution based on market mechanism. This paper makes a comprehensive analysis on the pollution discharge rights and its trade system, reveals the five major factors that determine the discharge trade costs in the sewage plants, they are the total sewage right, the initial price, the discharge trade mode, the market demand and the available limit for discharge right trade. Given the above, a pollution-discharge right trade cost control model is built based on the environmental protection, and tested in a real situation, for example, a sewage plant in the Yellow River Basin, in order to check whether it is accurate. The results show that the pollution-discharge right trade can make the environmental resources redistribute and maximize the economic and social benefits of the interested parties, thus providing the clues to controlling the sewage discharge trade cost.

1. Introduction

For the sake of practicing the green development concept of “blue hills and green streams are gold & silver mountains”, China has attached more importance to the impact of economic development on environmental protection in recent years (Hanpattanakit et al., 2018). The pollution-discharge right trading system is designed as a market economy method based on environmental protection. This system can guarantee the business operation without involving the crime against the environment development.
As a mature method for environmental protection, the system originated in the United States. It has been proven to be effective on practical projects such as USA sewage treatment and Europe carbon emission, and now prevalent in China as a pilot (Zhang et al., 2013; Seth et al., 2008) Seth et al. Conducted a survey on the relationship between pollution-discharge right trade expenditure and the pollution control cos and effect. They believe that transaction expense increases the cost of controlling pollution; Kato et al.(2006). believe that transaction expense could have a bearing on the activity of the pollution-discharge trade market, that is, the better the trading market develops, the lower the transaction cost, there is a negative correlation between the two; (Scott et al., 2004) Scott et al. believe that the pollution-discharge trade price is correlated to the marginal abatement cost; (Cui et al., 2014) Cui et al. quantified the factors affecting the trade of pollution-discharge rights, and (Ermolieva et al., 2014) Ermolieva et al. delved into the optimal pollution-discharge right trade cost and unveiled the change laws of pollution-discharge right trade conditions and corporate efficiency.
Trade of pollution discharge rights can not only yield profits to both parties but also reach the environmental target. On this basis, this paper explores the pollution discharge rights and transaction costs of the chemical industry, the sewage plant in the Yellow River Basin, to trace the balance point between corporate efficiency and environmental protection

2. Factors affecting pollution discharge right trade

Environment capacity is defined such that, based on the self restoring capacity of environment can withstand the maximum degree of ecological environment pollution, provided that the ecological environment is not ruined and the people's lives are not injured (Kempenaar et al., 2007). The pollution discharge right is just to use the environmental capacity allocated to the companies. By definition, the way the pollution discharge right is regarded as a scarce resource for distribution and transaction is called the pollution discharge right trading

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system. It has been thirty years since this system was studied in theory (Liu et al., 2017; Barrozo et al.,2018). Europe and the United States have set up a mature pollution discharge right trading market, and formed a relatively complete trading system. However in this field, China still in its infancy.

2.1 Factors affecting the pollution discharge right trade

Various parts involved in the pollution discharge right trading process are shown in Fig. 1 (Bandosz et al., 2000). It is clear that the trade of pollution discharge rights must first conduct an environmental capacity assessment, led by the environmental protection administration. On the premise that ecological balance is guaranteed, the total effluent must be strictly controlled; second, the total pollution discharge rights are rationally distributed, so that they can be traded as scarce resources in the market; in the end, the pollution discharge right is quantified, and then delegated to the companies by the relevant government authorities.

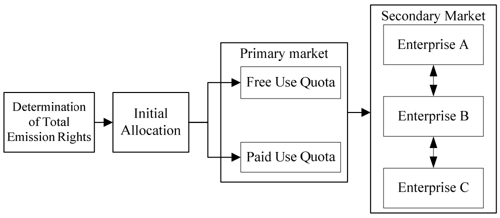

Figure 1: Emissions Right Trading Process

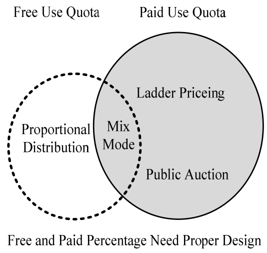

Figure 2: Initial Allocation Cost Mode

The government authorities allocate the pollution-discharge right in both paid and unpaid ways (as shown in Fig. 2). The total amount of paid use rights allocated to the company and as percentage of the total also directly affects the initial cost distribution. The unpaid distribution must be fair, reasonable, and transparent. Paid distribution is generally based on the ladder pricing and public auction, etc., and should balance the environmental protection and the unburdening the company.

In addition to the government-distributed pollution-discharge rights, the sewage plant can also buy and sell pollution-discharge rights in the secondary market. The factors affecting the buying and selling transaction mechanism mainly include the financing cost of trading pollution-discharge rights, and the government charge base price and penalty cost for exceeding the pollution discharge limit. Pollution discharge trade mainly occurs in the secondary market. In the primary and secondary markets, there are five main factors that constitute the pollution discharge trade cost (Table 1).

Table 1: Emissions Trading Cost Factors

	Main Factors
1	Initial allocation cost
2	Transaction fee
3	Financing costs
4	Sewage payment and fine
5	Emission reduction research investment

In the primary market, the total amount and initial price of the pollution discharge rights are determined. The total amount of the initial allocated pollution-discharge rights and the actual redundancy will determine the base price of the pollution discharge rights in line with the basic laws of commodity prices, that is, when the resources are scarce, the price will be relatively high. For the Yellow River Basin, as discussed in the paper, where the change in water yield is volatile, the ecological self-purification also fluctuates, so that the total amount of pollution discharge rights distributed each year is not consistent.

There are three factors that affect pollution discharge right trade in the secondary market, namely, the trading mode of pollution discharge rights, the market demand and the amount of pollution discharge credits that the government specifies for trading, as shown in Fig. 3 below. The relationship between the factors is described as follows: assume that the government estimates that the total amount of pollution discharge is 3Q tons, and in free and paid ways, Q cube is allocated to companies A, B, and C, respectively. E indicates the actual discharge capacity of different companies. Company A has a practical discharge capacity (E_A=Q+T) higher than the amount allocated; company B is just balanced (EB=Q); company C has the remaining tradable discharge rights due to the introduction of new sewage treatment technology T(E_C=Q-T). The discharge right of T tons sewage, saved by company C, is sold to Company A to obtain economic benefits, while the total discharge capacity is $E_A + E_B + E_C$ =3Q that falls within reasonable control range.

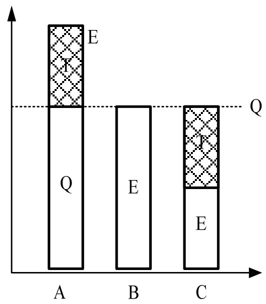

Figure 3: Emissions Trading Nature Example

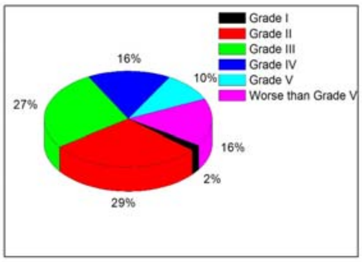

Figure 4: Proportion of Water Quality Categories in the Yellow River Basin in 2017

3. Pollution discharge right trade cost control model

3.1 Establishment of model

In order to quantify the pollution discharge rights, the paper assumes that the total pollution right in a certain area is E, and there are *n* companies that can have pollution discharge rights, so that the difference in pollution discharge rights owned by the company *i* is as follows (Devai and Delaune, 2002):

$$\Delta q_i = q_i - e_i \quad (1)$$

Where, e_i - the pollution discharge right owned by the company *i*;
q_i – the pollution discharge right required by the company *i*;
When $q_i > 0$, the company needs to conduct pollution discharge right trade to consume chemical sewage; when $q_i < 0$, the company can conduct pollution discharge right trade to obtain profits. At this time, the profit of the company is calculated by the following formula:

$$\pi(q) = R - C \quad (2)$$

Where, R - consumer income;
C - the sum of production costs;
q – the sewage discharge capacity
Company's profits can be expressed in terms of sewage discharge capacity (Dobos, 2005; Struijs et al., 2016). Study of Dobos et al. shows that there is a correlation between discharge capacity and corporate profits, which can be expressed by a concave function, that is, when the output of company increases, so do the profit and the corresponding sewage discharge capacity. The expressions of the company's sewage discharge capacity q and right trade cost are as follows:

$$q = e + x - y + d，e \geq 0, x \geq 0, y \geq 0 \text{de≥0, x≥0,y≥0} \quad (3)$$

$$c_e = px + T(x) + rl(x) + F(y) + G(d)V(d) \quad (4)$$

Where, x - trading volume;
Y- the level of corporate pollution control;
d – company's excess discharge volume.
T(x) - transaction cost, $T''(x) > 0$
$rl(x)$ - the gross trading cost of pollution discharge rights;
$F(y)$ - the cost of governance for environmental protection;
$G(d)V(d)$ – government's penalty cost, equal to the product of the penalty amount and the probability of government's spot check.
The corporate profit expressions involving a series of costs such as production, transaction, pollution-discharge trade coordination, environmental protection governance, and government penalties are as follows:

$$\max \pi(q) = R - C = R - c_e - c_s = R - （px + T(x) + rl(x) + F(y) + G(d)V(d)） - c_s =$$
（px+Tx+rlx+Fy+G(d)V(d)）-cs (5)

Where, c_s - production cost;
When the company gets stable business, the production cost and total sales can be considered as constants (Jouraiphy et al., 2005). Based on this, the trade cost model of the sewage bin discharge rights can be expressed as:

$$minc_e(\mathrm{q}) = \mathrm{px} + T(x) + rl(x) + F(y)) \quad (6)$$

3.2 Analysis and test of pollution discharge right trade cost control model

According to the *2017 China Ecological Environment Bulletin* issued by the *Ministry of Ecology and Environment*, as shown in Fig. 4, water of the trunk stream in the Yellow River Basin in 2017 was mildly polluted, and moderately polluted in the main tributaries. The main pollutants are CODs, ammonia nitrogen and total phosphorus. Class IV, Class V and Sub-Class V all account for 15.5%, while Class V and Sub-Class V increase by 4.7 and 2.9 percentile points, respectively. The water pollution situation is not optimistic.
Until this year, cities such as Zhejiang, Jiangsu, and Tianjin have fully opened up the market for pollution discharge rights. In the Yellow River Basin, there has already been a trial trading system for pollution discharge rights in Shaanxi and in other provinces. For example, the sewage plant in a city of Shaanxi. Established in 1995, it has passed the environmental assessment and examination processes, the corresponding chemical oxygen demand is maintained at 120 tons/year, and the relevant business sales and income are shown in Table 2.

Table 2: Enterprise Sales and Revenue

Reference index	Reference index value
Annual output	100000
Price per item	50 yuan
Annual production cost	400ten thousand yuan

When there is only pollutant discharge reduction in the sewage plant, the pollution control situation of the company calculated according to Formula 5 is shown in Table 3.

Table3： Corporate Pollution Control Costs and Profitability

Output	Coefficient of waste (Tons/ten thousand)	Production quantity (Tons/one year)	Emission reduction (Tons)	Cost of emission reduction(ten thousand)	Cost of production (ten thousand)	Sales revenue (ten thousand)	Porfit (ten thousand)
20	50	500	460	128	400	680	172
	60	600	530	148			152
	70	700	690	193			107
20	50	500	460	179			121
	60	600	530	207			93
	70	700	690	269			31
20	50	500	460	230			50
	60	600	530	265			15
	70	700	690	345			-25

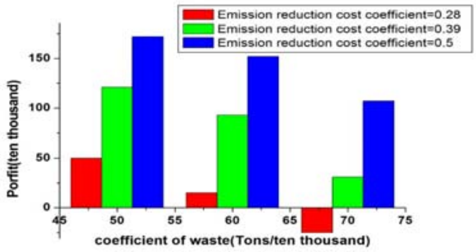

Figure 5: Pollution coefficient and profit analysis chart

As shown in Table 3 and Fig. 5, the pollutant production and abatement cost coefficients of the company have certain impact on the corporate profit. The greater the product coefficient, the higher the profit of the sewage plant; the greater the pollution abatement cost coefficient of the company, the less the profit of the sewage plant. It is thus clear that the sewage treatment cost of the sewage plant must consider the sewage discharge reduction cost and pollution discharge coefficient to ensure the company’s profit. In addition, when the abatement cost increases to RMB 5000, the sewage plant has a negative profit value. As the name suggests, when the COD marginal abatement cost is too high, it will inevitably cause the losses to the company. At this time, refer to the formula (6), when the profit is zero, the corresponding abatement cost threshold can be calculated.
When pollution reduction and discharge right trade exist in the sewage plant, according to formula 4, the COC reduction cost of the sewage plant is calculated, expressed as follows: reduction cost = transaction cost + pollution discharge right trade cost + abatement cost, among which, the transaction cost of the polluting discharge rights is available by multiplying its transaction price and volume. The abatement cost can be obtained by discharge reduction volume (deducting the transaction volume) and the unit abatement cost. According to the solution method, the cost control and the profit situation of the sewage plant are available as shown in Table 4.

Table 4: Cost control and profitability of enterprises under the trading system of pollution control and emission rights

	Trade not Exists			Trade Exists		
CERS(tons)	450	450	450	450	450	450
COD abatement cost (ten thousand/ Tons)	0.36	0.46	0.38	0.38	0.46	0.37
Emission trading volume (tons)				50	50	50
Transaction value (ten thousand/ Tons)				0.38	0.38	0.38
CODtrade cost (ten thousand/ Tons)				2	3	3
Reduction Volume (ten thousand/ Tons)				480	480	400
Cost cutting(ten thousand)	125	200	160	128	200	162
First cost((ten thousand))	400	400	400	400	400	400
Sales revenue(ten thousand)	680	680	680	680	680	680
Profit(ten thousand)	155	80	120	152	80	118

As can be seen from Table 4 above, whether the pollution discharge rights need to be traded depends on the market discharge price and the company's own marginal abatement cost. When the marginal abatement cost in the company is RMB 3800 /ton, the company that adopts the trading of pollution discharge rights has the profit of RMB 1.52 million, otherwise they earn RMB 1.2 million. At this time, the sale of the pollution discharge rights can bring the profit of RMB 0.32 million to the company; the pollution discharge right trade can redistribute the environmental resources, and maximize economic and social interests of both parties, which is conducive to sustainable green development based on environmental protection.

4. Conclusion

This paper describes the investigation on the pollution-discharge right and trade cost control in a chemical industry, the sewage plant of the Yellow River Basin. Here are several conclusions as follows:
(1) Some factors that affect the cost control of pollution-discharge right trade cost control in the sewage plants are available. It is believed that there are five major factors, i.e. the total pollution-discharge right and initial prices in the primary market and the pollution-discharge right trade mode, market demand, and the pollution-discharge trade credit specified by government, all of which should be considered in the pollution-discharge right trade cost control model;
(2) A cost control model is built for the pollution-discharge right trade. It takes into account the costs of any items, for example, production, transaction, pollution-discharge transaction management, environmental and government penalties, so that an overall performance is available for it;
(3) In a sewage plant, for example, we analyze and test whether the pollution-discharge trade cost control model is correct and accurate. It is believed that the pollution-discharge trade can redistribute environmental

resources, maximize the economic and social benefits of all interested parties, thus maintaining the environmental-based sustainable green development.

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