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중공업 오염원이 부동산 가격에 대한 미치는 영향 중국 마안산시 중심으로

The Impacts of Heavy Industrial Pollution Sources on The Real Estate Price Evidence from Maanshan City, China

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요약

현대사회의 환경오염 문제는 공업화에 따라 급격하게 변화하고 있기 때문에, 환경오염 문제는 다양한 분야에 직간접적인 영향을 미치고 있다. 특히 중공업 오염원은 입지 선택과 부동산 가치에 주요한 변수로 작용될 수 있다. 따라서 본 연구에서는 중국의 대표적인 철강 도시인 마안산시에 있는13개 아파트 단지의 거래 데이터에 기반하고 헤도닉 가격 모형 (HedonicPrice Model)을 이용해서 환경오염 중에 중공업 오염을 중심으로 부동산 가격에 대해서 미친 영향을 연구했고 결론을 내렸다. 연구 결과는 주택에서 오염원의 거리가 멀어 질수록 주택 가격에 인상 효과가 있다.

■ 중심어 : | 중공업 오염 | 헤도닉 가격모형 | 주택가격 | 중국 |

Abstract

As the environmental pollution problem in modern society is rapidly changing with industrialization, the environmental pollution problem has a direct or indirect effect on various fields. In particular, heavy industry pollutants can be a significant variable in site selection and realestate value. Therefore, this study is based on transaction data of 13apartment complexes in Maanshan City, a representative steel city in China, and uses the Hedonic Price Model to study the effect on real estate prices, mainly on heavy industry pollution during environmental pollution. The conclusion shows that the farther away from the source of pollution, the higher values are.

■ keyword : | Heavy Industry Pollution | Hedonic Price Model | Housing Price | China |

I. Introduction

1. Background and Objectives

With accession to the World Trade Organization (WTO), China's industrial modernization has developed rapidly, which promoted the rapid growth of economic while resulted in serious environmental pollution. Among the pollution problems, air pollution has the greatest impact on human beings[1]. Clean

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air once became a scarce resource in some areas. The impact of air pollution on the living environment has also become a widespread concern of scholars. Based on the data of Beijing urban area in 2000, Zheng found that for every 10ug/m^3 of PM2.5 increased, the gap of housing price will increase by 150 yuan. Good air quality can raise housing prices because people want a better living environment[2].

During the period of rapid industrialization in the 1950s and 1960s, China's heavy industries were built in relatively concentrated areas for efficiency[3]. Maanshan city is one of the old heavy industrial bases. The environment pollution caused by heavy industry is serious due to the high amount of pollutants and the high toxicity of contaminants released from heavy industry factories.

2. Research Area

The data in this research is from Maanshan city, Anhui province, China. Maanshan city is a steel-industry-based city. In 2018, the average per capita GDP achieved 11246 dollars. The average economic growth was at the top of the whole province. Heavy industry accounts for 91% of the entire industrial sector. The steel and ironworks are the symbols of Maanshan city. The local finance contribution from this industry accounts for 70% to 80% in its total local fiscal revenue[4]. The steel manufacturing industry led by Ma Steel Group and the related sectors has brought substantial economic income to Maanshan city[5]. But it has also brought severe pollution to the environment.

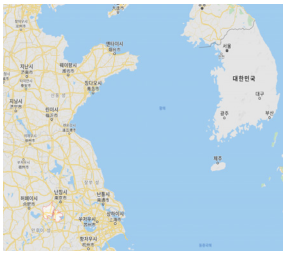

Figure 1. The Location of Maanshan City

The red part in [Figure 1] is Maanshan city.

II. Literature Review

Environmental risk increasingly affected people's lives. Frequent environmental risk incidents have gradually triggered public panic and resistance to environmental hazards, which has led to the "Not in My Backyard" (NIMBY) effect[6]. (Rong and Xie, 2015). Under the influence of NIMBY, people tend to choose a location away from the source of pollution[7].

Some previous studies have discussed the impact of the environment on housing prices. Henderson (1995) studied how air pollution affects the Boston housing, which discovered that high-income residents are more concerned about the environment surrounding their house[8]. Kim (2019) used 11498 sales of apartments in Busan Korean, found that environmental improvement will increase housing prices[9]. Hanna (2006) used Toxic Release Inventory (TRI) and census data from the 1980s for the six New England states, found that communities exposed to high levels of pollution will have lower housing prices[10].

In China, Chen (2017) used PM2.5 air quality data form 286 county-level cities found that air pollution has a significant negative impact on housing prices[11]. Zhao (2018) used a panel regression quantile method to analysis 35 large and medium-sized cities in China, found that improvement of air quality has a positive effect on housing prices[12]. Xiao (2019) used landscape data to find that Landscape proximity influences the impact of floor level on housing price significantly[13]. Chen (2020) found that environmental pollution is a significant threat to the health of Chinese residents and has caused substantial economic losses[14]. For every 10% increase in environmental pollution, local housing prices will fall by 1.12%. The decline in housing price leads to a decrease in total social wealth. Dai (2020) used the hedonic price model to investigate the impact of environmental risk on housing price in Nanjing China and showed that the higher ecological risks of chemical enterprises were associated with lower housing prices[15]. However, these studies have certain limitations in terms of research objects and perspectives.

Compared with previous studies, this paper used survey data. Which means we collected the data directly. As well known, there is not a complete real estate registration system in China. It is difficult to obtain data for a particular property. We choose Maanshan city to study with the aim to find the impact of environmental pollution on housing prices more clearly. Because Maanshan city is one of the top ten iron and steel cities in China. There are many iron and steel factories and related factories. The number of factories per square meter is higher than in other general regions. In other words, all of these factories are massive industry factories, which could bring more effective results about the impact of the research environment on housing prices.

Ⅲ. Empirical Results

1. Data

Maanshan city includes three districts and three counties[16]. In this research, we chose the Huashan district and Yushan district as the primary research areas because there are more commercial property here than other districts. we visited each local property developer and collected the data. finally, we collected 13 new apartment transaction data. The transaction time is from 2014-2016 but we collected the data in 2017. All missing observations were excluded from the sample data, and the resulting unabridged sample is 6,698. The address and opening date of each project can be obtained from the author.

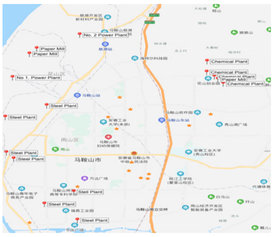

Figure 2. The Location of Real Estate Projects and Factories

2. Description of Variables

Butler (1982) pointed out that the hedonic price model should only include factors that affect housing prices[17]. In this paper, the dependent variable is the total price of housing. The distance to the pollution source is our interest variables. According to previous studies, other explanatory variables divided into three parts location, structure and neighbourhood variables. Dai (2020).

2.1 Locational Characteristics

(Dubin & Sung 1990). Found that Locational attributes are quantified through surrogate measures such as socioeconomic class, racial composition, aesthetic qualities, pollution levels, and proximity to local amenities. Transport accessibility is frequently associated with the ease of commuting to and from facilities and is measured by travelling time, convenience[18]. So, at this part, we choose the distance to the central hospital, city centre, and high-speed railway station to depict the locational of housing.

2.2 Structural Characteristics

As Ball (1973) pointed out, if a house had more desirable attributes than others did, the valuation of these attributes would be reflected in higher market prices for the house[19].

Chau (2003) said the single most crucial structural variable is the floor area[20]. Fletcher et al. (2000) found that the number of rooms and bedrooms are positively related to the sale price of houses[21]. And the number of bathrooms[22][23], the floor area[24][25] has a related to the housing prices too. Due to this reason, we choose the housing area, floor and the number of bedrooms, living room, bathroom and elevators as the variables to depict the structural attributes.

2.3 Neighbourhood Characteristics

Goodman (1989) argued that while neighbourhood attributes cannot be explicitly valued in the marketplace, they could be implicitly valued through hedonic pricing by comparing houses with differing neighbourhood qualities[26]. Goodman's caveat that failure to model neighbourhood attributes can lead to substantive errors when assessing individual properties and the market[23], in general, was validated by Linneman (1980).

In this paper, we force the local government services. The quality of public schools was found to have a significant impact on real house prices. School quality is more important to residents than either crime[27][28]. Therefore, in order to find the exact relationship between housing prices and environment pollution, we need to control this part in our model. So, we choose the distance to the nearest critical high middle, ordinary high middle school, critical junior school and total bus routes which pass by the building project as the neighbourhood attributes control variables.

Baidu maps were used to estimate the distances from each commercial property to each factory.

Residential architectural features are measured by using the residential actual real-world data. The air quality data were obtained from the ministry of ecology and environment of China.

The air quality data measured a month before the residential real estate sale, the number of days achieving better air quality days in a month, the number of days achieving light pollution in a month, and the number of days with air quality for moderate to severe pollution were selected as variables of the robustness test. Detailed information are listed in [Tables 1 and 2].

Table 1. List of Variables

	Variables	Label	Data Source
Dependent Var	LOGPRICE	Price in logarithm (yuan)	Real Estate Development Company
Variable of interesting	LOGSTEEL	Distance to nearest steel plant's logarithm view (meter)	Baidu Maps
	LOGPOWER	Distance to nearest power plant's logarithm view (meter)	Baidu Maps
	LOGCHEMICAL	Distance to nearest chemical plant's logarithm view (meter)	Baidu Maps
	LOGPAPER	Distance to nearest paper plant's logarithm view (meter)	Baidu Maps
Architectural characteristics	AREA	The area of each house (square meter)	Real Estate Development Company
	FLOOR	The floor that the house is located in	Real Estate Development Company
	ELEVATOR	Number of elevators in one house	Real Estate Development Company
	BED	Number of bedrooms in one house	Real Estate Development Company
	LIVING	Number of living rooms in one house	Real Estate Development Company
	BATH	Number of bathrooms in one house	Real Estate Development Company
Location characteristics	BUSLINE	Total bus routes which passing by the building project	Baidu Maps
	LOGSTATION	Distance to high-speed rail station's logarithm view (meter)	Baidu Maps
	LOGCITYCENTER	Distance to city center's logarithm view (meter)	Baidu Maps
Neighborhood characteristics	LOGHIGHSCHOOL1	Distance to nearest key high middle school's logarithm view (meter)	Baidu Maps
	LOGHIGHSCHOOL2	Distance to nearest ordinary high middle school's logarithm view (meter)	Baidu Maps
	LOGJUNIORSCHOOL	Distance to nearest key junior school's logarithm view (meter)	Baidu Maps
	LOGHOSPITAL	Distance to center hospital's logarithm view (meter)	Baidu Maps
Air quality	AIRQUALITY1	air quality better days	Ministry of Ecology and Environment.
	AIRQUALITY2	air quality light pollution days	Ministry of Ecology and Environment.
	AIRQUALITY3	air quality moderate to severe pollution days	Ministry of Ecology and Environment.

Descriptive statistics of variables are showed in [Table 2].

Table 2. Descriptive Statistics of Variables

Variables	N	Mean	Std. Dev.	Min	Max
LOGPRICE	6698	13.248	0.320	12.366	15.894
LOGSTEEL	6698	8.752	0.200	8.455	9.269
LOGPOWER	6698	7.863	0.374	7.244	8.666
LOGCHEMICAL	6698	8.129	0.364	7.090	8.716
LOGPAPER	6698	8.205	0.442	6.064	8.936
AREA	6698	106.728	22.336	51.200	298.170
FLOOR	6698	11.098	7.239	1.000	33.000
ELEVATOR	6698	1.826	0.517	0.000	2.000
BED	6698	2.638	0.712	1.000	5.000
LIVING	6698	2.001	0.162	1.000	3.000
BATH	6698	1.523	0.598	1.000	3.000
BUSLINE	6698	3.804	2.358	2.000	10.000
LOGHOSPITAL	6698	8.334	0.525	7.090	9.083
LOGHIGHSCHOOL1	6698	6.799	0.578	5.347	8.575
LOGHIGHSCHOOL2	6698	6.897	0.590	5.598	8.189
LOGJUNIORSCHOOL	6698	7.262	0.396	6.461	8.189
LOGCITYCENTER	6698	7.999	0.282	7.090	8.748
LOGSTATION	6698	7.980	0.500	7.170	9.071
AIRQUALITY1	6698	1.752	1.607	0.000	6.000
AIRQUALITY2	6698	7.299	3.197	3.000	12.000
AIRQUALITY3	6698	3.537	1.734	1.000	6.000

3. Model Specification

The Hedonic Price Model (HPM) was initially proposed in 1939. During the 1960s and 1970s, the Hedonic price method, also known as the Hedonic model and utility valuation method, proposed that real estate was composed of many different characteristics, and real estate prices were decided by all the characteristics that brought to people. As the number of each characteristic and the unusual combination varied, the real estate prices are different as well.

Therefore, if we can classify the influencing factors of real estate prices, we can find out the implied prices among each influential factor in real estate. In the control of real estate's characteristics (or quality) being fixed invariant, changes in real estate prices can reflect the changes in a fair price.

Hedonic Pricing Model can be expressed as: (1)

$$P = \alpha_0 + \sum \alpha_i * \quad X_i + \zeta \quad (1)$$

Where P are the logarithmic values of total price and total price; X_i is the housing attribute; ξ is error term, a_0 and a_i are the estimated coefficients.

To avoid the problem caused by multi-collinearity, correlation tests should be examined first. As the result shown is [Table 3] we can see there is no mult-collinearity problem.

4. Result and Discussion

4.1. Regression Model

To obtain more stable results, 5 equations are established as below:

Table 3. Correlation Coefficient

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
STEEL	1.000																			
POWER	0.377	1.000																		
CHEMICAL	-0.065	-0.250	1.000																	
PAPER	0.223	0.653	-0.266	1.000																
AREA	0.145	-0.074	-0.171	0.058	1.000															
FLOOR	-0.014	-0.278	0.196	-0.053	-0.001	1.000														
ELEVATOR	-0.377	-0.503	0.259	0.155	-0.091	0.333	1.000													
BED	0.276	-0.083	-0.038	0.033	0.846	0.114	-0.041	1.000												
LIVING	-0.073	-0.143	0.029	-0.164	0.330	0.101	0.002	0.314	1.000											
BATH	0.251	-0.133	0.014	0.001	0.818	0.122	0.031	0.894	0.234	1.000										
BUSLINE	0.482	0.184	-0.535	0.407	0.267	-0.011	-0.257	0.201	-0.083	0.120	1.000									
HOSPITAL	-0.360	-0.625	0.388	-0.924	-0.158	0.126	0.052	-0.108	0.162	-0.050	-0.633	1.000								
HIGHSCHOOL1	0.557	0.081	0.196	-0.420	-0.042	0.053	-0.508	0.107	0.044	0.113	-0.032	0.380	1.000							
HIGHSCHOOL2	0.162	-0.257	0.756	-0.326	-0.105	0.238	0.076	0.014	0.031	0.034	-0.159	0.373	0.390	1.000						
JUNIORSCHOOL	-0.138	-0.282	0.381	-0.769	-0.205	0.067	-0.173	-0.126	0.138	-0.062	-0.640	0.890	0.624	0.369	1.000					
CITYCENTER	-0.152	-0.177	0.417	-0.636	-0.335	0.047	-0.041	-0.232	0.082	-0.184	-0.732	0.805	0.558	0.335	0.893	1.000				
STATION	0.149	-0.520	0.385	-0.864	-0.051	0.130	-0.128	0.057	0.149	0.106	-0.386	0.853	0.643	0.495	0.844	0.699	1.000			
AIRQUALITY1	0.558	0.084	0.274	0.197	0.122	0.240	0.164	0.330	-0.038	0.364	0.014	-0.098	0.475	0.238	0.034	0.075	0.128	1.000		
AIRQUALITY2	-0.415	0.299	-0.052	0.532	-0.160	-0.178	0.184	-0.299	-0.119	-0.338	0.072	-0.508	-0.731	-0.322	-0.585	-0.375	-0.756	-0.514	1.000	
AIRQUALITY3	0.036	-0.405	-0.250	-0.612	0.198	0.022	-0.282	0.176	0.158	0.191	0.012	0.498	0.332	0.138	0.459	0.156	0.613	-0.150	-0.729	1.000

$$\begin{aligned} LOGPRICE_1 = \alpha &+ \beta_1 STEEL_1 + \beta_2 AERA_1 + \beta_3 FLOOR_1 + \beta_4 ELEVATOR_1 \\ &+ \beta_5 BEDROOM_1 + \beta_6 LIVINGROOM_1 + \beta_7 BATHROOM_1 + \beta_8 BUSLINE_1 \\ &+ \beta_9 LOGHOSPITAL_1 + \beta_{10} LOGHIGHSCHOOL1_1 + \beta_{11} LOGHIGHSCHOOL2_1 \\ &+ \beta_{12} LOGJUNIORSCHOOL_1 + \beta_{13} LOGCITYCENTER_1 + \beta_{14} LOGSTATION_1 \end{aligned}$$

$$\begin{aligned} LOGPRICE_2 = \alpha &+ \beta_1 POWER_2 + \beta_2 AERA_2 + \beta_3 FLOOR_2 + \beta_4 ELEVATOR_2 \\ &+ \beta_5 BEDROOM_2 + \beta_6 LIVINGROOM_2 + \beta_7 BATHROOM_2 + \beta_8 BUSLINE_2 \\ &+ \beta_9 LOGHOSPITAL_2 + \beta_{10} LOGHIGHSCHOOL1_2 + \beta_{11} LOGHIGHSCHOOL2_2 \\ &+ \beta_{12} LOGJUNIORSCHOOL_2 + \beta_{13} LOGCITYCENTER_2 + \beta_{14} LOGSTATION_2 \end{aligned}$$

$$\begin{aligned} LOGPRICE_3 = \alpha &+ \beta_1 CHEMICALP_3 + \beta_2 AERA_3 + \beta_3 FLOOR_3 + \beta_4 ELEVATOR_3 \\ &+ \beta_5 BEDROOM_3 + \beta_6 LIVINGROOM_3 + \beta_7 BATHROOM_3 + \beta_8 BUSLINE_3 \\ &+ \beta_9 LOGHOSPITAL_3 + \beta_{10} LOGHIGHSCHOOL1_3 + \beta_{11} LOGHIGHSCHOOL2_3 \\ &+ \beta_{12} LOGJUNIORSCHOOL_3 + \beta_{13} LOGCITYCENTER_3 + \beta_{14} LOGSTATION_3 \end{aligned}$$

$$\begin{aligned} LOGPRICE_4 = \alpha &+ \beta_1 PAPERMALL_4 + \beta_2 AERA_4 + \beta_3 FLOOR_4 + \beta_4 ELEVATOR_4 \\ &+ \beta_5 BEDROOM_4 + \beta_6 LIVINGROOM_4 + \beta_7 BATHROOM_4 + \beta_8 BUSLINE_4 \\ &+ \beta_9 LOGHOSPITAL_4 + \beta_{10} LOGHIGHSCHOOL1_4 + \beta_{11} LOGHIGHSCHOOL2_4 \\ &+ \beta_{12} LOGJUNIORSCHOOL_4 + \beta_{13} LOGCITYCENTER_4 + \beta_{14} LOGSTATION_4 \end{aligned}$$

$$\begin{aligned} LOGPRICE_5 = \alpha &+ \beta_1 STEEL_5 + \beta_2 POWER_5 + \beta_3 CHEMICALP_5 + \beta_4 PAPERMALL_5 + \beta_5 AERA_5 \\ &+ \beta_6 FLOOR_5 + \beta_7 ELEVATOR_5 + \beta_8 BEDROOM_5 + \beta_9 LIVINGROOM_5 \\ &+ \beta_{10} BATHROOM_5 + \beta_{11} BUSLINE_5 + \beta_{12} LOGHOSPITAL_5 \\ &+ \beta_{13} LOGHIGHSCHOOL1_5 + \beta_{14} LOGHIGHSCHOOL2_5 \\ &+ \beta_{15} LOGJUNIORSCHOOL_5 + \beta_{16} LOGCITYCENTER_5 + \beta_{17} LOGSTATION_5 \end{aligned}$$

The results are reported in [Table 4].

Table 4. Regression Model

LOGPRICE	Model 1 Coef. (Std.Err.)	Model 2 Coef. (Std.Err.)	Model 3 Coef. (Std.Err.)	Model 4 Coef. (Std.Err.)	Model 5 Coef. (Std.Err.)
LOGSTEEL	0.5077***				0.5776***
	(0.0198)				(0.0234)
LOGPOWER		0.1658***			0.4730***
		(0.0153)			(0.0232)
LOGCHEMICAL			0.0470***		0.1120***
			(0.0073)		(0.0072)
LOGPAPER				0.2109***	0.5785***
				(0.0126)	(0.0149)
AREA	0.0107***	0.0104***	0.0101***	0.0097***	0.0103***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
FLOOR	0.0061***	0.0060***	0.0060***	0.0057***	0.0052***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)
ELEVATOR	−0.0736***	−0.0565***	−0.1144***	−0.2066***	−0.1743***
	(0.0040)	(0.0064)	(0.0039)	(0.0068)	(0.0067)
BED	0.0011	0.0045	0.0027	−0.0084	−0.0305***
	(0.0047)	(0.0049)	(0.0050)	(0.0049)	(0.0043)
LIVING	0.1309***	0.1187***	0.1245***	0.1371***	0.1619***
	(0.0090)	(0.0093)	(0.0094)	(0.0093)	(0.0081)
BATH	−0.0310***	−0.0111	−0.0019	0.0138**	0.0004

	(0.0057)	(0.0058)	(0.0058)	(0.0058)	(0.0051)
BUSLINE	−0.0160***	−0.0216***	−0.0154***	−0.0232***	0.0113***
	(0.0015)	(0.0016)	(0.0020)	(0.0016)	(0.0019)
LOGHOSPITAL	0.3166***	0.3152***	0.1854***	0.2715***	0.9865***
	(0.0100)	(0.0153)	(0.0089)	(0.0103)	(0.0229)
LOGHIGHSCHOOL1	−0.0036	0.1414***	0.0976***	0.1316***	0.1165***
	(0.0066)	(0.0061)	(0.0055)	(0.0053)	(0.0100)
LOGHIGHSCHOOL2	0.0570***	0.0520***	0.0538***	0.0534***	−0.0558***
	(0.0029)	(0.0033)	(0.0037)	(0.0031)	(0.0046)
LOGJUNIORSCHOOL	−0.1417***	−0.6178***	−0.4486***	−0.6683***	−1.0211***
	(0.0213)	(0.0224)	(0.0180)	(0.0211)	(0.0413)
LOGCITYCENTER	−0.4340***	−0.4055***	−0.3148***	−0.1580***	−0.1619***
	(0.0121)	(0.0138)	(0.0121)	(0.0155)	(0.0135)
LOGSTATION	−0.2362***	0.0542***	−.00399***	0.1066***	0.3638***
	(0.0105)	(0.0109)	(0.0073)	(0.0110)	(0.0252)
CONS	10.9470***	14.0643***	−0.0399***	12.3394***	−5.1344***
	(0.2097)	(0.1840)	(0.1256)	(0.2254)	(0.0252)
R-squared	0.8898	0.8811	0.8798	0.8839	0.9123
N	6698	6698	6698	6698	6698
√ *** significant at 1%, ** significant at 5%, * significant at 10%.					
√ tables report regression coefficients and their standard errors (in parentheses)					

The results presented that four variables of interest are significant in all these models. In general, the closer the house was to the industrial pollution sources, the lower the price. The adverse effects of industrial pollution sources on the price of housing value was more significant as the distance shortened. The further the house was away from industrial pollution, or the less the house was influenced by industrial pollution, the higher the real estate value. Distances between the place of residence and industrial pollution sources are positively related. According to the regression results of model 5, for every 1% increase in the distance between the house and the steel plants, power plants, chemical plants, and paper mills, the housing price will increase by 0.58%, 0.47%, 0.11%, and 0.58% respectively.

The variables of interests including residential distance to the nearest steel plant, power plant, chemical plant and paper mill are highly correlated with the dependent variable. As expected, their signs are positive. When the control variables are held constant, the farther distances between residential areas to the steel plant, power plants, chemical plants and paper mills resulted in the higher housing prices.

The steel plant pollution mainly results in air pollution because lots of coal are used during steelmaking. The power plant and paper mill pollution leads mostly to air pollution as well. And the chemical plant pollution contributed highly to the air pollution as well due to equipment leakage. These pollutants can spread in the wind, and in turn, pollute rivers and groundwater. It will harm the health of humans, animals and plants when absorbing the pollutants from the poisoned air, rivers and land if the contaminants cannot be removed. Besides, the chemical plant is found to have the most significant impact on the explained variable in the research.

The architectural characteristics including housing area, floor, number of rooms, number and elevators are found to have significant effects. Housing area including the number of their floors and the number of living rooms are positively correlated with the housing prices. This suggests that a large residential area, a high floor, and more living rooms would increase the price of housing. The number of elevators and the number of bedrooms is found to be negatively correlated with the explanatory variable. That is, less elevators and bedrooms are supposed to increase the housing prices. The correlation between the number of bathrooms and housing prices was not significant.

Elevator installation is negatively correlated with the explained variable and those low-density residential buildings including garden houses and villas without elevators are popular because they have a higher greening rate. However, those small high-rise buildings usually have more than one elevator, and therefore, are unpopular among local people because they have higher plot ratio and construction density.

The impacts of location characteristics including distance to the downtown hospital, city center and railway station are significant as well. The distance to the downtown hospital and railway station is positively correlated with the residential prices. When the control variables remain the same, the farther distances of residential areas to the hospital or the city center as well as the railway station is, the higher the price of houses is. The distance to the city center is negatively correlated with the residential prices as we can expect.

Hospital is positively correlated with the explained variable. Generally, the residential building will be priced higher if it is farther away from the hospital. In China, people do not's want to live around the hospital because they think that there are more bacteria and viruses around the hospital, and it is unlucky to live around there.

The distances to key middle schools and bus routes are positively correlated with the residential prices. The other control variables being equal, the longer the distances from key middle schools or the higher number of bus routes is, the higher the housing prices are. The distances to normal middle schools or primary schools are negatively correlated with the residential prices of the explained variable. The other control variables being equal, the shorter the distance from normal middle schools or primary school is, the higher the housing prices are.

4.2 Robustness Test

In the robustness test, the air quality observed a month before the residential real estate sale, the number of days achieving better air quality days in a month, the number of days with light pollution, and the number of days with air quality for moderate to severe pollution were selected as variables of interest.

[Table 5] shows that both the number of days achieving better air quality in a month and the number of days with air quality of moderate to severe pollution have significant impacts on the housing prices, implying the considerable effect of pollution on housing transaction prices.

As shown from the results, the number of days achieving better air quality days in a month before the residential real estate sale is positively correlated with the residential prices. A better air quality or a greater number of days achieving better air quality days in a month before the residential real estate sale is expected to increase the housing price of this aera. The number of days with air quality for moderate to severe pollution is negatively correlated with residential prices. The

Table 5. Robustness Test

LOGPRICE	Model 1	Model 2	Model 3	Model 4
	Coef.	Coef.	Coef.	Coef.
	(Std.Err.)	(Std.Err.)	(Std.Err.)	(Std.Err.)
AIRQUALITY1	0.0606***			0.0553***
	(0.0014)			(0.0015)
AIRQUALITY2		−0.0041***		0.0539***
		(0.0006)		(0.0061)
AIRQUALITY3			−0.0116***	−0.1198***
			(0.0014)	(0.0125)
AREA	0.0103***	0.0102***	0.0102***	0.0105***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
FLOOR	0.0057***	0.0060***	0.0060***	0.0057***
	(0.0001)	(0.0002)	(0.0002)	(0.0001)
ELEVATOR	−0.1796***	−0.1152***	−0.1173***	−0.1868***
	(0.0038)	(0.0039)	(0.0039)	(0.0038)
BED	−0.0198***	0.0034	0.0034	−0.0184***
	(0.0045)	(0.0050)	(0.0049)	(0.0044)
LIVING	0.1605***	0.1233***	0.1233***	0.1566***
	(0.0084)	(0.0094)	(0.0094)	(0.0089)
BATH	−0.0183***	−0.0034	−0.0037	−0.0223***
	(0.0052)	(0.0059)	(0.0058)	(0.0052)
BUSLINE	−0.0014	−0.0230***	−0.0231***	−0.0064***
	(0.0015)	(0.0016)	(0.0016)	(0.0015)
LOGHOSPITAL	0.1347***	0.1890***	0.1874***	0.0961***
	(0.0080)	(0.0090)	(0.0089)	(0.0095)
LOGHIGHSCHOOL1	−0.0765***	0.1098***	0.1095***	−0.0686***
	(0.0064)	(0.0053)	(0.0052)	(0.0064)
LOGHIGHSCHOOL2	0.0657***	0.0651***	0.0636***	0.0554***
	(0.0027)	(0.0031)	(0.0031)	(0.0028)
LOGJUNIORSCHOOL	−0.2191***	−0.4687***	−0.4624***	−0.1765***
	(0.0169)	(0.0177)	(0.0177)	(0.0173)
LOGCITYCENTER	−0.3196***	−0.3524***	−0.3667***	−0.4029***
	(0.0106)	(0.0125)	(0.0127)	(0.0125)
LOGSTATION	−0.0211**	−0.0171***	−0.0036	0.0671***
	(0.0065)	(0.0078)	(0.0081)	(0.0099)
_CONS	15.3248	15.7559***	15.7572***	15.3760 ***
	(0.0871)	(0.0969)	(0.0967)	(0.0863)
R-squared	0.9043	0.8797	0.8803	0.9064
N	6698	6698	6698	6698
√ *** significant at 1%, ** significant at 5%, * significant at 10%.				
√ tables report regression coefficients and their standard errors (in parentheses)				

remaining control variables being the same, the more the number of days light pollution and the number of days with air quality for moderate to severe pollution are, the lower the price of housing is. However, the number of days with the air quality of light pollution is not very stable as we might expect. The results within this study show that housing area, the number of the floor, bedrooms, living rooms, restrooms, elevator installation, bus routes and distance to the hospital, city center, railway station, key middle school, general secondary school and junior school are all the significant factors determining the residential prices.

Among them, the housing area, floor and the number of the living rooms, the distance to the hospital and ordinary high school are positively related to the residential prices while the number of elevators, bedrooms, bathrooms, bus routes and distance to key middle school, primary school, city center and railway station are negatively related to the residential price

Ⅳ. Conclusion

The aim of this research is to construct the hedonic price model of real estate, analyze the factors affecting urban real estate prices, and focus on the influences of heavy industrial pollution on housing prices. We used survey data and conducted a robustness test. The results remained stable. Through this research, the effects of environmental pollution on real estate prices in heavy industrial city is confirmed.

As to the way to decrease the negative influence of environmental pollutants on house prices, we can control the output of industrial pollution sources from its origins. Steel enterprises, power plants, chemical plants and paper plants are primary pollution sources. Comprehensive treatment of industrial pollution should start from changing the energy structure, and low-waste and non-waste technologies should be adopted. Industrial enterprises should pay much attention to energy saving and exhaustion reduction and emphasize the recycling of secondary energy. Rigorous environment-friendly standards should be set, the advanced and highly efficient technologies of protecting the environment should be conducted to carry out overall and perfect treatment of the industrial pollutants. This paper only used 13 apartment transaction data and thus could not explore more comprehensively. Another limitation, in terms of research methods, spatial econometrics can be used. Future study may consider more micro data and research method.

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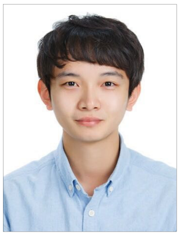

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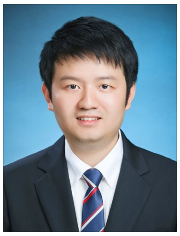

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