Does Environmental Pollution Affect Resident Well-Being?

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Abstract

The Ordered Logit regression model was constructed based on the data from Chinese General Social Survey and China Statistical Yearbook 2017. The empirical analysis shows that air pollution positively affects resident well-being through economic growth, water pollution and solid waste pollution negatively affects resident well-being, and environmental pollution can reduce resident well-being by damaging their health. The impact of environmental pollution on resident well-being is heterogeneous. The low-income people have lower requirements for environmental quality, while the high-income people are more affected, and the eastern region is more affected in the three regions. In addition, residents' subjective environmental pollution perception will negatively affect their well-being. In order to improve the resident well-being, it is necessary to strengthen the management of the environment and improve the quality of the environment so as to realize the increase of resident well-being and economic development.

Introduction

Since the outbreak of COVID-19 pandemic, the issue of resident well-being has been widely concerned(Petrovič et al.2021; Caputi et al.2021; Long 2021; Dahlen et al.2021). According to the theory of sustainable development, the goal of government’s public policy is not only the promotion of GDP, but also the improvement of social welfare. The well-being of residents is the ultimate goal of economic growth pursued by governments all over the world(Hou et al.2020). Similarly, the focus on the effect of government policy on resident well-being is essential to sustainable development of science and technology and the creation of right national vision(Lim et al.2016). Since the reform and opening up, China’s economic strength and international status have steadily increased, but resident well-being didn’t increase as fast as the economy grew. According to World Happiness Report of 2018, Chinese national happiness index ranked 86th among the world, which represented a low level of global resident well-being.

Since 1990, World Values Survey (WVS) has conducted a survey of global residents’ values every five years, which contains questions about resident well-being, which ranges from 1 to 4. The smaller the number is, the happier the respondent feels. Table 1 shows the result of WVS during these years. Respondents who felt very happy in 2011 only accounted for 11.5%, which was the lowest percentage among all the surveys. What’s more, the percentage of respondents who reported that they were “very happy” in 2018 was still lower than that in 1990. Although the total percentage of respondents who were “very happy” and “happy” has been over 80% since 1995, which indicated that most Chinese residents felt happy, we cannot ignore the fact that resident well-being has not grown harmoniously with the economic growth.

Table 1.Survey on Chinese resident well-being in WVS (unit: percentage)

Year	1990	1995	2001	2007	2012	2018
Number of Samples	1000	1500	1000	1991	2300	3036
Very happy	27.5	22.7	11.5	20.9	16.0	27.1
Happy	39.1	60.9	66.3	55.2	68.4	62.1
Unhappy	28.6	14.1	19.0	19.2	13.2	9.4
Not happy at all	2.1	1.7	2.8	4.0	1.1	1.4
No response	0.6	0.6	0.0	0.6	0.6	0.0
No idea	2.1	0	0.4	0.1	0.6	0.0

Based on calculation, the average level of resident well-being in 1990 was 1.999, and the number was 1.936, 2.213, 2.049, 1.968 and 1.851 in 1995, 2001, 2007, 2012 and 2018 respectively. Generally, resident well-being in China has been increasing since 1990, though, the level of resident well-being before 2012 has always been lower than that in 1990. It was not until recent years that national well-being has been increased, which showed that China has been strapped in the dilemma of “well-being stagnation”(Huang and He 2013). Now China has been experiencing the crucial period of economic transformation, with fairly incomplete system and social inequalities like income gap. China’s gini coefficient was 0.465 in 2019, higher than the international warning line, indicating that China’s regional development was unbalanced, and the gap between residents’ income was wide. Besides, economic growth might bring about some externality problems, such as traffic jam and environmental pollution, which are detrimental to the promotion of resident well-being. Therefore, researches on the factors that account for resident well-being are quite necessary to further improve resident well-being.

Well-being is a positive emotion(Dahlen et al.2021), as well as a cognition or judgement for the overall evaluation of life(Liao et al.2015). Among early studies on resident well-being, many scholars agreed on Easterlin Paradox(Easterlin 1995; Xing 2011; Clark et al.2008), which states that individuals’ income has a significantly positive impact on their well-being, while national economic development might not necessarily improve resident well-being. Soon the early belief in Easterlin Paradox was questioned, however, as many studies found a positive correlation between national well-being and GNP per capita(Veenhoven 1991), and a positive correlation between the overall well-being of residents and personal absolute income. It meant that resident well-being was positively influenced by economic growth(Liu et al.2012). Based on the study on 54 countries of different types, Easterlin further pointed out that as time goes by, resident well-being would not necessarily become stronger as the economy grew faster; instead, the relationship between them was proved to be an inverted-U shape. Especially in China, South Korean and Chile, when the economy grew at a high speed, resident well-being slightly declined(Easterlin et al.2010). In the current stage, the effect of economic growth on resident well-being has been gradually diminishing(Zhou et al.2015).

Later scholars continued to explore the factors that affected well-being, which were categorized into individual factors and social factors. Individual factors included individual income(Huang 2016),

gender(Petrovič et al.2021; Dai et al.2015), health status(Wang 2018), educational background(He and Pan 2011; Marujo and Casais 2021) and perfectionism(Badri et al.2021). Social factors included GDP growth(Cui 2019), social security(Zhou et al.2015), living environment(Huang and He 2013) , inclusive finance(Xie et al.2019) and leisure activity(Chu et al.2021).

Among all factors that influence well-being, environment is one of the most important factor(Lim et al.2016; Dai et al.2015; Song et al.2019). China has been confronted with severe environment pollution. As the Bulletin of China's Ecological Environment in 2019 reported, the air pollution in China was very serious, with the air quality in 180 cities of China not reaching the standard, which accounted for 53.4% cities in China. Solid waste pollution was serious in China as well. The production of general industrial solid waste in 2019 increased by 8% compared to that in 2018, and has been increasing through these years. The production of industrial hazardous waste has also been rising. Water pollution remained severe. In the cross-sectional monitoring of water quality in seven major river basins, including Yangtze River, water "inferior to Grade V" accounted for 3.4%, which meant 3.4% of water can barely be used. Increasingly deteriorating environmental pollution has influenced not only residents' health status, but also their living quality, well-being, etc. In the report of the 19th National Congress of the Communist Party of China, president Xi Jinping pointed out that "the original aspiration and the mission of Chinese Communists is to seek happiness for the Chinese people", and also, "lucid waters and lush mountains are important to people's happiness", which can never be replaced by wealth.

Besides, Environmental Kuznets Curve (EKC) was regarded to exist in China(Wu et al.2002; Zhang et al.2009; Yang et al.2011). But further studies found that the shape of EKC may depend on different selections of samples, control variables and indicators. For example, EKC may disappear in terms of different samples(Stern and Common 2001); the shape of EKC differed in terms of different environmental pollutants, with SO₂ and CO presented as an inverted-U shape, CO₂ presented as linear relationship, and soot presented to be random(Lu et al.2012). The research conducted in Beijing-Tianjin-Hebei area in China showed that the reason for the disappearance of EKC might be the spatial interaction among regions(Ma and Shi 2017). Also, EKC from 2006 to 2017 in Beijing-Tianjin-Hebei area might change to an inverted-N shape if environmental pollution was measured by air quality(Li et al.2019). Given that factors that influence well-being were not limited to economic growth, but also environment policy, technology, industrial structure, it was hard to include all variables in the study on EKC, which led to the incompleteness of model and deviation of measurement, therefore, a further study on the missing variables is rather necessary. Current studies on EKC remain inconclusive, and how to balance economic development and environmental governance remains to be explored.

Recent years, China has been improving the environmental protection policies. As China has entered a new normal in economic development, the environment issue brooks no delay. In addition to policies issued by the government, spontaneous actions for environmental protection from residents are required. Therefore, it's necessary to explore the coexistence between human beings and the environment. Some researches showed that residents' internal motivation of environmental protection was to improve the

well-being of themselves(Kang and Wang 2017). It's of great significance to study the effect of environmental pollution on resident well-being.

The influence of environmental pollution on resident well-being can be further studied in terms of the objective fact of environmental pollution and the residents' subjective perception of environmental pollution, in which the influence of objective environmental pollution on resident well-being includes absolute deprivation effect and relative deprivation effect(Li 2015).

Absolute deprivation effect means that environmental pollution affects resident well-being in a general way. Studies showed that air pollution(Huang and He 2013; Chu et al.2017), water pollution(Xu et al.2018) had negative effects on resident well-being. During the National People's Congress and the Chinese People's Political Consultative Congress in 2021, Premier Li Keqiang pointed out in his answer to reporters' questions that health is the foundation of well-being as well as productivity. Environmental pollution might affect residents' health status in many respects. Air pollution may lead to respiratory diseases. Soil pollution and water pollution may cause food safety problem by affecting the soil and water sources, thereby exerting a negative impact on people's health. Noise pollution can expose people to malignant stimuli, easily leading to the damage on auditory organs and nerves system. Among all environmental pollutions, air pollution is the one of damage that people are most exposed to and empathized with. According to Lancet's Study on Global Disease Burden in 2019, air pollution ranked fourth among the risk factors for death in global females and males, with 2.92 million and 3.75 million deaths in females and males, of which 1.95 million people died from air pollution in China, accounting for 29.23% of the global death toll. It's obvious that air pollution seriously damaged the health of Chinese residents. The absolute deprivation effect of environmental pollution was not only manifested in China. A relative analysis of German residents well-being and environmental pollution found that both air pollution and noise pollution had a significant negative impact on their well-being(Mitchell and Dorling 2003). A large number of studies have found that resident well-being largely depended on their own health status(He and Pan 2011; MacKerron and Mourato 2008; Ye and Zhang 2020). Poor health status would also affect residents' daily emotions and lead to a decrease in well-being(Nie and Zhong 2017). The following hypothesis is therefore suggested.

Hypothesis 1 (H1). *Environmental pollution affects resident well-being through residents' health status.*

In addition to physical health, environmental pollution may also affect resident well-being through economic growth. Studies have found that the relationship between economic growth and well-being was shapes as an inverted-U, that is, Easterlin paradox did exist(MacKerron and Mourato 2008; Lu and Sun 2017). The reason was that well-being was not only affected by income level, but also by health status and living environment. Further research found that among non-economic factors that affect well-being, environmental pollution was more essential. In the early stage of economic growth, residents were not sensitive to environmental pollution and their well-being increased. In the later period, residents gradually paid attention to environmental pollution, when the experience of well-being did not rise; instead, it

declined. Therefore it was believed that Easterlin paradox can be explained by environmental factors(Zhong and Yue 2020). This suggests the following hypothesis.

Hypothesis 2 (H2). *Environmental pollution affects resident well-being through economic growth.*

The relative deprivation effect refers to the heterogeneous impact of environmental pollution on resident well-being. After controlling the socioeconomic variables of various regions in Spain, resident well-being still differed significantly from region to region, and environmental pollution played an important role in explaining the regional differences(Cuñado and Pérez Gracia 2013). In China, compared with low-income groups, high-income groups had higher requirements for environment and paid more attention to air pollution, so they were affected to a greater extent(Zhou et al.2015). However, some scholars believed that environmental pollution usually affected people with lower income by a greater negative impact on their physical health because of the poor living environment. At the same time, they were not capable of improving their health status financially, which further reduced their well-being(MacKerron and Mourato 2008). Besides, because natural resources differ among regions, residents had different perceptions of environmental pollution, and the impact of well-being was also different. Compared with western regions of China, air pollution had a greater impact on the well-being of residents in eastern and central regions of China(He and Pan 2011). In addition, there are certain differences in water resources between the eastern region and the central-western regions. Therefore, the impact of water pollution on the residents in two regions was different as well, with greater impact on eastern region. Therefore, it affected the well-being of the residents in eastern region to a greater extent(Ma et al.2019). In addition, residents' willingness to pay for the reduction of different types of pollution was different as well. Chinese residents' average willingness to pay for the reduction of 1 μ g/m³ PM₁₀, SO₂, and NO₂ was 343.602 yuan, 45.197 yuan, and 232.443 yuan, respectively(Chen and Shi 2013). Queensland residents' average willingness to pay for reducing the concentration of PM₁₀ for a day was about US\$5,164(Ambrey et al.2014). The analysis of 10 European countries from 1990 to 1997 inferred the annual value of nitrogen oxides and lead in the air was US\$760 and US\$1390 respectively(Welsch 2006). In 2019, China's gini coefficient was still higher than the international warning line, indicating that the regional development in China was unbalanced and the income gap of residents was wide. Therefore, studying the heterogeneity of environmental pollution to different groups is of great significance in practice. The following hypothesis is then developed.

Hypothesis 3 (H3). *The impact of environmental pollution on residents well-being is heterogeneous.*

In addition to the impact of objective environmental pollution, residents well-being was also affected by their subjective perception of the environment(Ma et al.2019). Residents who were concerned about environmental issues felt greater impact of environmental pollution on their well-being, while residents who were not concerned barely feel the impact of environmental pollution on their well-being(Wu et al.2015). Taking air pollution as an example, due to the disparities in different groups of people's sensitivity, subjective perceptions varied under the same extent of objective air pollution. Based on residents' self-evaluated air pollution levels, it was found that air pollution on the subject level negatively

affected residents' well-being (MacKerron and Mourato 2008). That is to say, residents' subjective perception of environment negatively affected their well-being (Zheng et al. 2015). Furthermore, residents' subjective well-being has an adverse effect and can have a significant positive impact on their environmental behavior. Therefore, in order to solve the problem between economic development and environmental pollution, it is necessary to transform the economy with the aimed of improving residents' well-being (Kang and Wang 2017). This suggests the following hypothesis.

Hypothesis 4 (H4). *Resident well-being is affected by their subjective perceptions of the environment.*

Existing studies were mostly based on one or two aspects of air pollution, water pollution, and solid waste pollution to analyze how they affected residents' well-being, and the selection of indicators was inconclusive. Different types of environmental pollution have various impacts on residents' daily life, thus leading to various impacts on residents' well-being. Therefore, this article will comprehensively evaluate environmental pollution from three aspects: air pollution, water pollution and solid waste pollution. In addition, although there were little literature on the impact of residents' subjective perception of environment on their own well-being, therefore this article is aimed to further study on this impact.

Materials And Methods

The data was derived from Chinese General Social Survey (CGSS) in 2017 and China Statistical Yearbook of 2017. The dependant variable is resident well-being (WB), and the independent variable is environmental pollution (Pollution). The objective fact of environmental pollution was measured from three aspects: air pollution, water pollution and solid waste pollution. The subjective perception of environmental pollution was indicated by residents' satisfaction with their surrounding environment, measured by the item "how do you think of the following views: I am satisfied with the natural environment around me" in the CGSS. Objective environmental pollution was converted to a value between 0 and 1 (Song et al. 2019). The formula is as follows:

$$A_{ij}^* = \frac{1}{3} \sum_{j=1}^3 \frac{A_{ij} - \text{MIN}(A_j)}{\text{MAX}(A_j) - \text{MIN}(A_j)} \quad (1)$$

$$W_{ij}^* = \frac{W_{ij} - \text{MIN}(W_j)}{\text{MAX}(W_j) - \text{MIN}(W_j)} \quad (2)$$

$$S_{ij}^* = \frac{S_{ij} - \text{MIN}(S_j)}{\text{MAX}(S_j) - \text{MIN}(S_j)} \quad (3)$$

A_{ij} , W_{ij} , and S_{ij} represent the original value of indicator j of province i . MAX and MIN represent the maximum and minimum of indicator j respectively. Since air pollution is composed of three aspects, A_{ij}^* was divided by three. If $0 \leq A_{ij}^* \leq 0.3$, then A_{ij}^* is coded as 1, which means the air pollution is not serious. If

$0.3 \leq A_{ij}^* \leq 0.6$, then A_{ij}^* is coded as 2, which means that air pollution is serious. If $0.6 \leq A_{ij}^* \leq 1$, then A_{ij}^* is coded as 3, which means air pollution is very serious. W_{ij}^* and S_{ij}^* were defined in the same way.

An ordered logit model (Di Tella and MacCulloch 2007) was established to analyze how environmental pollution affected resident well-being.

$$WB_{ij} = \alpha_0 + \alpha_1 PollutionA_{ij}^* + \alpha_2 PollutionW_{ij}^* + \alpha_3 PollutionS_{ij}^* + \alpha_4 X_{ij} + \varepsilon \quad (4)$$

$$WB_{ij} = \beta_0 + \beta_1 PollutionX_{ij} + \varepsilon \quad (5)$$

WB_{ij} represents the well-being of respondent i in province j . $PollutionA_{ij}^*$, $PollutionW_{ij}^*$, and $PollutionS_{ij}^*$ refer to air pollution, water pollution and solid waste pollution respectively, which are objective factors for environmental pollution. X_{ij} represents residents' personal characteristic and macroeconomic status. $PollutionX_{ij}$ represents residents' subjective perception of environmental pollution, that is, the degree of their satisfaction with surrounding environment. Model (4) aims to analyze the impact of objective environmental pollution on residents well-being. Model (5) aims to analyze the impact of residents' subjective perception of environmental pollution on their well-being.

Control variables such as residents' region, gender, age is shown in Table 1, in which regions were divided into three parts: eastern, central and western regions according to the National Bureau of Statistics (the data of Hainan, Tibet and Xinjiang were not included in CGSS, so they were omitted). The variables and their definitions in this article are as follows.

Table 2. Variables and Definitions

Category	Variables	Symbol	Definition
Dependant variable	Resident well-being	WB	1: not happy at all 2: not happy 3: cannot tell 4: happy 5: very happy
Independent variables	Environmental pollution at the objective level	PollutionAij*	Air pollution sulfur dioxide emissions, nitrogen oxide emissions, soot or dust emissions
		PollutionWij*	Water pollution total wastewater discharge
		PollutionSij*	Solid waste pollution (general industrial solid waste generation)
	Environmental pollution at the subjective level	PollutionXij	1: not satisfied at all 2: not satisfied 3: fairly unsatisfied 4: fairly satisfied 5: satisfied 6: very satisfied
Control variables	Geographical location	City	1: eastern region 2: central region 3: western region
	Gender	Gender	0: male 1: female
	Age	Age	The age of respondents
	Age ²	Age ²	The square of respondents' age
	Educational background	Edu	0: illiterate or semi-literate 1: primary school
			2: secondary school 3: high school 4: college
			5: post-graduate or higher
	Political status	Political	0: the masses 1: party member
	Marital status	Marriage	1: single 2: married 3: widowed or divorced
	Income level	Ln Income	The logarithm of total household income
	Health status	Health	1: not healthy at all 2: not healthy 3: fairly 4: healthy 5: very healthy
	Socioeconomic status	Status	1: lower class 2: lower-middle class 3: middle class 4: upper-middle class 5: upper class
	Residential place	Isurban	0: rural 1: urban
	Provincial GDP growth	GDP	Provincial GDP growth rate per capita

Results

The Impact of Environmental Pollution at the Objective Level on Residents' Well-being

Table 3
Descriptive statistics

Variable	Obs	Min	Max	Mean	Std. Dev.
Well-being	10 981	1	5	3.860 0	0.844 0
Waste gas	10 981	1	3	1.448 8	0.629 5
Waste liquid	10 981	1	3	1.415 4	0.640 8
Solid waste	10 981	1	3	1.047 6	0.290 7
Geographical location	10 981	1	3	1.711 0	0.769 7
Gender	10 981	0	1	0.520 0	0.500 0
Age	10 981	18	103	50.840 0	16.449 0
Age^2	10 981	324	10 609	2 854.937 1	1 700.576 2
Educational background	10 981	0	5	2.130 0	1.305 0
Political status	10 981	0	1	0.120 0	0.320 0
Health status	10 981	1	5	3.480 0	1.089 0
Marital status	10 981	1	3	2	0.474 0
Socioeconomic status	10 981	1	5	2.220 0	0.869 0
Residential place	10 981	0	1	0.640 0	0.480 0
Provincial GDP growth rate per capita	10 981	0.980 0	1.100 0	1.068 5	0.019 0
Ln(Household income)	10 981	1.950 0	16.120 0	10.628 5	1.238 5
Number of valid cases	10 981				

Table 3 shows descriptive statistics for each variable in Model (4). Table 4 gives the results estimation of Model (4), which focuses on analyzing the effect of environmental pollution at the objective level on residents' well-being. Regression (1) contains only the individual-level independent variables. Among the direct effects of these variables on residents' well-being, annual household income has positive and significant effects on it. With regard to geographical location, residents in the western region had higher level of well-being, which may be due to the implementation of policies such as the great western

development strategy. As for the gender, the female are happier, and it is believed that the concept of "male superiority" makes men less happy(Huang and Guo 2019). In terms of political status, communists have higher level of well-being, thinking that possible reasons are income premium, social capital enhancement, and status premium(Lu et al.2016). Health status and socioeconomic status also positively affect the well-being of residents and have a greater impact. Compared to widowed or divorced people, married residents have higher level of well-being. Although the data in this article show that marriage has a positive impact on residents' well-being, some scholars believe that marriage negatively affects well-being and marriage will also be affected by other factors such as gender(Xing and Jin 2003), so the effect of marriage on well-being needs further research. Urban residents have lower level of well-being compared with rural people, which is thought to be influenced by national macro policies in the country and fierce competition in the city. On the one hand, macroscopic policies, such as Three Rural Issues improve the living standards of farmers and contribute to the well-being of rural residents. On the other hand, urban competition brings more anxiety and loss to residents in the city, leading to lower level of well-being. Therefore, there is a significant difference in the well-being between urban and rural residents.

The provincial GDP growth rate per capita is added to Regression (2), and it has a significant negative effect on residents' well-being, which can be considered that China has entered the late stage of the Easterlin Paradox, residents' well-being decreasing with economic growth. The indicator of air pollution is added to Regression (3). With severe air pollution as the reference variable, the coefficient is significantly negative, which means that air pollution has a significant positive effect on residents' well-being, contrary to the conclusion of most scholars. The reason is probably that economic development at the cost of air pollution promotes residents' well-being to a certain extent, that is, economic growth is the key to explain the positive effect of objective environmental pollution on well-being(Zheng et al.2015). There is an inverted U-shaped relationship between air pollution and residents' well-being(Zhu et al.2020), meaning that air pollution enhances residents' well-being through economic growth when it is limited to a certain level, arguing that Hypothesis 2 is corroborated.

The indicator of water pollution is add to Regression (3) and the coefficient is significantly positive, which means that water pollution has a significant negative effect on residents' well-being. The indicator of solid waste pollution is added to Regression (5) and the coefficient is significantly positive, that is, solid waste pollution has a significant negative effect on residents' well-being. Regression (6) includes all three indicators of environmental pollution, and it can be seen that the effects of air pollution and solid waste pollution are still significant, the significance of solid waste pollution slightly reducing, while the effect of water pollution is not significant. The reason may be that air pollution is more intuitive to people, because it is more mobile compared to water and solid waste pollution, and is wider in coverage, with no "discrimination" on residents(Ye and Zhang 2020). Therefore, people are more inclined to pay attention to air pollution when all three play a role in their well-being.

Table 4
The impact of environmental pollution at the objective level on residents' well-being

Explained variable: residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
Age	-0.055*** (0.008)	-0.056*** (0.008)	-0.055*** (0.008)	-0.055*** (0.008)	-0.055*** (0.008)	-0.055*** (0.008)
Age^2	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001 (0.000)
Ln(Household income)	0.095*** (0.021)	0.103*** (0.021)	0.113*** (0.021)	0.107*** (0.021)	0.103*** (0.021)	0.113*** (0.021)
GDP growth rate per capita		-5.446*** (1.085)	-6.645*** (1.147)	-5.179*** (1.094)	-5.973*** (1.125)	-6.597*** (1.288)
Reference variable: Air pollution=3, referring to severe air pollution						
[Air pollution=1]			-0.272*** (0.081)			-0.228** (0.098)
[Air pollution=2]			-0.390*** (0.087)			-0.304*** (0.102)
Reference variable: Water pollution=3, referring to severe water pollution						
[Water pollution=1]				0.188** (0.075)		0.078 (0.103)
[Water pollution=2]				0.276*** (0.080)		0.122 (0.098)
Reference variable: Solid waste pollution=3, referring to severe solid waste pollution						
[Solid waste pollution=1]					0.310** (0.148)	0.262* (0.154)

Note: Robust standard errors in brackets; Significance levels * p < 0.1, ** p < 0.05, *** p < 0.01; 0.000 in the table represents approximately zero.

Explained variable: residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
[Solid waste pollution=2]					0.682*** (0.258)	0.584** (0.269)
Reference variable: Geographical location=3, referring to the western region						
[Geographical location=1]	0.048 (0.056)	-0.046 (0.059)	-0.164 (0.064)	-0.011 (0.061)	-0.039 (0.06)	-0.115 (0.077)
[Geographical location=2]	-0.188*** (0.055)	-0.224*** (0.055)	-0.271*** (0.058)	-0.221*** (0.055)	-0.195*** (0.057)	-0.228*** (0.063)
Reference variable: Gender=1, referring to the female						
[Gender=0]	-0.273*** (0.040)	-0.27*** (0.040)	-0.269*** (0.040)	-0.268*** (0.040)	-0.27*** (0.040)	-0.268*** (0.040)
Reference variable: Education=5, referring to graduate students or above						
[Education=0]	-0.187 (0.193)	-0.163 (0.193)	-0.164 (0.193)	-0.156 (0.193)	-0.169 (0.193)	-0.169 (0.193)
[Education=1]	0.047 (0.186)	0.058 (0.186)	0.051 (0.186)	0.059 (0.186)	0.052 (0.186)	0.044 (0.186)
[Education=2]	0.200 (0.180)	0.207 (0.180)	0.192 (0.180)	0.202 (0.180)	0.201 (0.180)	0.185 (0.181)
[Education=3]	0.273 (0.179)	0.280 (0.179)	0.266 (0.18)	0.270 (0.180)	0.280 (0.180)	0.263 (0.180)
[Education=4]	0.378** (0.175)	0.373** (0.175)	0.366** (0.176)	0.367** (0.176)	0.374** (0.176)	0.364** (0.176)
Reference variable: Political status=1, referring to the communist						
[Political status=0]	-0.204*** (0.066)	-0.204*** (0.066)	-0.197*** (0.066)	-0.203*** (0.066)	-0.204*** (0.066)	-0.199*** (0.066)

Note: Robust standard errors in brackets; Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; 0.000 in the table represents approximately zero.

Explained variable: residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
Reference variable: Health status=5, referring to very good health						
[Health status=1]	-1.714*** (0.107)	-1.722*** (0.107)	-1.728*** (0.107)	-1.709*** (0.107)	-1.728*** (0.107)	-1.721*** (0.108)
[Health status=2]	-1.277*** (0.074)	-1.276*** (0.074)	-1.271*** (0.074)	-1.268*** (0.074)	-1.279*** (0.074)	-1.268*** (0.074)
[Health status=3]	-0.981*** (0.063)	-0.983*** (0.063)	-0.978*** (0.063)	-0.975*** (0.063)	-0.985*** (0.063)	-0.975*** (0.063)
[Health status=4]	-0.636*** (0.057)	-0.64*** (0.057)	-0.633*** (0.057)	-0.633*** (0.057)	-0.642*** (0.057)	-0.632*** (0.057)
Reference variable: Marital status=3, referring to the widowed or divorced						
[Marital status=1]	0.125 (0.094)	0.128 (0.094)	0.138 (0.094)	0.131 (0.094)	0.130(0.094)	0.140(0.094)
[Marital status=2]	0.533*** (0.065)	0.535*** (0.065)	0.527*** (0.065)	0.533*** (0.065)	0.537*** (0.065)	0.529*** (0.065)
Reference variable: Socioeconomic status=5, referring to the upper class						
[Socioeconomic status=1]	-2.905*** (0.459)	-2.886*** (0.458)	-2.841*** (0.458)	-2.88*** (0.458)	-2.882*** (0.459)	-2.844*** (0.458)
[Socioeconomic status=2]	-2.441*** (0.458)	-2.421*** (0.458)	-2.378*** (0.457)	-2.416*** (0.457)	-2.418*** (0.458)	-2.382*** (0.457)
[Socioeconomic status=3]	-1.892*** (0.458)	-1.872*** (0.457)	-1.831*** (0.457)	-1.869*** (0.457)	-1.865*** (0.457)	-1.833*** (0.457)
[Socioeconomic status=4]	-1.456*** (0.465)	-1.435*** (0.464)	-1.396*** (0.464)	-1.432*** (0.463)	-1.433*** (0.464)	-1.401*** (0.464)
Reference variable: Urban and rural=1, referring to urban residents						

Note: Robust standard errors in brackets; Significance levels * p < 0.1, ** p < 0.05, *** p < 0.01; 0.000 in the table represents approximately zero.

Explained variable: residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
[Urban and rural=0]	0.360*** (0.048)	0.363*** (0.048)	0.333*** (0.049)	0.346*** (0.048)	0.367*** (0.048)	0.333*** (0.049)
Note: Robust standard errors in brackets; Significance levels * p < 0.1, ** p < 0.05, *** p < 0.01; 0.000 in the table represents approximately zero.						

To verify that environmental pollution may affect residents' well-being through their health, we made Table 5(Lu and Sun 2017), controlling for variables other than health status. Three variables of pollution are included in Regression (1), (3), and (5), while the variables of health status are included in Regression(2), (4), and (6). If Hypothesis 1 holds, then the effect of environmental pollution on residents' well-being should be reduced or insignificant after including the variables of health status. Table 5 shows that the effect of air pollution and water pollution on residents' well-being becomes smaller or insignificant with the inclusion of health status, indicating that these two types of pollution may reduce residents' well-being by damaging their health, arguing that Hypothesis 1 is corroborated. Solid waste pollution does not affect residents' well-being through health damage, and the possible reason is that sites of solid waste pollution are more concentrated and far away from residential live quarters, which is less damaging to residents' health.

Table 5
Mechanism of environmental pollution on residents' well-being

Explained variable: residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
Reference variable: Air pollution=3, referring to severe air pollution						
[Air pollution=1]	-0.384*** (0.081)	-0.272*** (0.081)				
[Air pollution=2]	-0.432*** (0.086)	-0.390*** (0.087)				
Reference variable: Water pollution=3, referring to severe water pollution						
[Water pollution=1]			0.135*** (0.074)	0.188** (0.075)		
[Water pollution=2]			0.315*** (0.080)	0.276*** (0.080)		
Reference variable: Solid waste pollution=3, referring to severe solid waste pollution						
[Solid waste pollution=1]					0.179 (0.146)	0.310** (0.148)
[Solid waste pollution=2]					0.668*** (0.257)	0.682*** (0.258)
Reference variable: Health status=5, referring to very good health						
[Health status=1]		-1.728*** (0.107)		-1.709*** (0.107)		-1.728*** (0.107)
[Health status=2]		-1.271*** (0.074)		-1.268*** (0.074)		-1.279*** (0.074)
[Health status=3]		-0.978*** (0.063)		-0.975*** (0.063)		-0.985*** (0.063)
[Health status=4]		-0.633*** (0.057)		-0.633*** (0.057)		-0.642*** (0.057)
Note: Robust standard errors in brackets; Significance levels* p < 0.1, ** p < 0.05, *** p < 0.01.						

The Impact of Environmental Pollution at the Subjective level on Residents' well-being

As the number of respondents to the question "Are you satisfied with the surrounding natural environment?" in the CGSS is small, Model (2) contains cross-sectional data of 3588 respondents after removing missing values and outliers. Table 6 shows the descriptive statistics of each variable.

Table 6
Descriptive Statistics (2)

	Obs	Min	Max	Mean	Std. Dev.
Residents' well-being	3 588	1	5	3.850 0	0.839 0
Gender	3 588	0	1	0.530 0	0.499 0
Educational background	3 588	0	5	2.150 0	1.309 0
Age	3 588	18	96	50.840 0	16.509 0
Age^2	3 588	324	9216	2 857.449 8	1 704.252 9
Ln(Household income)	3 588	1.950 0	16.120 0	10.648 3	1.221 3
Political status	3 588	0	1	0.120 0	0.322 0
Health status	3 588	1	5	3.490 0	1.080 0
Marital status	3 588	1	3	2	0.481 0
Socioeconomic status	3 588	1	5	2.220 0	0.856 0
Residential place	3 588	0	1	0.640 0	0.480 0
Environmental satisfaction	3 588	1	6	4.100 0	1.207 0
Geographical location	3 588	1	3	1.712 7	0.763 8
Provincial GDP growth rate per capita	3 588	0.980 0	1.100 0	1.068 2	0.018 6
Number of valid cases	3 588				

Table 7 analyzes the effect of residents' subjective perception of environmental pollution on well-being. Regression (1) in Table 7 includes only the individual-level independent variables of residents, and the significance of some results differ slightly from that in Table 4, probably because of the small sample size, so we have omitted these results. Regression (2) includes the provincial GDP growth rate per capita. Regression (3) includes indicators of environmental satisfaction, taking "very satisfied with the environment" as the reference variable. It can be seen that the coefficient of environmental satisfaction is significantly negative, indicating that the higher the residents' satisfaction with the environment, the

higher the residents' well-being. Therefore, residents in China are very averse to environmental pollution, which corroborates Hypothesis 4.

Table 7
The impact of environmental pollution at the subjective level on residents' well-being

Explained variable: Residents' well-being	(1)	(2)	(3)
Age	-0.042 ^{***} (0.014)	-0.044 ^{***} (0.014)	-0.044 ^{***} (0.014)
Age^2	0.001 ^{***} (0.000)	0.001 ^{***} (0.000)	0.001 ^{***} (0.000)
Ln(Household income)	0.074 ^{**} (0.037)	0.084 ^{**} (0.038)	0.076 ^{**} (0.038)
GDP growth rate per capita		-6.568 ^{***} (1.962)	-5.826 ^{***} (1.978)
Reference variable: Environmental satisfaction=6, referring to very satisfied			
[Environmental satisfaction=1]			-1.297 ^{***} (0.235)
[Environmental satisfaction=2]			-1.385 ^{***} (0.171)
[Environmental satisfaction=3]			-1.486 ^{***} (0.162)
[Environmental satisfaction=4]			-1.153 ^{***} (0.147)
[Environmental satisfaction=5]			-0.722 ^{***} (0.142)
Note: Robust standard errors in brackets; Significance levels* p < 0.1, ** p < 0.05, *** p < 0.01; 0.000 in the table represents approximately zero.			

The Heterogeneity of the Impact of Environmental Pollution on Residents' well-being

Whether environmental pollution has differential effects on the well-being of different groups has been an issue of academic interest. Lower income levels, older age, or different locations may further reduce people's well-being for economic or physical reasons, so this section will further study the inequity of environmental pollution. First, we sorted the household income from low to high and determine the 1/4 quartile (about 20,000 yuan), 2/4 quartile (about 50,000 yuan), and 3/4 quartile (about 100,000 yuan) of household income. Residents below the 1/4 quartile is defined as low-income earners, between the 1/4 and 2/4 quartile as lower-income earners, between the 2/4 and 3/4 quartile as middle-income earners, and above the 3/4 quartile defined as high-income earners(Huang and He 2013). Then we constructed the intersection of environmental pollution and each income stratum, still controlling for other variables.

Regression (1), (2), and (3) in Table 8 show the results of cross-multiplication regressions of air pollution, water pollution, and solid waste pollution with income strata, respectively. The results of these three columns indicate that people with higher income have lower level of well-being under the same air or water pollution. It is believed that low-income people are more inclined to focus on their economic status and have lower requirements for environmental quality, while high-income people have higher requirements for environmental quality, are more sensitive to environmental pollution, and experience greater negative impact of it on their well-being. Therefore, in order to improve the overall well-being of residents, it is necessary to coordinate the heterogeneous needs of residents in different income strata.

Regressions (4), (5), and (6) shows the results of cross-multiplication regressions of air pollution, water pollution, and solid waste pollution with regions, respectively. Among them, air pollution has a significant positive effect on the well-being of residents in the eastern region, which may be due to the higher level of economic development there, and air pollution plays a role in promoting residents' well-being through economic growth(Zheng et al.2015). Water pollution negatively affects the eastern and central regions, and has a greater impact on the eastern region. The reason may be that the eastern region is significantly scarcer in water resources per capita than the central and western regions. Therefore, regional differences in environmental pollution does exist, which corroborates Hypothesis 3.

Table 8
The heterogeneity of the impact of environmental pollution on residents' well-being

Explained variable: Residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
Reference variable: Air pollution*Residents with high income						
Air pollution*Residents with low income	0.148** (0.070)					
Air pollution*Residents with relatively low income	0.067** (0.027)					
Air pollution*Residents with middle income	0.033*** (0.013)					
Reference variable:Water pollution*Residents with high income						
Water pollution*Residents with low income		0.083 (0.068)				
Water pollution*Residents with relatively low income		0.049** (0.025)				
Water pollution*Residents with middle income		0.025** (0.011)				
Reference variable:Solid waste pollution*Residents with high income						
Solid waste pollution*Residents with low income			-0.020 (0.242)			
Solid waste pollution*Residents with relatively low income			0.031 (0.083)			
Solid waste pollution*Residents with middle income			0.017 (0.033)			
Reference variable:Air pollution*the Western region						
Air pollution*the Eastern region				0.265** (0.110)		

Note: Robust standard errors in brackets; Significance levels* p < 0.1, ** p < 0.05, *** p < 0.01; 0.000 in the table represents approximately zero.

Explained variable: Residents' well-being	(1)	(2)	(3)	(4)	(5)	(6)
Air pollution*the Central region				0.013 (0.033)		
Reference variable:Water pollution*the Western region						
Water pollution*the Eastern region					-0.215** (0.106)	
Water pollution*the Central region					-0.126*** (0.035)	
Reference variable:Solid waste pollution*the Western region						
Solid waste pollution*the Eastern region						-0.626 (0.487)
Solid waste pollution*the Central region						-0.234* (0.126)
Note: Robust standard errors in brackets; Significance levels* p < 0.1, ** p < 0.05, *** p < 0.01; 0.000 in the table represents approximately zero.						

Discussion

As president Xi Jinping noted, “good ecological environment is the fairest public good and the most inclusive well-being of the people”, the pursuit of well-being is the fundamental motivation of human behavior. Especially as people’s living standards continue to improve, people’s demands for clean water, fresh air and beautiful environment are higher and higher. People’s focus have shifted from “subsistence” to “sustainability”, from “economy” to “ecology”, therefore environmental issues have become one of the most pressing livelihood issues in China. The key to controlling environmental pollution is to change the pattern of economic development(Huang and He 2013). In 2020, the government’s report to the National People’s Congress made it clear that we should carry out the campaign to protect the blue sky, clean water and pure land, and achieve the phased goals in the battle against pollution, that is, to put forward environmental policies at the national level and to focus economic development on pollution control. In order to realize the sustainable development of society and satisfy the dual pursuit of residents’ material and spiritual needs, we need to pay attention to the coordinated development between economy and environment. Therefore, this article aims to answer whether the impact of different types of objective environmental pollution on residents’ well-being is different, whether there is heterogeneity in the impact of objective environmental pollution on different residents and whether subjective environmental pollution affects residents’ well-being.

In this paper, we believe that we can continue our research on environment and residents' well-being from three aspects: First, we can further analyze the impact of air pollution on residents' well-being. Most of the existing literature believes that air pollution negatively affects residents' well-being, while a few scholars' studies and our paper consider that air pollution has an positive effect on residents' well-being to a certain extent, which can be studied in depth. Secondly, there are many other factors affecting the happiness of residents, not limited to environmental pollution, income level, regional differences, etc. For example, the influence of political status on residents' well-being is less studied, and this can be further researched. Thirdly, much more research can be done in the impact of environmental protection tax on residents' well-being and its mechanism. In 2018, China's Environmental Protection Tax was officially promulgated, so we can explore the changes in residents' well-being before and after the implementation of this policy, and whether it can effectively improve residents' well-being.

Conclusions

Based on the data from CGSS, this paper researched the impact of environmental pollution on residents' well-being. The main conclusions are as follows. First, air pollution can positively affect residents' well-being through economic growth, while water pollution and solid waste pollution negatively affect residents' well-being. Moreover, residents' health is closely related to the surrounding environment. The more severe the environmental pollution, the worse the residents' health, which in turn reduces their well-being. Second, the impact of environmental pollution on residents' well-being is heterogeneous. Residents with high income have lower level of well-being for the same air or water pollution, while solid waste pollution does not differ significantly for residents in different income strata. There is also regional heterogeneity in environmental pollution. Air pollution has a significant positive impact on the well-being of residents in the eastern region, and water pollution has a significant negative impact on the eastern and central regions, with a greater effect on the eastern region.. Third, residents' well-being is influenced by their own subjective feelings about the environment. Using the index of environmental satisfaction to evaluate residents' subjective feelings about the environment and analyze residents' well-being, we find that residents' satisfaction with the environment positively affects their well-being.

Therefore, various environmental protection policies should be continuously improved to clarify the positioning and responsibilities of governments, enterprises and the public, so as to jointly build the "happy city". Cai Lan(2014) pointed out that after the Industrial Revolution, the main reason that Britain was able to tackle the extremely severe air pollution was the active participation of residents in air pollution control. Hence, the Government should attach importance to nongovernmental forces, such as guiding people to take the initiative to protect environment, so as to mobilize residents' enthusiasm for environmental protection and to increase residents' recognition of the government's work of environmental protection. In addition, during the process of environmental management, the government should focus on the heterogeneity of the impact of environmental pollution on residents' well-being, tailoring it to local and individual conditions, curb the further aggravation of social inequality, and make the fruits of economic development shared by all, so as to promote the overall well-being of residents.

Declarations

Availability of Data and materials: Data was obtained from CGSS (Chinese General Social Survey) and China Statistical Yearbook.

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Figures

Figure 1

Survey on Chinese resident well-being in WVS