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Economic Analysis on Pollution Control for Textile Industry

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Abstract: Since the present researches on pollution control for textile printing & dyeing industry are mainly focused on qualitative description up to now, instead of special quantitative analysis, based on the census data of pollution sources, this paper adopts literature collection method and single-factor variance components method for continuous variables to identify the factors influencing cost for pollution control, and then establishes a function of investment and operation cost for textile printing & dyeing industry by MLE (maximum likelihood estimation) method on the basis of normal distributional hypothesis, so as to calculate pollution control cost for the textile industry and provide a quantitative basis for pollution control of the textile printing & dyeing industry. The research result shows that nature of enterprise, pollution-control method, regional distribution and industry type are all important factors which influence cost control of textile industry, there are significant variations of pollution control cost for textile industry between among different regions, treatment processes, or industry types.

Introduction

Due to complicated components, wastewater discharged by the textile industry is a kind of sewage difficult to be purified. China is a large textile producer and also a large dye manufacturer and user, so it is of great significance to strengthen research on pollution control of the textile industry. Presently, the researches on pollution control for the textile industry are mainly focused on qualitative description and the relevant technical methods [1-3], lack of quantitative analysis on pollution-control cost for textile industry to support macroeconomic decisions. Therefore it is also of great significance to conduct cost analysis on pollution control of textile industry for macroeconomic decisions.

For the research methods, the technical & economic analysis and researches on cost function for water pollution control were began to develop since late 1960s, including Fraas and Munley (1984) conducted an estimation on wastewater treatment cost for pollution control; McConnell (1991) and Schwartz broadened that model; Macal (1984) establish a function for wastewater treatment cost with taking treatment cost as a function of wastewater flow; Morgan and Owens (2001) provided an estimation on benefit from wastewater treatment through analysis on water quality from 1972 to 1996, especially for variation of nitrides and phosphides among of them; in 1993, National Academy of Sciences on Wastewater Treatment also worked out the cost function of wastewater treatment plants, etc. As we review China's major functions for water pollution control, main defects could be summed up as following: the researches on cost function were mainly limited within certain regions, lack of availability for different regions in whole country and systematic method study on technical & economic decisions for pollution control, most of researches were focused on theoretic method about analysis on cost benefits and effects, few of practices about them converting into applicable results.

The First National Pollution Source Census laid a foundation which researches on function for water pollution control could break through regional limitation and established a cost model of wastewater treatment for different regions and levels. Based on the data from the First National Pollution Source Census, this paper stimulates a function for investment and operation cost in China's textile industry, constructs a quantification model for function of investment and operation cost during wastewater treatment, so as to calculate wastewater treatment cost for the textile industry.

Methodology

Model Construction. For the model selection, it is shown by the research output from the Policy Research Bureau of World Bank(Susmita Dasgupta, etc. 1997) that simple fixed elastic model could provide not only better goodness of fit of linear regression, but also reasonable symbol of each major variables and higher significance, so it could explain relation among variables much well. The model could be represented as the following formula:

$$C = e^{\alpha_0} \bullet W^{\alpha_1} \bullet \prod_{k=1}^{n} (E_k)^{\beta_k} \quad . \qquad (1)$$

Where: C : cost for pollution control (RMB 10 000); W : Annual capacity for wastewater treatment (ton) or design treatment capacity (ton/day); E_k : Concentration of pollutant at the inlet/outlet; k : Kind of pollutant; α_0 , α_1 and β_k : the relevant parameters.

Operation Function Construction. According to the literature review, the factors which influence operation cost of pollution control in the textile industry include the actual treatment capacity of continuous variable wastewater, treatment effect of major pollutant COD[4], as well as categorical variable, nature of enterprise, region, industry category and treatment method.

According to the single factor analysis of variance for continuous variable, there are significant differences of operation cost for pollution control among the enterprises of various natures, comparing the private enterprise and oversea-funded enterprise with other types of enterprise; the significant differences also exist between the eastern and central & western enterprises. The wastewater treatment methods in the textile industry mainly include the physical method, chemical method, biological method, physical-chemical method and combined method. According to the single factor analysis of variance, the former three methods have passed the significance test, while the later two methods show no significant difference in statistics. The textile industry could be divided into six sub-industries, including cotton & chemical fiber weaving and printing & dyeing and finishing, woolen weaving, dying and finishing, bast fiber weaving, silk weaving & finishing, textiles manufacturing as well as knitwear manufacturing, among of them the first one has maximum sample size, up to 60.4%. The analysis shows that there are generally significant differences of operation cost among each sub-industry.

To combine the variables passed the detection into the above model, the function for operation cost of pollution control could be established.

Investment Function Construction. According to the literature review, the factors which influence operation cost of pollution control in the textile industry include the actual treatment capacity of continuous variable wastewater, treatment effect of major pollutant COD, as well as categorical variable, nature of enterprise, region, and industry category and treatment method.

According to the single factor analysis of variance for continuous variable, just like analysis on operation cost, there are also significant differences of investment cost for pollution control among enterprises of various natures, comparing private enterprise and oversea-funded enterprise with other types of enterprise; the significant differences also exist between the eastern and central & western enterprises, and between each treatment method. The investment costs for cotton & chemical fiber weaving and printing & dyeing and finishing, and silk weaving & finishing, have also quite differences from the other sub-industries.

To combine the variables passed the detection into the above model, the function for investment cost of pollution control could be established.

Calculation of Total Cost for Wastewater Treatment. For the composition and calculation of wastewater treatment, the operation cost in the pollution source census means the cost occurred for normal operation of the wastewater treatment facility in whole year of 2007, including energy consumption, equipment maintenance, employee salary, management overhead, agent cost and other costs relative to operation of wastewater treatment facility, etc. excluding depreciation cost of equipment. Since depreciation cost isn't contained within the operation cost of wastewater treatment, so it shall be brought into consideration with the formula as following:

$$C_{pre} = C_{ope} + \eta \bullet I \quad (2)$$

Where: C_{pre}: Total operation cost of wastewater treatment (RMB 10 000); C_{ope}: operation cost of wastewater treatment excluding depreciation cost (RMB 10 000); I: fixed asset investment (RMB 10 000);η: basic depreciation rate with depreciable life as 20 years for fixed assets such as wastewater treatment facility, and net residual value rate of fixed asset as 4%, and then η could be worked out as 4.8% [5].

Results

Regression Results. Table 1 shows parameter estimation results of the model, from which we could find significant parameter test and better goodness of fit. The regression results could illustrate the following conclusions:

Generally, the operation and investment costs for wastewater treatment of the private enterprises are lower than enterprises of other nature no matter what investment function or operation cost function is adopted, dummy variables are -0.113 and -0.169 respectively; while for the overseas-funded enterprises, the relevant costs are higher with dummy variables of 0.104 and 0.175 respectively. For treatment methods, the operation and investment costs of the physical method is the lowest with dummy variables of -0.662 and -0.910 respectively, the following is physical-chemical method (-0.595 and -0.690), and then chemical method (-0.261 and -0.633); the biological method and combined method have no obvious variation in the operation cost, but the later needs higher investment cost than the former. The regional differences also exist in the operation and investment costs for wastewater treatment in the textile industry, the relevant costs in the eastern are remarkably higher than that of the central and western. In addition, the difference of control cost can also be contributed by the different processes, wastewater types, or sub-industries, the silk weaving & finishing sub-industry has the lowest operation and investment costs, while the sub-industries of bast fiber weaving and textiles manufacturing have the relative higher costs.

Table 1 Parameter estimation and test results for operation and investment costs

Parameter	Function of operation cost					Function of investment cost				
	B	Standard error	Hypothesis testing			B	Standard error	Hypothesis testing		
			Wald Chi-Square	df	Sig.			Wald Chi-Square	df	Sig.
(intercept)	-4.089	.0753	2951.975	1	.000	.587	.0603	94.655	1	.000
Private enterprise	-.113	.0276	16.831	1	.000	-.169	.0269	39.476	1	.000
Overseas-funded enterprise	.104	.0345	9.090	1	.003	.175	.0335	27.435	1	.000
Physical method	-.662	.0424	243.768	1	.000	-.910	.0419	472.816	1	.000
Chemical method	-.261	.0344	57.316	1	.000	-.633	.0345	336.433	1	.000
Physical-Chemical method	-.595	.0524	128.530	1	.000	-.690	.0517	178.379	1	.000
Biological method						.085	.0320	7.109	1	.008
The eastern region	.514	.0405	160.743	1	.000	.113	.0385	8.546	1	.003
Cotton & chemical	.163	.0435	13.942	1	.000	-.069	.0272	6.464	1	.011

fiber weaving and printing & dyeing and finishing										
Woolen weaving, dying and finishing	.137	.0560	5.988	1	.014					
Bast fiber weaving	.434	.1100	15.527	1	.000					
Silk weaving & finishing	-.384	.0529	52.668	1	.000	-.923	.0400	533.170	1	.000
Textiles manufacturing	.231	.0574	16.171	1	.000					
Treatment capacity	.603	.0060	10185.205	1	.000	.588	.0065	8231.567	1	.000
COD	.107	.0108	98.464	1	.000	.197	.0105	353.011	1	.000
Pearson Chi-Square		1.016					0.970			

Discussions. Estimate the results of above parameters, and then the treatment costs could be obtained for different industries, regions, processes and efficiency.

Fig. 1 is taken cotton & chemical fiber weaving and printing & dyeing and finishing sub-industry as an example, which indicates the variation of treatment cost of the different processes for the same sub-system with design treatment capacity of 10 000 ton/day. Under the above conditions, the treatment costs are respectively about RMB 1.68~2.07 CNY/ton for the physical process; about RMB 2.50~3.09 CNY/ton for the chemical process; about RMB 3.28~4.07 CNY/ton for the biological process; about RMB 1.80~2.23 CNY/ton for the physical-chemical process; and about RMB 3.27~4.05 CNY/ton for the combined process.

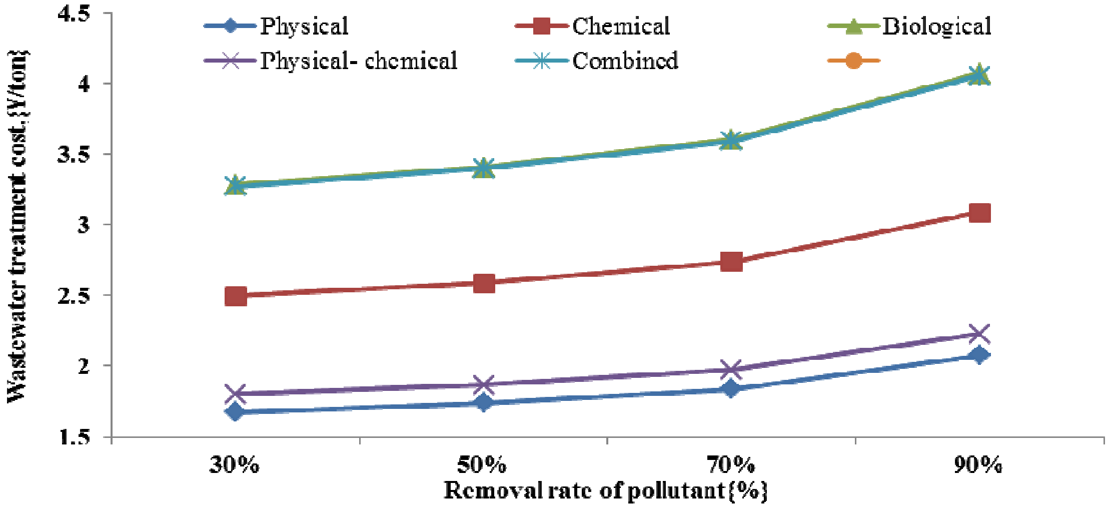

Fig.1: The treatment cost of cotton & chemical fiber weaving and printing & dyeing and finishing sub-industry under various processes (with design treatment capacity of 10 000 ton/day)

Fig. 2 is taken the biological process in the eastern region as an example, which indicates the variation tendency of treatment cost in six sub-industries against treatment efficiency increasing under design treatment capacity of 10 000 ton/day. Among six sub-industries of the textile industry, the cotton & chemical fiber weaving and printing & dyeing and finishing accounts for 60.4%; the woolen weaving, dying and finishing 8.6%; the bast fiber weaving 1.3%; the silk weaving & finishing 13.5%; the textiles manufacturing 7.7%; and knitwear manufacturing 8.4%. From distribution of pollution control equipment, the cotton & chemical fiber weaving and printing & dyeing and finishing is a key point in pollution treatment. As shown in Fig. 2, the bast fiber weaving needs the highest treatment cost, when treatment capacity increases from 30% to 90%, its treatment cost with biological process will be increased from 4.30 CNY/ton to 5.33 CNY/ton; the silk weaving & finishing needs the lowest treatment cost, ranging from 1.88 ~ 2.33 CNY/ton.

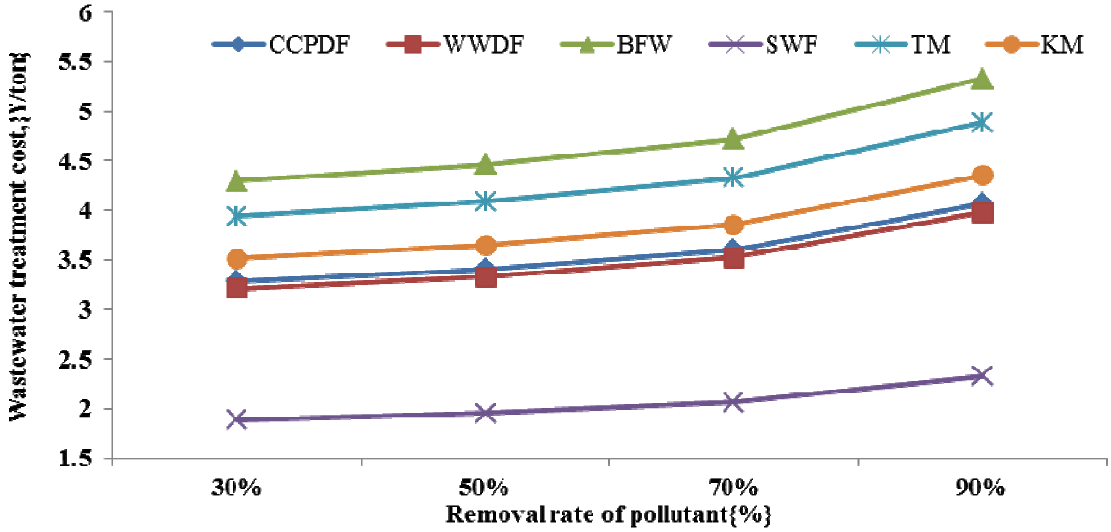

Fig. 2 The treatment cost of various sub-industries with biological processes (with design treatment capacity of 10 000 ton/day)

Fig. 3 is taken the combined process in the eastern region as an example, which indicates the variation tendency of treatment cost for the different nature of enterprises against design treatment capacity increasing under pollutant removal rate of 70%. As shown in Fig. 3, the unit investment cost for wastewater treatment of the overseas-funded enterprises are higher than enterprises of other nature, while the relevant cost of the private enterprise is the lowest. In addition, the treatment cost presents strong decline tendency of scale effect. When treatment capacity reaches to 100 000 ton/day, its treatment cost of combined process is only 0.59~0.66 CNY/ton; when treatment capacity is 10 000 ton/day, the treatment cost increases to 3.5~3.9 CNY/ton; and when treatment capacity lowers to 100 000 ton/day, the treatment cost jumps to 8.8~9.9 CNY/ton.

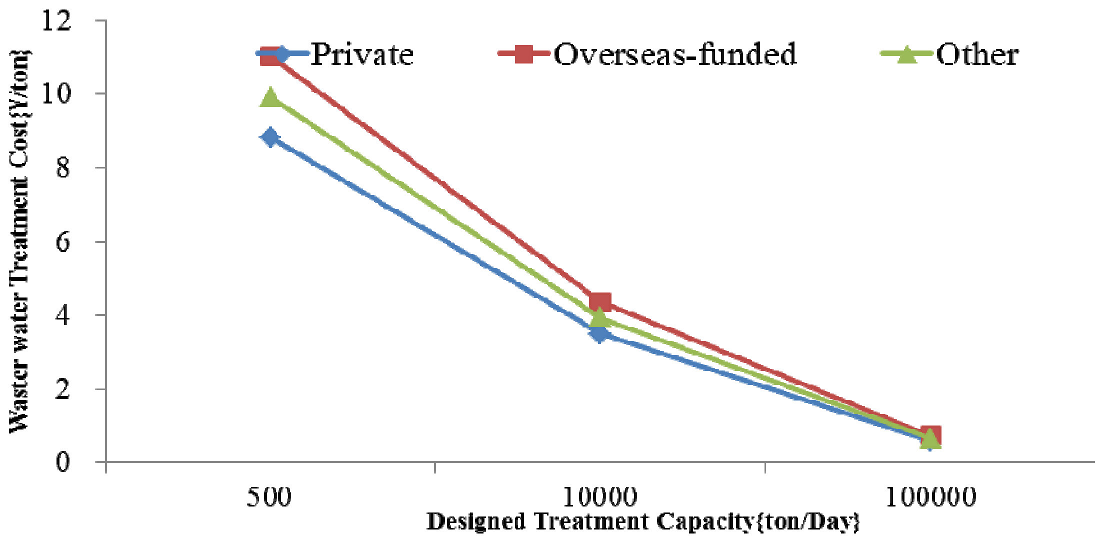

Fig. 3: Variation tendency of treatment cost for the different nature of enterprises against design treatment capacity increasing under pollutant removal rate of 70%.

Conclusions

According to single-factor variance analysis, the factors influencing treatment cost of the textile industry is identified, and models for operation and investment cost functions of industrial wastewater are established. The operation and investment costs of the textile industry are influenced by various factors, including region, nature of enterprise, treatment capacity, category of sub-industry, and treatment process, etc.

The wastewater treatment cost of private enterprise is lowest among the other types of enterprise, and that of the overseas-funded enterprise is highest. The former is about 0.07 ~ 1.1 CNY/ton than the later. The wastewater treatment costs with biological process and combined process are relative higher than others, which ranges 3.04 ~ 4.98 CNY/ton for wastewater treatment facility with capacity of 10 000 ton/day, and about 1.50~2.0 CNY/ton higher than that of the physical process.

The research results show that, taking treatment facility with capacity of 10 000 ton/day as example, wastewater treatment cost in the eastern is 0.50~2.0 CNY/ton higher than that in the central and western, which may result from cluster effect of the industry (90% of pollution control activities are centralized in the eastern region)

The pollution treatment costs of different sub-industries exist significant variation, the relevant cost of baste fiber weaving sub-industry with the highest cost is 1.42~3.0 CNY/ton highest that of Silk weaving & finishing with lowest cost.

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