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# Acceptance of pay-as-you-throw solid waste charging methods among urban residents in China

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**Aim:** Pay-as-you-throw (PAYT) is a recognized waste-charging method commonly used in developed countries to reduce waste effectively and improve resource utilization efficiency. China is currently transitioning from a traditional fixed-fee model to a PAYT model.

**Method:** In this study, a sample of 1,346 urban residents in China is analyzed empirically to investigate their willingness to accept this change and the waste fees they are willing to pay for it.

**Results:** The results indicate that, 1) at present, the proportion of urban residents willing to accept the PAYT charging model is low, accounting for only 54.53%. 2) The average annual cost for residents' households willing to pay for PAYT is 58.616 RMB, which is relatively low. 3) The main reasons for the residents' low acceptance of PAYT are behavioral attitudes, social norms, and perceived behavioral control factors. 4) Income and education levels mainly explain the low level of expenses paid by residents.

**Conclusion:** Therefore, we suggest that, in the short term, publicity and education should be used to encourage residents to establish a correct environmental concept and a sense of environmental governance ownership, increase their knowledge of waste recycling and disposal and their awareness of waste charging rules, and thus improve their willingness to accept the PAYT charging model. In the long term, the PAYT charging model should be compatible with the levels of economic development and family education, and residents' waste charges for PAYT should increase steadily.

KEYWORDS

**urban residents, waste recycling, pay-as-you-throw, theory of planned behaviour, charging methods**

## 1 Introduction

"Waste besieged cities" pose a huge threat to the development of mankind. Driven by population growth and rapid urbanization, the global annual output of municipal solid waste is now more than 2 billion tons, and domestic waste is expected to increase to 3.4 billion tons in the next 30 years (Kaza et al., 2018). The municipal solid waste charging method plays a key role in solving the "waste besieged city" problem. A reasonable municipal solid waste charging method can not only reduce the source of waste production (Kinnaman et al., 1995; Tai et al., 2011), but also improve the efficiency of waste recycling (Bergeron, 2017; Tong et al., 2020; Agamuthu and Fauziah, 2011). Generally, pay-as-you-throw (PAYT) enables residents to become gradually aware of "polluter pays," which presents positive behavioral

incentives for residents to reduce waste and improve processing efficiency. Consequently, this helps to solve the "waste besieged" dilemma (Fullerton and Kinnaman, 1994; Kinnaman and Fullerton, 1997; Linderhof et al., 2001; Viscusi et al., 2011; Zhang and Wen, 2014; Starr and Nicolson, 2015; Meng et al., 2018; Meng et al., 2019).

China's waste siege problem continues to worsen, as it is one of the world's most rapidly urbanizing countries. By 2021, the total amount of municipal solid waste had reached 248.69 million tons, with an average growth rate of 4.25%, from 2011 to 2021. As the fixed-fee charging method has the advantages of a lighter economic burden on residents, simpler charging processing, and easier supervision, China has been implementing it based on the living area or number of residents (Wang, 2008; Ma and Du, 2011; Chen and Cai, 2017; Xue and Fan, 2017). However, under the fixed-fee charging method, problems such as low efficiency of waste discharge management and heavy burden on the government have become increasingly prominent (Chen and Liang, 2002; Peng et al., 2006; Xiao et al., 2020; Zhang et al., 2022). For this reason, the Chinese government is attempting to promote the transformation of the waste charging model from the traditional fixed-fee model to the PAYT model. In July 2018, the Chinese government promulgated the "Opinions on Innovating and Improving the Price Mechanism for Promoting Green Development" to implement metered and differentiated charges for residential users gradually.

Waste-charging models are closely related to the daily lives of most urban residents. For effective implementation of the PAYT model, it needs to be effectively integrated with the psychological demands and cultural traditions of urban residents. The theory of planned behavior (TPB), proposed by Ajzen and Fishbein (1980) and Ajzen (1991), is one of the theoretical frameworks widely used to study individual decision-making and demands. Empirical studies have shown that TPB has a strong predictive ability and realistic interpretation of individual behavioral intentions (Chan, 1998; Kuang and Lin, 2021; Lou et al., 2022). Therefore, it has become a research tool for studying waste recycling (Pakpour et al., 2014; Kirakozian, 2016; Wang et al., 2018; Chen et al., 2019; Pei, 2019; Zhang et al., 2019; Peng et al., 2021), low-carbon consumption (Ertz et al., 2017; Jiang et al., 2020), tourist environmental behaviors (Liu et al., 2017; Wang et al., 2020) and other important theories of individual behavioral issues.

The above-mentioned research provides an analytical framework for exploring the willingness of Chinese urban residents to accept the PAYT model and their behavioral intention regarding the waste fee they are willing to pay for it. The evaluation items include "Does the effect of waste recycling in the community affect your living mood and happiness" to describe behavioral attitudes, "Confidence in community residents' conscious compliance with PAYT regulations" to describe social norms, and "knowledge about waste recycling" to describe perceived behavioral control. In addition, variables such as families' monthly income are used to reflect the impact of residents' socioeconomic characteristics on their behavioral intention. Thereafter, this study analyzes the impact of residents' behavioral attitudes on their willingness to accept PAYT and the waste fees they are willing to pay for it. To this end, based on the TPB framework, this study conducts a questionnaire survey of 1,346 urban households in the Beijing-Tianjin-Hebei region, empirically analyzing the influencing factors of Chinese urban residents' willingness to accept the PAYT charging model and the waste fees they are willing to pay for it.

The study finds that the acceptance of PAYT charging model between Chinese urban residents is only 54.53%, which is mainly caused by behavioral attitudes, social norms and perceived behavioral control factors; urban residents in China are willing to pay a low average of 58.616 yuan per year for PAYT, mainly due to their income level and education level. This study not only provides important enlightenment for the Chinese government to implement the PAYT charging model, but also a practical guidance for the reform of waste charging models in other developing countries.

The remainder of the paper is organized as follows. Section 2 is questionnaire survey and data analysis. Section 3 discusses the empirical model used. The results analysis and further discussions are conducted in Section 4. Section 5 presents the conclusions and some policy implications.

## 2 Questionnaire and data analysis

To accurately understand the willingness of urban residents to accept PAYT and their behavioral intention regarding the waste fee they are willing to pay for it, we conducted a questionnaire survey of households in major cities in Beijing, Tianjin, and Hebei Province in China in 2020, based on the TPB framework. In total, 1,560 questionnaires were distributed, and 1,346 valid questionnaires were returned. Based on the analysis of the returned questionnaires, the basic situations of Chinese urban households and their willingness to accept the PAYT charging model are shown in Table 1. Of the survey participants, 58.84% are female, and male participants are fewer. Most participants are of working-age (18–60 years), accounting for 96.06% of the population. Overall, the population is in a healthy physical condition, and the total proportion in "well" and "general" physical conditions reaches 98.37%. From the educational level perspective, the main population (84.32%) has a university or junior college degree or above. Most families (50.00%) have three members, followed by families of four at 32.69%, with the sum of the two reaching 82.69%. Their occupations mostly includes "business, service workers, and self-employed persons," (54.83%), followed by "civil servants, heads of institutions," "professional technicians, researchers," "operators of production and transportation equipment and related personnel," and "production personnel in agriculture industries" accounted for 18.28, 14.86, 4.09%, and 1.34%, respectively. Those who don' t work or are not stable employees accounts for 6.61%. Data from the National Bureau of Statistics of China shows that, in 2019, the annual *per capita* urban disposable income was 42,359 yuan, and the monthly *per capita* disposable income was approximately 3,530 yuan. The questionnaire data shows that the residents' monthly per-capita income is 6,194 yuan, which is higher than the national average. From the perspective of the distribution of monthly *per capita* income, the proportion of households with a monthly *per capita* income of less than 3,530 yuan, 3,530–7,060 yuan, 7,060–10,590 yuan, and more than 10,590 yuan are 59.51%, 24.96%, 6.69%, and 8.84%, respectively, showing the differences among families and indicating a significant income gap.

**TABLE 1 Survey questions and data statistical analysis.**

| Item | Response | Frequency | Percentage (%) |
|---|---|---|---|
| 1) Gender | Male | 554 | 41.16 |
| | Female | 792 | 58.84 |
| 2) Age | 0–18 | 41 | 3.05 |
| | 18–60 | 1,293 | 96.06 |
| | >60 | 12 | 0.89 |
| 3) Physical condition | Well | 884 | 65.68 |
| | General | 440 | 32.69 |
| | Bad | 22 | 1.63 |
| 4) Education level | Below senior high school | 58 | 4.31 |
| | High school and technical secondary school | 153 | 11.37 |
| | University and junior college | 1,009 | 74.96 |
| | Postgraduate | 126 | 9.36 |
| 5) Family size | ≤ 2 | 80 | 5.94 |
| | 3 | 673 | 50.00 |
| | 4 | 440 | 32.69 |
| | 5 | 108 | 8.03 |
| | ≥ 6 | 45 | 3.34 |
| 6) Occupation | Civil servants, heads of institutions | 246 | 18.27 |
| | Professional technicians, researchers | 200 | 14.86 |
| | Business, service workers, self-employed persons | 738 | 54.83 |
| | Operators of production and transportation equipment and related personnel | 55 | 4.09 |
| | Production personnel in agriculture industries | 18 | 1.34 |
| | others | 89 | 6.61 |
| 7) Monthly family income *per capita* | <3530 RMB | 801 | 59.51 |
| | 3,530–7060 RMB | 336 | 24.96 |
| | 7,060–10590 RMB | 90 | 6.69 |
| | ≥ 10,590 RMB | 119 | 8.84 |
| 8) Average amount of domestic waste generated by households per day | ≤ 2.5L | 314 | 23.33 |
| | 2.5–7.5L | 795 | 59.06 |
| | ≥ 7.5L | 237 | 17.61 |
| 9) Satisfaction with the current environment | Very much | 500 | 37.15 |
| | General | 524 | 38.93 |
| | Not at all | 322 | 23.92 |
| (10) Does the effect of waste recycling in the community affect your living mood and happiness? | Yes | 1,242 | 92.27 |
| | No | 104 | 7.73 |
| (11) Are you willing to adopt the PAYT charging model? | Yes | 734 | 54.53 |
| | No | 612 | 45.47 |

(Continued on following page)

**TABLE 1 (*Continued*) Survey questions and data statistical analysis.**

| Item | Response | Frequency | Percentage (%) |
|---|---|---|---|
| (12) Amount you are willing to pay per month under PAYT charging model for waste recycling | ≤ 5 RMB | 605 | 44.95 |
| | 5–10 RMB | 310 | 23.03 |
| | 10–15 RMB | 212 | 15.75 |
| | ≥ 15 RMB | 219 | 16.27 |
| (13) Satisfaction with your community's efforts to promote waste recycling | Very much | 194 | 14.41 |
| | General | 317 | 23.55 |
| | Not at all | 835 | 62.04 |
| (14) Confidence in community residents' conscious compliance with PAYT regulations | Very much | 385 | 28.60 |
| | General | 615 | 45.69 |
| | Not at all | 346 | 25.71 |
| (15) Assessment of accessibility of waste disposal infrastructure in your city | Good | 500 | 37.15 |
| | General | 553 | 41.08 |
| | Bad | 293 | 21.77 |
| (16) Satisfaction with the implementation of waste disposal by city government | Very much | 169 | 12.55 |
| | General | 309 | 22.96 |
| | Not at all | 868 | 64.49 |

For 59.06% of households, the average amount of domestic waste generated per day is more than 2.5–7.5 L, while 23.33% and 17.61% of households generate below 2.5 L and above 7.5 L, respectively, which is relatively less waste. Satisfaction with the current environment is low. The proportions who indicated "Very much" and "General" are 23.92% and 38.93%, respectively. The total proportion was 62.85%. The vast majority of respondents (92.27%) believed that waste recycling in the community is an important factor affecting living mood and happiness. The proportion of residents who were willing to adopt the PAYT charging model was 54.53%, reflecting a low overall acceptance. On this basis, the level of fees that the residents were willing to pay per month under the PAYT charging model for waste recycling was low. Among them, 44.95% of families were willing to pay less than 5 yuan per month, 23.03% were willing to pay 5–10 yuan, 15.75% were willing to pay 10–15 yuan, and 16.27% were willing to pay 15 yuan and above. Simultaneously, there was some dissatisfaction with the waste disposal methods, community management, and government policies. Among the answers to the questions, "satisfaction with your community's efforts to promote waste recycling," "confidence in community residents' conscious compliance with PAYT regulations," "assessment of accessibility of waste disposal infrastructure in your city," and "satisfaction with the implementation of waste disposal by city government" accounts for 62.04%, 25.71%, 21.77%, and 64.49%, respectively, of the families expressed dissatisfaction or lack of confidence.

## 3 Empirical model

To analyze the willingness of Chinese urban residents to accept PAYT and their behavioral intention regarding the waste fee they are willing to pay for it, the following empirical analysis is carried out. First, a probit model is used to estimate the factors influencing the residents' willingness to accept the PAYT charging model.

$$probit\left(y_i = 1|x_i\right) = \alpha_0 + \alpha_1 comfort_i + \alpha_2 sati_i + \alpha_3 atti_i + \alpha_4 comply_i + \alpha_5 exert_i + \alpha_6 force_i + \alpha_7 know_i + \alpha_8 faci_i + \alpha_9 X_i + \varepsilon_i \quad (1)$$

In Eq. 1, y is a variable of 0 and 1, and the household is willing to accept PAYT as 1 and 0 as the opposite. Based on the theory of planned behavior, explanatory variables introduces into empirical model. The variables comfort, sati and atti are used to reflect the behavioral attitude of the respondents; comply, exert and force reflects the subjective norms; know and faci are used to reflect the perceived behavioral control. Besides, $X_i$ represents the economic and social characteristics of the respondents, which controls the influence of individual and family heterogeneity of the respondents. $\varepsilon_i$ is the error term. Table 2 shows the specific variable descriptions.

Next, based on residents' willingness to accept PAYT, we analyze the factors influencing the waste fees they are willing to pay.

$$lnWTP_i = \beta_0 + \beta_1 comfort_i + \beta_2 sati_i + \beta_3 atti_i + \beta_4 comply_i + \beta_5 exert_i + \beta_6 force_i + \beta_7 know_i + \beta_8 faci_i + \beta_9 X_i + \epsilon_i \quad (2)$$

**TABLE 2 Variable description and descriptive statistics.**

| Variable category | Variables | Variable description | Mean | Std. deviation |
|---|---|---|---|---|
| Explained Variable | exchange | Are you willing to adopt PAYT (0 = no, 1 = yes) | 0.545 | 0.498 |
| | lnwtp | Willingness to pay for PAYT charging model (RMB). ln is the natural logarithm | 4.071 | 1.215 |
| Attitude | comfort | Does the effect of waste recycling in the community affect your living mood and happiness? (1 = not at all, 2 = general, 3 = very much) | 2.675 | 0.612 |
| | sati | Satisfaction with the current environment (1 = not at all, 2 = general, 3 = very much) | 1.958 | 0.720 |
| | atti | Satisfaction with the implementation of waste disposal by city government (1 = not at all, 2 = general, 3 = very much) | 1.724 | 0.677 |
| Subjective norms | comply | Confidence in community residents' conscious compliance with PAYT regulations (1 = not at all, 2 = general, 3 = very much) | 2.029 | 0.737 |
| | exert | Satisfaction with your community's efforts to promote waste recycling (1 = not at all, 2 = general, 3 = very much) | 1.524 | 0.734 |
| | force | Is waste sorting mandatory in your community, a variable of 0 and 1 (0 = no, 1 = yes) | 0.197 | 0.398 |
| Perceived behavior control | know | Knowledge about waste recycling (1 = not at all, 2 = general, 3 = very much) | 1.958 | 0.514 |
| | faci | Whether the city's waste disposal infrastructure is complete or not, a variable of 0 and 1 (0 = no, 1 = yes) | 0.371 | 0.483 |
| Economic and social characteristics | lnfamincome | Monthly family income *per capita* (RMB). ln is the natural logarithm | 9.423 | 0.839 |
| | familysize | Number of family members | 3.527 | 0.922 |
| | gender | Gender (1 = male, 2 = female) | 1.588 | 0.492 |
| | age | Respondents' age | 33.585 | 12.270 |
| | education | Education level (1 = below senior high school, 2 = high school and technical secondary school, 3 = university and junior college, 4 = postgraduate) | 2.894 | 0.607 |
| | health | Physical condition (1 = bad, 2 = general, 3 = well) | 1.360 | 0.513 |

Eq. 2 shows the amount that the residents are willing to pay under the PAYT charging model. The selection and description of the other variables are the same as in Eq. 1.

# 4 Empirical results analysis

## 4.1 Benchmark regression results

As shown in Table 3, residents' attitude, subjective norms, and perceived behavior control have a significant impact on their willingness to accept the PAYT charging model. Regarding the residents' attitude, the coefficient of comfort is 0.145, which is significant at the 5% statistical level, indicating that the more residents pay attention to the effect of waste recycling on their mood and happiness, the more willing they are to accept PAYT. The coefficients of sati and atti are −0.175 and −0.163, respectively, and they are significant at the 1% and 5% statistical levels, indicating that the more satisfied the residents are with the government's current environmental and waste disposal implementation in the city, the less willing they are to accept PAYT. This also indicates that residents rely strongly on the traditional government-led fixed-rate fee model. Regarding the subjective norms factors, the coefficient of comply is 0.206, which is significant at the 1% statistical level, while the coefficients of exert and force are not statistically significant, indicating that residents' satisfaction and compulsory waste sorting measures are not only sensitive, but highly sensitive, to the trust in community residents' conscious compliance with PAYT regulations. This indicates that residents pay special attention to whether other members of the community can comply with the relevant requirements of the PAYT charging model. In the perceived behavior control factors, the coefficient of know is 0.227, which is significant at the 1% level, while the coefficient of faci is not statistically significant, indicating that residents' understanding of waste recycling affects their acceptance. Residents' waste knowledge is perceived as the most important behavioral control factor in the PAYT charging model. In addition, individual heterogeneity characteristics, such as family size and physical condition, also affect the willingness of urban residents to accept PAYT.

For residents who accept PAYT, the waste fees that they are willing to pay are primarily affected by comfort, lnfamincome, and education. The coefficients are 0.170, 0.282, and 0.197, respectively, all of which are statistically significant at the 1% level. In general, behavioral intention factors such as attitude, subjective norms, and perceived behavior control have no significant effect on residents' waste payment amounts. The key to increasing the payment amount of residents' waste charges lies in the increase of their income and education levels.

The empirical results of residents' willingness to accept PAYT and the waste fees they are willing to pay for it are compared. As a result, residents' behavioral intention factors are found to have a more significant impact on their willingness to accept the PAYT

**TABLE 3 Benchmark estimation result.**

| | | Base sample | | Winsorize income level variables at 1% | |
|---|---|---|---|---|---|
| | | exchange | lnwtp | exchange | lnwtp |
| Attitude | comfort | 0.145** (0.059) | 0.170*** (0.076) | 0.161*** (0.060) | 0.175** (0.075) |
| | sati | −0.175*** (0.062) | −0.065 (0.079) | −0.182*** (0.063) | −0.041 (0.078) |
| | atti | −0.163** (0.065) | 0.045 (0.078) | −0.176*** (0.066) | −0.000 (0.078) |
| Subjective norms | comply | 0.206*** (0.057) | 0.088 (0.072) | 0.209*** (0.058) | 0.076 (0.072) |
| | exert | 0.065 (0.056) | 0.019 (0.069) | 0.080 (0.056) | 0.016 (0.068) |
| | force | 0.103 (0.099) | −0.104 (0.120) | 0.102 (0.101) | −0.045 (0.119) |
| Perceived behavior control | know | 0.227*** (0.074) | −0.080 (0.097) | 0.219*** (0.075) | −0.072 (0.095) |
| | faci | 0.006 (0.081) | 0.107 (0.101) | 0.012 (0.082) | 0.093 (0.099) |
| Economic and social characteristics | lnfamincome | 0.023 (0.043) | 0.282*** (0.055) | 0.120** (0.051) | 0.289*** (0.061) |
| | familysize | 0.062 (0.038) | 0.020 (0.052) | 0.049 (0.038) | 0.018 (0.052) |
| | gender | −0.072 (0.072) | −0.038 (0.090) | −0.070 (0.073) | −0.023 (0.089) |
| | age | 0.004 (0.003) | −0.005 (0.004) | 0.004 (0.003) | −0.004 (0.004) |
| | education | 0.059 (0.061) | 0.197*** (0.077) | 0.040 (0.062) | 0.182** (0.075) |
| | health | −0.138* (0.071) | 0.092 (0.094) | −0.154** (0.072) | 0.112 (0.094) |
| Log-likelihood | | −894.738 | | −868.823 | |
| $R^2$ | | 0.035 | 0.078 | 0.042 | 0.074 |
| N | | 1,346 | 734 | 1,316 | 710 |

Note 1: ***, **, and * Represent statistical significance at 1, 5, and 10 percent levels, respectively. ( ) represents the standard deviation of coefficient. Note 2: The sample of lnwtp is a sample whose answer is "willing to adopt PAYT, charging model" and "willing to pay for PAYT, charging model" with an amount greater than 0. Note 3: The $R^2$ for the probit model is Pseudo $R^2$, for the OLS, model is $R^2$. Note 4: This paper also uses two-stage selection method to estimate, and finds that the potential sample selection bias problem in model 2 is not valid.

charging model, while economic and social characteristic variables have a more significant effect on the amount that residents pay for waste recycling and PAYT. Therefore, we believe that encouraging residents to establish the correct environmental concept and sense of environmental governance ownership through publicity and education can increase their willingness to accept PAYT and the waste fees they are willing to pay for it. In addition, strengthening the awareness of community residents to abide consciously by the relevant requirements of PAYT and enhancing their understanding of waste recycling-related knowledge can increase their willingness to accept the PAYT charging model. Improvement in residents' household income and education levels can promote their willingness to pay higher fees for waste recycling.

## 4.2 Analysis results of winsorization on income level variables

During the data cleaning process, the income-level data exhibits truncated characteristics. To smooth the data and maintain the integrity of the sample information by optimizing data quality, this study conducts a re-examination after the income level is winsored at 1%. The winsorization method uses data at the 1% and 99% quantiles of income levels to replace the data for less than 1% and greater than 99% of the sample, respectively. Table 3 reports the estimated results after winsorization. The results reveal that, although the estimated coefficient levels of residents' willingness to accept PAYT and the waste fees they are willing to pay for it differs slightly, they are consistent with the impact relationship obtained from the baseline regression results, which verifies the robustness of the baseline regression estimation results.

## 4.3 Further analysis

The PAYT charging model of the municipal solid waste management may increase the expenditure of households with high waste discharge. Therefore, this article further discusses whether there are differences in the willingness of households with different waste discharges to accept PAYT and in the waste fees that they are willing to pay for it. We divides the base samples into high and low waste discharge groups, according to the daily output of household waste, and find (see Table 4) that the difference in the willingness to accept PAYT between the high and low waste discharge groups is 0.065. The difference in the treatment fee payments is 0.555. The high waste discharge group is significantly more willing to accept PAYT and pay the waste fees for it than is the low waste discharge group, which is inconsistent with the general understanding. The Oaxaca-Blinder decomposition method (Oaxaca 1973; Blinder 1973) is used to decompose and analyze the causes of the gap from two

**TABLE 4 Oaxaca-blinder decomposition results of high-low waste discharge groups.**

| | Overall differences of high-low waste Discharge groups | |
|---|---|---|
| | exchange | lnwtp |
| Average of high waste discharge group | 0.577 | 4.348 |
| Average of low waste discharge group | 0.512 | 3.792 |
| Difference between high and low waste discharge groups | 0.065 | 0.555 |

| | Oaxaca-Blinder Decomposition of High-Low Waste Discharge Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Endowment effect | | Coefficient effect | | Endowment effect | | Coefficient effect | |
| | Coefficient | Std. error | Coefficient | Std. error | Coefficient | Std. error | Coefficient | Std. error |
| comfort | −0.003 | 0.003 | −0.223* | 0.14 | −0.014 | 0.013 | 0.190 | 0.412 |
| sati | 0.002 | 0.004 | 0.214** | 0.095 | −0.003 | 0.007 | 0.117 | 0.302 |
| atti | 0.001 | 0.002 | −0.048 | 0.086 | −0.002 | 0.005 | −0.021 | 0.258 |
| comply | 0.006 | 0.004 | −0.104 | 0.094 | 0.003 | 0.006 | −0.087 | 0.298 |
| exert | 0.001 | 0.002 | −0.030 | 0.067 | 0.000 | 0.002 | 0.200 | 0.210 |
| force | 0.000 | 0.000 | −0.001 | 0.015 | 0.001 | 0.009 | 0.062 | 0.052 |
| know | 0.001 | 0.002 | 0.126 | 0.113 | −0.002 | 0.005 | −0.083 | 0.379 |
| faci | 0.000 | 0.002 | −0.000 | 0.022 | −0.004 | 0.009 | 0.036 | 0.069 |
| lnfamincome | 0.003 | 0.003 | −0.265 | 0.322 | 0.021 | 0.015 | 1.147 | 1.037 |
| familysize | 0.001 | 0.001 | 0.082 | 0.105 | −0.014 | 0.013 | 1.167*** | 0.370 |
| gender | 0.001 | 0.003 | 0.247 | 0.088 | −0.006 | 0.008 | 0.132 | 0.283 |
| age | −0.004 | 0.005 | 0.045 | 0.076 | −0.022 | 0.018 | −0.573** | 0.246 |
| education | −0.001 | 0.003 | 0.246* | 0.246 | 0.013 | 0.013 | 0.321 | 0.448 |
| health | 0.002 | 0.003 | 0.183** | 0.075 | −0.007 | 0.009 | 0.419* | 0.252 |

aspects: the endowment effect and the coefficient effect. Based on the decomposition results, none of the variables has a significant endowment effect on the difference in the willingness to accept PAYT and the difference in the willingness to pay the waste fees for it. This indicates that there is no difference in the level of behavioral attitudes, subjective norms, perceived behavioral control, and socioeconomic characteristics between the two groups of residents, nor is it the cause of the gap. Further analysis shows that the sum of the positive and negative coefficient effects is positive, and the coefficient effect of comfort on the willingness to accept PAYT is significantly negative, while the coefficient effects of sati, education, and health are significantly positive. This indicates that households in the high-discharge group are more willing to accept the PAYT charging model because of their sensitivity to changes in sati, education, and health. The total coefficient effect of the difference in the waste fees between the high- and low-waste discharge groups willing to pay is significantly positive, indicating that households in the high-discharge group are more sensitive to changes in family size and physical condition; therefore, they are willing to pay more waste treatment fees. Specifically, the coefficient effect of family size and health on the difference in residents' willingness to pay waste fees is significantly positive, whereas the coefficient effect of age is significantly negative.

## 5 Conclusion and policy implication

Pay-as-you-throw (PAYT) is considered an effective way to encourage residents to reduce waste and improve resource utilization efficiency. China is attempting to transition from a traditional fixed-fee charging model to PAYT. Based on the data of 1,346 survey questionnaires of urban residents in the Beijing-Tianjin-Hebei region, this study analyzes the willingness of urban residents to accept the PAYT charging model and the behavioral intention of the waste fees they are willing to pay under the framework of the theory of planned behavior. The results of the survey indicate that 59.06% of households generate an average of 2.5–7.5 L in domestic waste per day. The proportion of residents who are willing to accept the PAYT charging model is only 54.53%, indicating a low degree of acceptance. Residents who accept the PAYT charging model are willing to pay an average annual fee of

58.616 yuan to improve the efficiency of waste disposal and the living environment, which is relatively low. This study uses a probit model to analyze the willingness of urban residents to accept PAYT and an OLS model to analyze the factors influencing their willingness to pay waste fees. Behavioral attitudes, social norms, and perceived behavior control factors are all found to affect residents' willingness to accept PAYT, while income and education levels are the main factors affecting the waste fees that residents are willing to pay. In addition, the Oaxaca-Blinder decomposition results for households with different waste discharges reveals that the difference in the willingness to accept PAYT between the high-low waste discharge groups is 0.065, and the difference in the payment of waste recycling fees is 0.555, presenting a relatively obvious gap. Behavioral attitudes, subjective norms, perceived behavioral control, and levels of economic and social characteristics do not differ among residents, nor are they the causes of these gaps. Households in the high-discharge group are more sensitive to changes in sati, education, and health, and thus accept the PAYT charging model more willingly. At the same time, households in the high-discharge group are more sensitive to family size and health, which explains the gap between the high-low waste discharge groups in terms of willingness to accept PAYT and willingness to pay waste recycling fees.

Based on the above conclusions, this study proposes four suggestions to improve residents' willingness to accept the PAYT charging model and the waste fee they are willing to pay for it.

First, promote residents to establish the correct environmental concept and a sense of ownership of environmental governance through publicity and education. Second, strengthen the publicity of the PAYT charging model and enhance residents' understanding of waste recycling and disposal. Third, improve community residents' awareness regarding abiding by the rules for waste charging. Fourth, increase the amount of waste metering charges for residents steadily, in line with the levels of economic development and family education.

It must be admitted that this paper is just an initial study on the acceptance and paying willingness of residents to PAYT charging model in China, so several limitations exist. For instance, we only conduct surveys on the urban residents in the Beijing-Tianjin-Hebei region. and future research can incorporate more cities into the research framework. With the deepening of research and the implementation of policies, more cities will be included in the analytical framework in the future.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Author contributions

WY: Conceptualization, Formal Analysis, Methodology, Writing–review and editing. XZ: Investigation, Methodology, Software, Writing–original draft.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2023.1263565/full#supplementary-material

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