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Pollution, Happiness and Willingness to Pay Taxes: The Value Effect of Public Environmental Policies

Zanieczyszczenie, szczęście i chęć płacenia podatków: efekt wartości w ramach publicznych polityk ekologicznych

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Abstract

As China's economic development pattern is marked by an excessive consumption of fossil fuels, environmental pollution problems in China are getting increasingly serious and threatening residents' fundamental demands for a high quality of life. It has become a handicap to sustainable economic development and social well-being. In this paper, the happiness index method were used, and models depicting the relationship between residents' sense of happiness and environmental pollution factors and between the willingness to pay taxes and environmental pollution factors have been established. The results show that environmental pollution, especially air pollution, significantly affects the residents' sense of happiness. To improve residential environment quality and reduce pollution, residents are willing to pay the relevant taxes. If pollution control is considered a public policy, there exists a substantive weight of government between residents' income and environmental quality. This will influence the choice of environmental public policy.

Key words: environmental pollution, sense of happiness, Willingness to Pay Taxes, public policy

Streszczenie

Rozwój ekonomiczny Chin powiązany jest z nadmiernym zużywaniem paliw kopalnych, a zanieczyszczenia środowiska osiągają poziom, który stanowi zagrożenie dla oczekiwanego przez obywateli wysokiego poziomu życia. Stało się to przeszkodą dla zrównoważonego rozwoju gospodarczego i dobrobytu społecznego. W niniejszym opracowaniu wykorzystano metodę wskaźnika szczęścia. Opracowano modele obrazujące związek między poczuciem szczęścia mieszkańców a zanieczyszczeniami środowiska oraz między chęcią płacenia podatków a czynnikami zanieczyszczenia środowiska. Wyniki pokazują, że zanieczyszczenie środowiska, w szczególności zanieczyszczenie powietrza, znacząco wpływa na poczucie szczęścia mieszkańców. Aby poprawić jakość środowiska mieszkańców i zmniejszyć zanieczyszczenie, obywatele są skłonni zapłacić odpowiednie podatki. Jeżeli kontrola zanieczyszczeń jest uważana za politykę publiczną, rząd odgrywa istotną rolę w kształtowaniu relacji między dochodami mieszkańców a jakością środowiska. Wpłynie to bowiem na wybór polityki publicznej dotyczącej środowiska.

Słowa kluczowe: zanieczyszczenia środowiska, poczucie szczęścia, podatki oparte na gotowości do zapłaty, polityka publiczna

1. Introduction

In the 30 years since reforms and opening-up policies were implemented in China, fossil fuel consumption has become the main route for the economic development. While the energy-based economic pattern brought rapid development, it also increased environmental pollution, thus causing environmental deterioration. The pollution problem has become a major hurdle to the sustainable economic and social development of China. According to World Bank data, the annual economic losses caused by air and water pollution in China range from 8% to 12% of GDP (Zhang et al., 2009). Fu Miao and Huang Zhuoming (2008) analysed the relationship between China's economic development phase and environmental pollution. Their findings suggested that the conflict between economic development and environmental deterioration is increasingly serious and the pollution problem must be solved in the early phase of industrialization. In addition, a good ecological environment is an essential condition for survival and a sense of happiness. However, environmental pollution threatens the most fundamental factors that ensure a high quality of life for Chinese residents. In China, 86% residents believe that environmental pollution significantly harms their health. Hence, environmental pollution has become a major issue hindering economic development and improvement of social well-being in China. Therefore, formulating effective environmental public policies, assessing the effects of such policies and addressing environmental pollution problems are the need of the hour.

Considering that environmental pollution is a negative externality, both the neoclassical and institutional economic theories suggest that the external costs of an enterprise should be internalised, the use of environmental resources should be linked with economic benefits and pollution control should be market-based. According to the Pigovian tax theory, if a producer causing a negative externality is taxed at the rate equal to the value of the negative externality, his private cost will rise in accordance with the social cost. In this case, the profit maximization principle will enable the producer to limit his output level to the level where the price is equal to the marginal social cost, and this is the condition for effective allocation of resources (Pigou, 1932). Xiaoying Zhang and Jinwen Zhong (2011) pointed out that the carbon tax, as a Pigovian tax, can reduce CO_2 emissions. It may impede economic growth in the short run, but it is beneficial for the sustainable development of the economy in the long run. Xiangju Li and Na He (2017) found that under the fiscal decentralization, the environment tax burden exerted positive influence on the environment pollution, but less elastic. Meanwhile, the level of tax collection and administration had negative influence on the environmental pollution. According to the Coase theorem, when transaction costs are very low or zero, no matter how property rights are distributed, the market can solve the externality problem such that the emission of pollutants is controlled. When the transaction cost is not zero or very high, different allocations of rights may result in resource configurations with different efficiencies. Therefore, it is important to clarify property rights and determine a property rights system (Coase, 1960). The Coase theorem provides two pollution control measures. The first measure is environmental governance or emission standards, where the government specifies statutory restrictions to the emission of pollutants. If enterprises exceed these restrictions, they will face severe economic and legal penalties. Zhengge Tu and Xiao Geng (2009) estimated China's environmental efficiency based on the industrial statistics of 30 provinces in China from 1998 to 2005 by using the directional distance function. The result showed that environmental total factor productivity (ETFP) has become the core driving force for high industrial growth and pollution reduction in China. Environmental governance has not substantially impeded industrial growth. Neng Shen (2012) assessed the influence of environmental governance on the growth of productivity based on China's two-digit industrial data by using the regression analysis method. The result showed that environmental governance based on pollution control cost reduces the productivity of pollution-intensive industries in the short run but increases it in the long run. The second measure is the emission rights system, where the government issues pollution permits to enterprises. The number of pollution permits is determined by the amount of pollution, considering a socially optimum level of pollution. The permits are distributed among enterprises and only the enterprises holding these permits are entitled to discharge pollutants. The amount of pollutants they discharge should not exceed the number of permits they have; otherwise, they will face severe punishment. Stavins (1995) and Abeygunawaredna (2000) pointed out that the emission rights system can reduce the environmental pollution at the minimum social cost and is thus a useful way to control environmental pollution using a market-based method. In addition, seeking new environmental innovations to reduce emissions at their source is also a solution. Malin Song and Shuhong Wang (2013) shows that a reliable solution can result from transferring the advanced environmental protection technologies from East China to Central and West China and strengthen the environmental governance of the central and western provinces. Jinzhen Ye and Husen An (2017) found that three conclusions: first, the environmental tax that was in the market-oriented reasonable rate would have positive influence both on controlling environmental pollution and maintaining steady growth of welfare. Second, the polluting industries would transfer with the regional differentiated environmental tax policy. However, the national united

policy had a better impact than the regional policy in the long time. Third, administrative intervention that was unreasonable would decrease the positive influence of environmental tax.

The above public environmental policies solve environmental pollution problems by *commanding and controlling* enterprises to use state-of-the-art environmental protection technologies, or by internalizing the external costs of enterprises through taxation and emissions trading. These studies focus on the economic value effect of public environmental policies, but they do not analyse the social value effect of public environmental policies. Studies showing the benefits of environmental pollution control policies on social well-being are lacking. Furthermore, the operability of the above method is restricted, and the actual effect of environmental pollution control is not obvious. The paper argues that government, enterprises and individuals are the stakeholders in environmental pollution and in pollution control policies. Therefore, a rational and effective assessment of the value effect of environmental pollution, assigning the environmental protection responsibilities of every party concerned, are the pr-econdition and basis for the government to formulate public environmental policies. In this study, the happiness index method is introduced to assess the value effect of public environmental policies on a personal level and explore the microcosmic foundation for the control of pollution. This is different from the existing studies in which pollution control is studied from the point of view of government or enterprises.

The happiness index method is a new assessment method based on a happiness survey. Easterlin (1974) introduced the subjective psychological indicator, happiness, into economic research as a method for pricing public goods. According to the understanding of happiness by the New Economics Foundation, environment is one of the three factors that affect the sense of happiness of residents, and environmental pollution has a significant impact on the sense of happiness (New Economic Foundation, 2017). On one hand, residents' sense of happiness directly reflects on environmental quality. On the other hand, environmental quality may affect health, and thus human capital, income and the sense of happiness. Welsh and Kühling (2009) state that many factors exert more influence on residents' sense of happiness, and environmental pollution is one of them. Studies reported that noise (Van Praag and Baarsma, 2005), climate (Rehdanz and Maddison, 2005), natural disasters (Luechinger and Raschky, 2009) and other environment problems considerably affect residents' sense of happiness. According to a survey of Chinese residents, 67.9% of respondents think that environmental protection is closely related to an individual's sense of happiness, and 82.3% of respondents are willing to pay environmental protection fees. This suggests that Chinese residents are strongly aware of environmental protection, and environment quality has become a major factor in their sense of happiness. In this study, China's 1994–2012 data from WVS are used to establish a model depicting the relation between residents' sense of happiness and environmental pollution factors. A relationship model of environmental pollution and residents' willingness to pay environmental taxes is also established to investigate whether residents are willing to pay taxes for pollution control. Finally, building a relational model of objective indexes between happiness and environmental pollution can enable an indirect evaluation (as a monetary value of public goods) of the tax price that residents are willing to pay for reducing environmental pollution.

2. Literature review

It was Welsch (2002) who first proposed that air pollution caused by lead and NO_2 emissions has a measurable influence on the subjective sense of happiness of residents, and the improvement in air quality has substantial monetary value. Welsch (2005) further investigated how the individuals' subjective well-being scale varies with wealth and environmental conditions in ten European countries. Reducing lead and NO_2 emissions would bring monetary value of $1400 and $750 per capita respectively every year. There is synergy among different pollutants. Debra Israel and Arik Levinson (2003) found that different pollutants may have different degrees of influence on residents' sense of happiness. More specifically, the sense of happiness declines with an increase in water pollution per capita but is not closely related to Total Suspended Particulates (TSP) in air. Susana Ferreira et al. (2006) estimated that Irish residents are willing to pay €1100 to reduce PM10 by one unit. Katrin Rehdanz and David Maddison (2007) surveyed the influence of air pollution and noise pollution on residents and found that residents' subjective well-being scale declines with increase of air pollution and noise pollution levels when other relevant factors remain constant. Russell Smyth (2008) showed that when air pollution changes by 1%, individuals' subjective well-being scale moves up or down by one grade on the five-point well-being assessment table. The influence of air pollution is the greatest among all the environmental pollution variables. Di Tella and MacCulloch (2008) found that the suffering of American residents as a result of increases of SO_2 emissions by one unit is equivalent to a reduction of total income by 17%. Simon Luechinger (2009) estimated that German residents are willing to pay €183 to €313 to reduce SO_2 concentration per capita each year. George MacKerron and Susana Mourato (2009) estimated that whenever the NO_2 concentration in air in London, UK rises by $10ug/m^3$, the life satisfaction score declines about 0.5 (the full score is 11). Marconi (2010) pointed out that solely adopting

an environmental protection tax policy may accelerate technical modification but slow down the reduction of pollution. Tobias Menz noticed (2011) that health disorders caused by suspended particles were emerging. Residents may be, to some extent, accustomed to the local air pollution, so the level of pollution may be underestimated. According to the unbalanced datasets of 48 countries from 1999 to 2006, he found that the previous pollution level significantly lowered the current life satisfaction score. However, the emerging PM10-related diseases exceeded the possible habitual effect, and control of the past pollution increased the value coefficient of clean air by approximately 2.5. Arik Levinson (2012) established a measurement model between residents' sense of happiness and the logarithms of PM10 and resident income based on the air pollution problems in USA. By using the OLS estimation method and marginal rate of substitution theory, it was estimated that whenever the air pollution rises by one unit, the resultant negative effect on the American residents' sense of happiness is equivalent to an annual average income reduction of $459-$1.26 every day. Zhangtao Li, Henk Folmer and Jianhong Xue (2014) studied the residents in the Jinchuan region. They indicated that residents' happiness was more influenced by atmospheric pollution, and measures should be immediately taken to reduce atmospheric pollution. Rong Tingting and Zhao Zheng (2015) studied the residents in the Long River Delta region. They indicated that residents' happiness was more influenced by the regional environment, age and education levels. They suggested that the government should implement green environmental protection measures. Since the 1970s, economic studies have focused on the relationship between wealth and happiness. The existing foreign literature shows that residents' sense of happiness is closely related to environmental quality. Assessment of the value of pollution control by using the happiness index method has great theoretical and practical significance. It not only quantifies the economic value of environmental pollution but also provides options for pollution control. The Chinese literature in this field has the following two short points: 1. previous studies only focused on the influence of pollution control on the economy, and Chinese scholars did not pay sufficient attention to the relationship between environmental quality and a sense of happiness.

Like, Qingquan Fan et al. (2016) found that the dynamic environmental tax policy had two benefits. First, increasing the tax ensured economic growth and protecting environment. Second, the tax could maximize the social welfare on the saddle path. Government should choose the optimum timing to levy the dynamic environmental tax, which was same with the timing of environmental pollution increasing. Pu Liao and Sujin Zheng (2016) studied the environmental tax with considering the relationships between environment and life expectancy, and issuing an optimal environmental tax which have given consideration to the dual benefits of reducing environmental pollution and economic growth. Hongyou Lu and Yunchan Zhu (2017) found that the current environmental tax and fee policies in China exerted little influence on reducing environmental pollution, but these policies had better influence on economic transformation and upgrade of industrial structure. Hong Li and Zhenxing Xiong (2017) used CGE model to study the policies of levying environmental tax and decreasing enterprise and individual income tax policies in eastern, central and western regions, and found that the environmental tax burden would exert negative influence on the use of natural resources and energy resources, not the cleaning inputs such as capital and labor. They suggested that the environmental tax had a good effect on restraining ecological excess occupation. They also suggested that the environmental tax rate should be less than 5%, and the corresponding tax revenue should be used to reduce enterprise and individual income tax in the same proportion, thus accelerating the transfer of economic development motivation to capital and labor elements.

2. Previous studies maintained a normative analysis level, but empirical studies based on actual data are lacking, especially studies that use economic methods to assess the relationship between environmental pollution and a sense of happiness and environmental tax policies. Like Shan Ye (2016) found that owing to the increasing economic cost of dealing with the pollutant, taxpayers of the environmental tax had less motivation to use excess energies and nature resources. Therefore, the environmental tax might attain the better effect of prohibition. She also issued the criterion to whether the design of the environmental tax burden was rational. This criterion was that whether taxpayers were more tend to induce environment-friendly techniques and high-technique for tax-cost reason. Revenues from the environmental tax she issued belonged to local governments and divided between the provincial government and city-level government and county-level government at a fixed ratio. Ming Su et al. (2016) found that three conclusions: first, the revenue from environmental tax should be shared between central government and local government as a shared tax, not be allocated to local governments as a local tax. Second, the revenue from environmental tax should be induced into the general public budget, not be earmarked. Third, the county government was the major for the implementation of the environmental tax policy. Therefore, they proposed that the county-level government should have a good guarantee of the fiscal expenditure, if the county-level government wanted to handle the environmental protection well. Hongyou Lu et al. (2017) studied the relationship between the preferential tax policy in enterprise income tax and corporates in polluting industries, and found that preferential tax policies had little

influence on corporates in polluting industries to invest the green production.

In this paper, environmental pollution control is treated as a public policy. Models depicting a relationship between pollution control and sense of happiness and between pollution control and willingness to pay environmental taxes are established, and Order-Logit, Order-Probit and FGLS measurement analyses of a series of data are performed. On the one hand, the associated relationship between water pollution, atmospheric pollution and happiness is clear and definite. In particular, a detailed analysis of all kinds of pollution sources is conducted so that the effect, degree, source and manner of environmental pollution on residents' happiness can be established. On the other hand, according to the measurement and analysis results of the relationship between pollution control and residents' willingness to pay environmental taxes, a substantial balance between government taxation and environmental quality improvement is found. The value effect of public environmental policies is assessed, breaking through the bottleneck that emission and pollution reduction only rely on government or enterprises. Effective and practical public environmental control policies are proposed.

3. Analytic framework

3.1 Model setup: relationship of subjective indexes among happiness, Willingness to Pay Tax and environmental pollution

A sense of happiness refers to the residents' subjective feeling for their external living environment, their economic condition and their social condition. Environmental pollution considerably affects residents' external living environment and social condition and thus affects their sense of happiness. Guided by this factor, we further investigated whether the residents were willing to pay the corresponding taxes for the prevention and treatment of environmental pollution so as to pursue more happiness. In this paper, subjective and objective indexes are the ordinal and categorical data. Therefore, the Ordered Choice Model (OCM) is adopted in this paper to estimate the relationships among happiness, willingness to pay tax and the subjective and objective evaluations of environmental pollution, whereas the subjective and objective evaluations of environmental pollution are taken as criteria to calculate the price residents are willing to pay for environmental protection. The model details are set as follow:

$$H_{ijt}^{*} = \alpha P_{jt} + \beta Y_t + \gamma X_{ijt} + j^{*} + \varepsilon_{jt} \quad (1)$$

$$U_{ijt}^{*} = \mu P_{jt} + \vartheta X_{ijt} + \sigma_{jt} \quad (2)$$

where H_{ijt}^{*} is the happiness of resident i in region j at time t and has four values 1, 2, 3 and 4, from low to high. U_{ijt}^{*} is the willingness of resident i in region j to pay taxes for the prevention and treatment of environmental pollution and has four values 1, 2, 3 and 4, from low to high. P_{jt} shows each index of environmental pollution in region j at time t. It mainly includes the subjective perceptions of residents on the aspects of pollution, as well as some observable objective indexes of atmospheric pollution, which mainly include a comprehensive index of atmospheric pollution and emission concentration levels for the main pollutants such as PM10 NO_2 etc.[1] Y_t means residents' income levels, which are valued by four values 1, 2, 3 and 4, from low to high. X_{ijt} expresses the control variable, which mainly controls the influence of residents' personalities and emotional characteristics on their decisions. Individual characteristics include age, gender, degree of education, health condition, employment, religious beliefs, marital status, number of children and resident region size. Emotional characteristics include the residents' satisfaction with their recent family life and family property, as well as their freedom and control in decision making. ε_{jt} and σ_{jt} are independent, identically distributed random variables. Meanwhile, the regional effect is controlled in this paper's model, which is expressed as j^{*}.

Two estimation methods, Order Probit and Ordered Logit, will be adopted to estimate the different models. Furthermore, in the model of happiness, the tax payment price of residents for the prevention and treatment of environmental pollution under the subjective data will calculated as the partial derivative of income and the environmental pollution index. The calculation formula is as follows:

$$\frac{\partial y}{\partial p}\Big|_{dH=0} = \frac{\partial\left(\frac{dH}{dY}\right)}{\partial\left(\frac{dH}{dP}\right)} = -\frac{\alpha_{jt}}{\beta_t}$$

3.2 Model setup: relation between Sense of Happiness and Environmental Pollution

About the relation model between happiness and atmospheric pollution, this paper will refer to Arik Levinson (2012) to set the model as $H_{ijt}^{*} = \tau P_{jt} + \varphi LnY_t + \omega X_{ijt} + j^{*} + \delta_{jt}$ (the corresponding esti

[1]In estimating the model details, P_{jt} in Model (1) respectively means the subjective perceptions of residents on atmospheric pollution, water pollution etc, namely, Models 1–4 in Table 2. P_{jt} in Model 2 separately means the subjective perceptions of residents on atmospheric pollution, water pollution etc., namely, Models 1–4 in Table 3. In addition, it is pointed out in the paper that P_{jt} in Model (1) also means the objective indexes of some atmospheric pollutants. Since their data types are the order type, the order will still be adopted to choose the models, namely, the two models of 2001 and 2007 in Table 4. Due to length limitations, and to reduce the tedious degree of text representation, only the basic model is shown in this paper and the sub-model set is introduced in the footnotes.

mated results of this model is the model of 2012 in Table 4)[2]. Inside, P_{jt} expresses the atmospheric pollution index of region j at time t, which mainly means the emission concentrations of main pollutants, such as PM10, NO_2 etc. in units of ug/m^3. Y_t means the income level of residents. Due to the unavailability of data, the annual average disposable income of region is taken as the substitute variable in this paper. δ_{jt} is an independent, identically distributed random variable. The variable sets of H^*_{ijt}, X_{ijt} and $j^*$are the same as those above.

Furthermore, the tax payment price of residents for the prevention and treatment of environmental pollution under the objective data will be worked out by calculating the partial derivative of income and environmental pollution index. The calculation formula is $\frac{\partial Y}{\partial P}|_{dH=0} = -Y\frac{\tau}{\varphi}$. In this paper, the FGLS method will be adopted to estimate the model.

4. Empirical analysis

4.1 Specifications of variables and data

The data used in this paper are from the World Values Survey (WVS) on China and the China Environmental Statistics Yearbook. The WVS recorded the survey data on Chinese values across the last three time waves, namely, 1999-2004, 2005-2007 and 2010-2014. The sample year of the first wave is 2001, the second is 2007, and the third is 2012. The number of respondents in the first wave is 1000, the second is 1991, and the third is 2300. In combination with the relevant environmental pollution indexes from the China Environmental Statistics Yearbook, there are 24 variables across three years (2001, 2007 and 2012), which constitute the pooled cross-sectional data of the study (see table 1).

4.1.1 Choice of explained variables

In response to the needs of the model setting, this paper will select happiness and WTP environmental tax as the two variables to be explained.

Happiness is a subjective feeling that is difficult to quantify. Therefore, WVS used the question *Taking all things together, would you say you are happy or not?* to measure the residents' happiness. WVS required respondents to use a four-item scale to state their unhappiness or happiness level (1= not at all happy, 2 = not very happy, 3 = rather happy, 4 = very happy). The residents' willingness to pay for environmental protection can be measured by their WTP environmental tax. WVS designed a four-item scale to assess residents' willingness level (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree).

4.1.2 Choice of explanatory variable

Choice of independent variables

The income variable is an important factor influencing residents' happiness. It mainly includes two indexes: the level of residents' income, which is set by four levels, and residents' disposable income. As there were no specific income data available in WVS, this study used the per capital disposable income level in districts where the respondents live in as a substitute for the income variable.

The environment variable has two dimensions; namely, the subjective variables and objective variables. The subjective variables encompass residents' subjective feeling and comments on the water and air pollution. They have four options: not serious at all, not very serious, somewhat serious and very serious, respectively, evaluated as 1, 2, 3 and 4. Objective variables are mainly derived from the air pollution index, including the air pollution index of our country's cities as well as the annual average concentration and pollution index of main air pollutants. Data are mainly from *The Environmental Statistics Yearbook of China* (2001, 2007, 2012). According to the WVS data, environmental monitoring points where the surveyed population live can be determined and air quality data can be collected according to the surveyed years. Meanwhile, since the short-term change of atmospheric environment is not sufficient to draw attention, the happiness and willingness to pay tax will not be greatly changed. Therefore, the annual report data for each environmental monitoring point are used as the environmental pollution index in this paper.

Choice of control variables

Happiness is a subjective sensation largely influenced by the individual characteristics of residents. If the real relation among environmental pollution, happiness and willingness to pay environmental taxes is going to be investigated, then the effects of some factors must be controlled. These factors mainly include residents' individual personality characteristics. Inside, individual characteristics mainly mean age, gender, education level, health status, employment status, religious belief, marital status, number of children and regional size. The personality characteristics are mainly emotional characteristics. In this paper, three variables will be chosen to express the emotional characteristics of residents: the happiness of residents with their recent family life, happiness with family property and the degree of freedom and control residents have in decision making.

[2] The corresponding estimated results of this model is the model of 2012 in Table 4.

On the treatment of age data, in this paper, the ages of respondents provided by the WVS are classified as youth (18-40) middle age (41-60) and old age (over 60 years), with assigned values of 1, 2 and 3, respectively.

On the treatment of gender data, female respondents are denoted by 0 and males by 1.

On the treatment of education level data, respondents are assigned a value of 1, 2, 3 or 4, respectively, for non-education, primary school, junior-senior high school and university.

Health data are categorised as poor health, not too healthy, healthy and very healthy, with assigned values of 1 to 4, respectively.

On the treatment of WVS employment data, two indexes of 1 and 0 are set, respectively, for employment and unemployment. Inside, employment status includes full-time job, part-time job, self-employment and retirement. The unemployment status includes unemployment, housewife, student and others. In this paper, we classify the retirees as employed since the psychological states of respondents are mainly considered here. Because they normally have their retirement pay or subsidies, the psychological states of retirees in China are more tended to the employed persons and are different than the psychological states of real unemployed persons.

On the treatment of religious beliefs, three classes are ordered from 1 to 3, respectively, as atheist, non-religious but theist and religious.

On the treatment of marital data, two indexes are set as single (0) and married (1). In the WVS data, single means the individual resident status of respondent, which includes unmarried, divorced and widowed, whereas married includes married and cohabitating with the goal of marriage.

On the treatment of the number of children, data are ordered and valued 1 to 4, respectively, for no child, one child, 2-3 children and more than 4 children.

On the treatment of regional size where the respondent lives, two indexes are set for regions larger than 50,000 m^2 (1) and regions less than 50,000 m^2 (0).

WVS data for satisfaction degree of respondent with the recent family life and family property are assigned a value of 1 to 4, respectively, for very dissatisfied, dissatisfied, satisfied and very satisfied. The two indexes indicate residents' satisfaction with family life and family property in the last year. They can be regarded as the first-lagged variables of two factors that influence happiness and can be taken as the control variables of residents' emotional characteristics.

In addition, it is also important to measure the personality characteristics of residents and the degree to which they can independently judge or choose something, which is further ordered from low to high and assigned values of 1 to 4, respectively.

4.2 Empirical results

4.2.1 Relation analysis between happiness and Subjective Index of Environmental Pollution

Two subjective feeling indexes for environmental pollution are chosen in this paper: subjective perceptions on the degree of atmospheric pollution and of water pollution. According to the basic model between happiness and the subjective index of environmental pollution, two models waiting for estimation are set in this paper. They are shown as the vertical number sequence in Table 2. The parameter estimation results of models are expressed as the crosswise sequence of numbers in Table 2. The results under the Order-Probit estimation method show that first, a reverse relation appears between residents' perceptions of atmospheric pollution and their happiness. When the subjective perception of residents on atmospheric pollution goes up by one unit, the probability of happiness dropped down will be 0.095. Second, a reverse relation appears between residents' perceptions of water pollution and their happiness. When the subjective perception of residents on water pollution is higher, the probability of happiness decreases to 0.042; however, the results are not very significant.

A significant correlation appears between the variables of income level, health condition, marital status, A significant correlation appears between the variables of income level, health condition, marital status, age, happiness of residents with their family life status and satisfaction degree of residents with their family property and the happiness of residents. Inside, there exists a significant positive correlation between income level and happiness. When the income level is increased by one unit, the probability that the happiness of residents will be raised with the increased income level is 0.14. A significant positive correlation appears between health status and happiness. When the health status is increased by one unit, the probability that the happiness of residents will be raised with increased health status is 0.43. There exists a significant positive correlation between marital status and happiness, namely, the perception of happiness for married residents is higher than that of single ones. A positive correlation appears between age and residents' happiness, namely, the older the respondent the happier they feel. The higher the degree of satisfaction with family life the happier they feel. The reaction coefficient between both is 0.47. The higher the degree of satisfaction with the family property status the happier they feel. The reaction coefficient between both is 0.21. The influences of gender, the ability of free choice, employment status and degree of education on happiness all fail the significance test. This shows there is no significant correlation between each of these factors and happiness.

Table 1. Explanation of Variables, source: WVS Database; China Environment Statistics Yearbooks; CEInet Statistics Database.

Depended variables				
Happiness	Not at all happy, 1	Not very happy, 2	Rather happy, 3	Very happy, 4
Pay to environment: income	Disagree strongly, 1	Disagree, 2	Agree, 3	Agree strongly, 4
Independed variables				
Poor water quality	Not serious at all, 1	Not very serious, 2	Somewhat serious, 3	Very serious, 4
Poor air quality	Not serious at all, 1	Not very serious, 2	Somewhat serious, 3	Very serious, 4
Scale of incomes	Lowest, 1	Second, 2	Third, 3	Highest, 4
Control variables: Individual characteristics				
Age	18-40, 1	41-60, 2	>60, 3	
Gender	Female, 0		Male, 1	
Education	No formal school, 1	Primary, 2	Secondary and high, 3	University & above, 4
Health state	Poor, 1	Fair, 2	Good, 3	Very good, 4
employment	No, 0		Yes, 1	
Size of town	Small(< 50000), 0		Big(≥ 50000), 1	
Children number	None, 1	One, 2	Two and Three, 3	Four and more, 4
Marital status	Single, 0		Married, 1	
Religious denomination	Atheist, 1	No religious, 2	Religious, 3	
Control variables: Emotional characteristics				
How satisfied with your life	Dissatisfied strongly, 1	Dissatisfied, 2	Satisfied, 3	Satisfied strongly, 4
How satisfied with financial situation	Dissatisfied strongly, 1	Dissatisfied, 2	Satisfied, 3	Satisfied strongly, 4
Freedom of choice	None, 1	Second, 2	Third, 3	Highest, 4
Real air pollution variables and the income variable				
	Year	Mean	Min	Max
PM10 density(ug/m^3)	2012	93	60	136
NO_2 density(ug/m^3)	2012	42	26	54
PM10 index	2007	1.39	1	2
NO_2 index	2007	2.43	1	3
Air pollution index	2007,2001	2.29	0.73	3.65
Income(Ln-value)	2012	10.06	9.75	10.6

Table 2. Evaluation Results of Relation Model between Happiness and the Subjective Index of Environmental Pollution (according to the availability and integrity of data, the estimated results in Tables 2 and 3 are obtained from the related data in 2007).

	Order-Probit		Order-Logit	
	Model 1	Model 2	Model 1	Model 2
Air pollution	-0.095***(0.041)		-0.16***(0.075)	
Water pollution		-0.042(0.038)		-0.077(0.067)
Control variables				
Health	0.43***(0.04)	0.427***(0.036)	0.79***(0.07)	0.78***(0.07)
Marital status	0.24***(0.1)	0.21***(0.1)	0.35***(0.11)	0.32*(0.18)
Freedom of choice	0.1** (0.044)	0.12**(0.044)	0.18** (0.08)	0.2**(0.08)
Life satisfied	0.47***(0.053)	0.48***(0.053)	0.88***(0.1)	0.89***(0.1)
Finance satisfied	0.21***(0.049)	0.21***(0.049)	0.37***(0.1)	0.36***(0.1)
Gender	-0.11(0.072)	-0.12*(0.072)	-0.16(0.13)	-0.17(0.13)
Age	0.15*** (0.059)	0.15*** (0.058)	0.29***(0.1)	0.29***(0.1)
Education	0.072(0.051)	0.067(0.05)	0.11(0.09)	0.11(0.1)
employment	-0.01(0.097)	0.01(0.06)	-0.02(0.097)	0.004(0.17)
Income scale	0.14**(0.057)	0.14***(0.057)	0.21**(0.1)	0.2**(0.1)
religious	0.02(0.58)	0.02(0.58)	0.02(0.1)	0.01(0.1)
Area effect	controlled	controlled	controlled	controlled
Obs	1301	1297	1301	1297
LR chi2	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0
Pseudo R^2	0.252	0.25	0.255	0.257

Standard errors in parentheses * P<0.1, ** P<0.05, *** P<0.01

Meanwhile, the robustness test is carried through for the results of models. The Order-Logit method is utilised to carry through the parameter estimation again for the two models which are awaiting estimation. It is found that the estimated coefficient results of Order-Logit method are in accordance with the results of Order-Probit method. This shows that the results obtained in this paper are robust.

4.2.2 Relation analysis between Willingness to Pay Tax and the Subjective Index of Environmental Pollution

According to the basic model between willingness to pay tax and the subjective index of environmental pollution, atmospheric and water pollution are still taken as the study objects to set two models for estimation. They are shown as the vertical number sequence in Table 3, whereas the parameter estimation results of two subjective index models are expressed as the crosswise number sequence in Table 3. The results show that under the Order-Probit estimation method, a positive correlation exists between residents' perceptions of atmospheric and water pollution and their willingness to pay environmental tax. Inside, when the perception of residents on atmospheric pollution goes up by one unit, the probability that the residents are willing to pay the treatment taxes for the pollution will be 0.05. When residents' perceptions of water pollution are increased by one unit, the probability that the residents are willing to pay the treatment taxes for the pollution will be 0.086.

As for the control variables, there exists a positive correlation between the two variables of life satisfaction and ability of free choice and the willingness to pay environmental tax. The results show that the higher the degree of life satisfaction the more willing the resident is to pay the tax for environmental pollution treatment. The stronger the residents' ability for free choice the more willing the resident is to pay the tax for environmental pollution treatment.

Meanwhile, the robustness test is carried through for the results of models. The Order-Logit method is utilised to carry through the parameter estimation again for the two models which are waiting for estimation. It is found from the results that the estimated coefficient results of all variables are in accordance with the results of the Order-Probit method. This shows that the results obtained in this paper are robust.

4.2.3 The Tax Payment Willingness of residents for atmospheric pollution treatment

By the relation analysis between happiness and the subjective index of environmental pollution, the reaction of residents on the influence of atmospheric pollution is most significant. Therefore, the relation between happiness of residents and objective atmospheric pollution levels will be further investigated in this paper and the willingness to pay tax of residents for the treatment of atmospheric pollution will be calculated.

According to the annual division, three models will be given out for the relation analysis between residents' happiness and objective atmospheric pollution level. In the three models, the objective indexes of atmospheric pollution will be expressed by the different types. For example, in the two models of 2001 and 2007, the objective indexes of atmospheric pollution are the classes of pollution, with standards set by *The Environmental Statistics Yearbook of China*. In the 2012 model, the objective indexes of atmospheric pollution are the specific pollutants such as the emission concentrations of PM10 and NO_2.

According to the data shown in Table 4, atmospheric pollution in China has a significant negative effect on residents' happiness. In the 2001 model, once the atmospheric pollution level is increased by one unit, the probability that the happiness of residents will be reduced with increased atmospheric pollution levels is 0.114. However, in 2007, the probability increased to 0.269. This shows that the problem of atmospheric pollution in China has become more serious over time. In the 2012 model, when the emission concentration of NO_2, is increased by one unit, the happiness of residents is decreased by 0.01 levels; hence, NO_2 pollution has a negative effect on the happiness of residents. A positive correlation appears between PM10 and residents' happiness. However, it is found that such a positive correlation is weaker and the reaction coefficient is only 0.005. Therefore, it is presumed in this paper that the reaction of residents to PM10 before 2012 is not very obvious.[3]

4.2.4 Estimation of environmental tax price

According to the formula of marginal willingness to pay the environmental tax derived from the theoretical parts, the tax levels paid by the residents for environmental governance in 2001, 2007 and 2012 are calculated as the price residents are willing to pay for environmental protection. Since the same estimation method is used, there is comparability between the environmental tax prices of 2001 and 2007. It can be seen from the results that in 2001 the price residents were willing to pay for the prevention and treatment of atmospheric pollution was 0.36 units. By 2007, the price residents were willing to pay had increased to 1.21 units. This shows that the awareness and ability of residents to prevent and treat environmental pollution have increased while the environmental problem has become more serious day by day.

In the 2012 model, the data of real income are used. Therefore, the actual payment price of residents for the prevention and treatment of environmental pollution can be calculated. According to the results of data in Table 4, the willingness-to-pay price of residents for the prevention and treatment of NO_2 pollution is an annual average of 1009 RMB.

[3] The robustness test is carried through for the results of models. Due to space limitations, the paper will no longer be listed.

Table 3. Evaluation Results of Relation Model between Willingness to Pay Taxes and the Subjective Index of Environmental Pollution

	Order-Probit		Order-Logit	
	Model 1	Model 2	Model 1	Model 2
Air pollution	0.05*(0.029)		0.086*(0.05)	
Water pollution		0.06**(0.026)		0.11**(0.047)
Control variables				
Health	-0.02(0.032)	-0.02(0.032)	-0.03(0.06)	-0.03(0.057)
Marital status	-0.067(0.092)	-0.075(0.091)	-0.15(0.17)	-0.17(0.16)
Freedom of choice	0.08**(0.038)	0.075**(0.038)	0.16**(0.07)	0.15**(0.07)
Life satisfied	0.12***(0.039)	0.12***(0.039)	0.19***(0.07)	0.2***(0.07)
Children number	-0.01(0.048)	-0.02(0.048)	-0.003(0.09)	-0.02(0.09)
Gender	0.063(0.06)	0.068(0.06)	0.14(0.11)	0.15(0.11)
Age	0.047(0.052)	0.05(0.053)	0.09(0.09)	0.1(0.09)
Education	-0.001(0.038)	-0.008(0.034)	0.01（0.07）	-0.001(0.07)
Town size	-0.043(0.06)	-0.032(0.06)	-0.096(0.11)	-0.07(0.11)
Religious	0.034(0.047)	0.04(0.046)	0.075(0.08)	0.085(0.08)
Obs	1516	1515	1516	1515
LR chi2	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0
Pseudo R^2	0.01	0.01	0.255	0.01

Standard errors in parentheses * P<0.1, ** P<0.05, *** P<0.01

Table 4. Evaluation Results of Relation Model between Happiness and Atmospheric Pollution (affected by the data type, models at 2001 and 2007 data are estimated by method of Order-logit, and the model at 2012 data is estimated by the method of FGLS).

	Coefficients (2001)	Coefficients (2007)	Coefficients (2012)
Air pollution index	-0.114*(0.068)	-0.269*(0.15)	--
PM10 index	--	0.125(0.15)	--
NO_2 index	--	0.124(0.14)	--
PM10 density	--	--	0.005**(0.001)
NO_2 density	--	--	-0.01***(0.002)
Income(Ln-value)			0.23***(0.077)
Control variables			
Income scale	0.28***(0.113)	0.23***(0.087)	--
Married	0.294(0.233)	0.4***(0.15)	0.1***(0.035)
Freedom of choice	--	0.13*(0.07)	0.25***(0.02)
Life satisfied	1.16***(0.125)	0.81***(0.09)	--
Finance satisfied	0.053(0.112)	0.42***(0.08)	--
Age	--	0.26***(0.09)	--
Gender	--	--	-0.04*(0.024)
Employment	0.54**(0.27)	--	-0.067*(0.04)
Education	-0.16(0.14)	--	0.057***(0.015)
Number of obs	843	1450	2154
LR chi2	225	693	F statistics=37,Prob>F=0
Prob>chi2	0	0	Heteroskedasticity test: P=0.1
Pseudo R^2	0.14	0.22	R-squared=0.14
Marginal coefficients and the willingness income to govern pollution			
	Marginal coef. (2001)	Marginal coef. (2007)	Marginal coef. (2012)
Air pollution index(p)	-0.01(0.11)	-0.029*(0.017)	--
Income scale(y)	0.028(0.36)	0.024**(0.01)	--
$\partial y/\partial p$	0.36	1.21	1009RMB

Standard errors in parentheses * P<0.1, ** P<0.05, *** P<0.01

5. Conclusions

This paper demonstrates that the environment has become one of the most important factors influencing residents' subjective well-being. By respectively building the relationship models between happiness, residents' willingness to pay environmental tax and the environmental pollution, it can be concluded from the validated empirical analysis that environmental pollution, especially atmospheric pollution, has a strong impact on the happiness of residents. The residents are willing to pay tax to reduce atmospheric pollution. The two main conclusions are as follows: 1. Compared with water pollution, atmospheric pollution has the most remarkable impact on the happiness of residents in China. When the atmos-

pheric pollution index goes up by one unit, the probability of happiness dropped down will rise to 0.269 in 2007 from 0.114 in 2001; in other words, the negative influence of atmospheric pollution on the happiness of residents is increasing. When the emission concentration of NO_2 is increased by one unit, the happiness of residents will be reduced by 0.01. 2. In the estimated results from the relation models between residents' willingness to pay environmental tax and environmental pollution, it is found from the study that if the problems of atmospheric and water pollution need to be treated, then the residents are willing to pay some environmental taxes. It can be seen from the actual results that to prevent and treat atmospheric pollution, the price residents are willing to pay was increased to 1.21 units in 2007 from 0.36 units in 2001. In 2012, the price that the residents are willing to pay for the prevention and treatment of NO_2 pollution is annual average 1009 RMB.

Combined with the aforementioned empirical results, this paper suggests that the nation should treat environmental pollution control as an important public policy and formulate and implement policies accordingly. Actively promote environmental tax reform and establish a long-term and effective fundraising mechanism for environmental pollution and prevention to ensure the efficiency of pollution control. The study demonstrates that residents are willing to pay a certain amount of tax and fees and that their willingness to pay rises as the environmental pollution increases. Therefore, the study also suggests that the state should encourage people to actively participate in local environmental pollution control efforts and mobilize the public to co-manage environmental pollution while making public policies.

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