

Research on Pricing of Domestic Waste Disposal Fees Based on Two-part Pricing Model

Fulei Zhu, Hongrui Zhu

School of North China University of Science and Technology, Hebei 063210, China

Abstract: According to the different nature, domestic waste is divided into kitchen waste, recyclable waste, hazardous waste and other types of garbage. The two-part pricing model of household garbage classification is constructed by using the two-part pricing method, and the model is applied to a real case of a university in Zhengzhou. The result shows that the model is reasonable and feasible to be applied to the pricing of household garbage classification.

Keywords: Garbage sorting, Two-part pricing model, Pricing mechanism.

1. Introduction

With the rapid development of Chinese economy, the output of urban solid garbage is more and more, and "garbage encircling city" is common [1]. A large amount of household waste not only pollutes our daily living environment, but also the different kinds of biochemical waste to deal with the cost is high, difficult, so it is particularly important to classify urban household waste, and adopt a reasonable pricing mechanism to charge.

In recent years, many scholars at home and abroad have studied the treatment fees and pricing of municipal solid waste, and the reduction effect. Li Dayong and Guo Ruixue (2005), after analyzing theories related to garbage charge, believe that establishing and improving a scientific household garbage charge system can effectively solve the problem of urban household garbage treatment to a certain extent [2]. Gao Zhiying, Xia Xinming and Liu Dongdong (2013) suggested that the policy of charging by discharge for household garbage could motivate people to reduce the emission of daily household garbage. In order to implement the discharge fee system smoothly, different garbage bags can be designed for different kinds of garbage, and garbage bags with different capacities can be used to measure the amount of garbage discharged [3]. Lu Zhuojian and Xiao Yao (2017) calculated the external cost of the environment by using the conditional valuation method (CVM for short) and analyzed the influence of the external environment on the pricing and charging of waste treatment [4]. Jia Xingjie (2021) analyzed the reduction effect of different MSW charging policies on the volume of MSW and believed that the reduction effect of metering charging policy was better than that of fixed charging policy [5]. There are also abundant researches on garbage sorting fees in foreign countries. Diaz et al. (2005) believed that the management function of the government plays an important role in the rational management of garbage charging pricing [6]. Scott & Watson (2009) calculated the collection cost, transportation cost, treatment cost and income of the whole urban solid waste cycle, and priced the urban solid waste charge according to its net value [7]. Miranda et al. (2010), by setting assumptions, practices the pricing model of MSW fees in selected empirical cities and draws the following conclusions: When the unit treatment cost is equal to the unit price, the selected MSW fee pricing model is the most effective [8].

To sum up, although there have been various researches on the pricing of domestic garbage treatment fees, the existing researches have not adopted different charging standards for different kinds of garbage. In this paper, the two-part pricing method is used to establish the pricing model of urban solid waste classification and treatment, and the charging coefficient is determined according to the types of solid waste and the amount of garbage produced. And the model is applied to the actual case to provide some suggestions for the pricing mechanism of MSW classification.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

2. Two-part Pricing Method

The two-part pricing is a combination of basic pricing and specific pricing, that is, the price is divided into two parts: fixed cost and specific cost. The fixed cost, also known as basic cost, is determined according to the average fixed cost calculated by the number of consumers under normal circumstances, and has nothing to do with consumption. According to the principle that marginal cost equals marginal utility, the cost is directly related to consumption. The formula is as follows:

$$P=X+Y=C/N+AQ \quad (1)$$

Where:

P- Unit price of product

X- Fixed fee

Y- Slave charge

C- Total fixed costs

N- Number of consumers

A- Variable marginal cost

Q- The amount consumed or demanded

The two-part pricing method divides the product price into fixed cost and variable cost, refines the pricing factors that affect the product, and is based on marginal cost pricing method, which is actually an optimal pricing. However, the premise of the two pricing methods is that the basic fixed fees will not cause consumers to quit, so if consumers do not want

to bear the fixed fees, it will cause losses. For the activities that public utilities must consume but the number of users is small, it will cause the low-income people to subsidize the high-income people, which is not conducive to social equity.

3. The Construction of Garbage Classification Pricing Model

The disposal cost of domestic waste includes the initial investment cost, the collection cost, the transportation cost and the disposal cost. When we construct the pricing model, we should consider two factors: fixed facility cost and variable cost. Therefore, the university household garbage classification and disposal pricing model established according to the two pricing methods is as follows:

$$T=X+Y \quad (2)$$

Where: T is the total cost of household garbage classification and treatment; X is a fixed expense; Y is the variable expense.

In theory, zero household waste emission is also a waste of resources, because it does not take full advantage of the self-absorption of nature and the operational role of established waste disposal stations. Therefore, in order to maximize the net income after pollution elimination, Q1 is the optimal emission of local household garbage allowed. When Q is less than the optimal discharge, only fixed household garbage disposal fee is required. We can express fixed expenses as follows:

$$X= C_1 \quad (3)$$

Where C₁ is the fixed facility cost of the household waste treatment station.

And the more household waste emissions, the higher the cost of waste disposal. When the resident's household garbage emission Q is greater than the optimal emission Q₁, we need to charge a certain amount of slave charge, which can be expressed as follows:

$$Y =(1+R) C_2 /(Q-Q_1) \quad (4)$$

Where: R is the average profit rate of enterprises in the domestic waste treatment industry; C₂ is the total operating cost of household waste treatment.

At this point, the pricing model of household garbage classification can be expressed as:

$$T= \begin{cases} C_1/Q_1; & Q < Q_1; \\ C_1/Q_1+ (1+R) C_2/(Q-Q_1); & Q > Q_1; \end{cases}$$

University solid waste is a part of urban solid waste, so its fixed cost of waste treatment and optimal emissions can be regarded as the same as urban solid waste. In the process of the total amount of household waste discharged by students, the total proportion of expenses to be borne is the product AB of matrix A and B. Therefore, the pricing model of college household waste classification treatment can be expressed as:

$$T= \begin{cases} (C_1/Q_1)(a_1b_1+a_2b_2+a_3b_3+a_4b_4) ; & Q < Q_1; \\ [(C_1/Q_1+(1+R)C_2/(Q-Q_1)] (a_1b_1+a_2b_2+a_3b_3+a_4b_4); & Q > Q_1; \end{cases}$$

4. Setting of Model Parameters

It has been learned from relevant departments that before, almost all domestic waste in urban areas of Zhengzhou had to be removed and transported to Houzhai garbage Disposal site and the second garbage disposal site for harmless treatment. At present, due to the differences in technical facilities and operation levels of different projects, the annual fixed cost of domestic waste disposal in Zhengzhou is set to include: When the annual depreciation cost and the annual average operating cost of the construction facilities of the garbage station are used, some small domestic waste disposal problems are ignored.

1) Houzhai Household Garbage Disposal Site

Zhengzhou No.1 Garbage Disposal Site (Houzhai Garbage Dump) is located in the southeast of Zhongli Village, Houzhai Township, Erqi District. The construction of Houzhai garbage Dump started in 1997 with a total investment of 580 million yuan and was put into use in 2005. The project is expected to last 30 years with a designed daily disposal capacity of about 2,000 tons of household garbage. The cost of the construction of Houzhai garbage disposal site includes three major parts: investment in the early stage of construction, investment in the construction period and production and operation costs. The composition of expenses is shown in the figure below:

Table 1. Total Cost Composition of Houzhai Garbage Dump

Numble	Project	Amount	Note
1	Up front investment	527.87	Annual fixed depreciation cost =(527.87+23924.56)/30=815.08 Annual fixed operating costs =33719.67/30=1123.99
2	Construction period investment	23924.56	
3	Production and operating expenses	33719.67	
4	Total cost	58172.1	

2) The Second Garbage Disposal Site (Dongju)

The second garbage disposal Plant of Zhengzhou is located in Lixi Village, Shiglihe Town, Guancheng District, with a total investment of 160 million yuan. The construction began

in 1999 and the plant was put into operation in 2005, with a daily disposal capacity of more than 1,000 tons of household garbage. The project is expected to last 20 years and is in good running condition at present.

Table 2. Total Cost Composition of Dongzhou Garbage Dump

Numble	Project	Amount	备注
1	Up front investment	117.68	Annual fixed depreciation cost =(117.68+5817.43)/20=296.75
2	Construction period investment	5817.43	
3	Production and operating expenses	11319.39	Annual fixed operating costs =11319.39/20=565.97
4	Total cost	17254.5	

Through the above analysis, we can calculate that the annual fixed investment cost of Zhengzhou household waste treatment station is as follows: $C_1=815.08+1123.99+296.75+565.97=280.1779$ million yuan; The daily harmless disposal capacity of household garbage is 3,500 tons, that is, $Q_1=0.35*365=1,277,500$ tons. Here, Q_1 is the optimal annual emission of Zhengzhou. Now there are more than 10 million permanent residents in Zhengzhou. Therefore, the optimal annual emission of domestic garbage per capita in Zhengzhou is 0.12 tons. In the formula, R is the average annual interest rate of domestic waste treatment enterprises. This paper refers to the net interest rate of 10 enterprises involved in domestic waste treatment in Zhengzhou, and finds that their average net interest rate is 6%. Therefore, this paper selects the average annual profit rate $R=6\%$.

From this, we can conclude that the fixed cost and specific cost of unit household waste treatment in Zhengzhou are respectively:

$$Y = (1+R) C_2 / (Q-Q_1) = 1.06 * C_2 / (Q-127.75)$$

At this point, we can represent the model as:

$$T = \begin{cases} C_1/Q_1 = 21.93 \text{ Yuan/ton}; & Q < Q_1; \\ C_1/Q_1 + (1+R) C_2 / (Q-Q_1) & \\ = 21.93 + 1.06 * C_2 / (Q-127.75) & Q > Q_1; \end{cases}$$

5. Case study

This study takes Y Campus of X University in Zhengzhou, Henan Province as an example, and investigates the discharge of domestic waste in the campus by interviewing. Y Community was put into use in 2010, with 12 colleges and more than 17,000 students, including 7500 boys and 9500 girls. A total of 23 dormitory buildings (10 for boys and 13 for girls), two dining halls, four teaching buildings, one administration building and one library have been put into use. To facilitate data collection, we divided the campus into five areas. They are: (a) dormitory building, (b) dining hall, (c) playground, garden and road, (d) teaching area and (e) library. The teaching area includes teaching buildings and administrative buildings.

Colleges and universities generally outsource the disposal of household waste. Garbage collection on Campus Y is handled by two private companies, a property company and a transportation company. Campus cleaners and garbage removal personnel by the property company responsible for hiring. Cleaners are mainly responsible for the cleaning work in the five areas of the school, as shown in Table 4. The garbage collector is responsible for transporting the garbage from all areas to the school garbage room, and will transport all the garbage in the garbage room to the domestic garbage treatment plant for harmless treatment every day or two.

Table 3. Distribution of cleaners in each region of the school

Area	The scope of	Number of cleaners
a	Dormitory Building	23
b	The restaurant	10
c	Playgrounds, gardens and roads	6
d	Teaching area	9
e	The Library	3

According to the Comprehensive Management Office of the campus, the average domestic waste emission of each

region in the school district during January 2021 to December 2021 is shown in the table below:

Table 4. Analysis Table of household waste output of X university in 2021

Month	Average daily production of domestic waste (tons)					Total
	Area a	Area b	Area c	Area d	Area e	
2021.01	0.92	1.38	0.24	0.02	0.03	2.59
2021.02	2.91	3.57	2.29	1.48	0.83	11.08
2021.03	2.74	3.68	2.13	1.36	0.94	10.85
2021.04	2.43	3.63	2.26	1.37	1.02	10.71
2021.05	2.51	3.47	2.35	1.42	1.14	10.89
2021.06	2.67	3.54	2.41	1.29	1.08	10.99
2021.07	1.12	1.37	1.02	0.36	0.42	4.29
2021.08	1.03	1.29	0.98	0.43	0.37	4.10
2021.09	2.85	3.59	2.53	1.54	0.94	11.45
2021.10	2.69	3.62	2.32	1.35	1.24	11.22
2021.11	2.73	3.46	2.47	1.29	1.07	11.02
2021.12	2.58	3.51	2.39	1.43	1.26	11.17

Its household garbage collection, transportation, treatment and other related expenses. The details are as follows:

Table 5. Cost Analysis Table of household garbage collection in X colleges and universities

Number	Project	Breakdown of expenses	Annual expenditure amount (Ten thousand Yuan)
1	Campus General Management Office		
2		Special management staff salary	3.62
3		Social insurance premium	0.42
4		Provident fund	0.67
5		Cost of welfare	0.96
6	Property Management Company		
8		Cleaning collection staff salary	10.24
9		Property management fee	0.62
10		Social insurance premium	1.35
11	Other Expenses		
		Office expenses	0.41
12		Cost of transportation	0.09
13		Cost of tools	0.13
Subtotal			18.51

Table 6. Cost Analysis Table of Household garbage transportation in X colleges and universities

Number	Project	Breakdown of expenses	Annual expenditure amount (Ten thousand Yuan)
1	Wage		
2		Driver/warehouse manager/maintenance staff salary	8.72
3		Social insurance premium	0.79
4		Provident fund	1.43
5		Cost of welfare	0.96
6	Other Expenses		
7		Office expenses	0.46
8		Transfer station utilities	0.85
9		Transfer station management and disinfection fees	0.52
10	Cost of vehicle		
11		Fuel	1.48
12		Insurance premium	1.3
13		Cost of maintenance	0.9
Subtotal			17.41

As can be seen from the above tables, the annual collection cost of domestic waste in X university is 185,100 yuan. Based on the annual emission of waste of 3,358 tons, the collection cost per ton of domestic waste is 55.12 yuan. The annual transportation cost is 174,100 yuan, and the transportation cost per ton of household waste is 51.85 yuan. Since the household waste of X University is transferred to the urban household waste treatment station for harmless treatment, it is difficult to accurately calculate the disposal cost. We take the average disposal cost of the municipal household waste as 26.31 yuan/ton.

To sum up, the annual discharge of domestic waste in X University is 3,358 tons, the total operating cost of domestic waste treatment is 447,550 yuan, and the unit treatment cost is 133.28 yuan.

In the last section, we calculated that the optimal per capita emission of household waste in Zhengzhou is 0.12 tons/year, and the number of students in X university is 17,000. Therefore, the optimal annual discharge of domestic waste in the university is 2040 tons/year. The actual amount of household waste discharged by the university is 3,358 tons/year, and the total operating cost of household waste treatment is 447.55 million yuan. Therefore, the calculation results of the two-part pricing model of the school's household waste disposal cost are as follows:

$$T=21.93+1.06 *447550/(3358-2040)=381.87 \text{ Yuan/ton}$$

In other words, based on the two-part pricing model, we obtained the pricing of university household waste treatment cost as 381.87 yuan/ton without classifying household waste.

6. Conclusion

This paper focuses on the pricing mechanism of university life garbage classification treatment. At present, most of Chinese university life garbage classification uses the quota valuation and mixed treatment mode. Through drawing on the advanced experience of domestic and foreign urban life

garbage classification and taking X University in Zhengzhou as an example, the pricing mechanism of university life garbage classification based on the two pricing methods is studied. The classification method of college household waste is applied to two pricing models, which are extended, and a scientific and reasonable pricing model of college household waste classification is established. Taking the Y campus of X university in Zhengzhou as an example, the extended model is solved and its feasibility is analyzed.

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