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The Effect of Three Incineration Plants on Residential Property Values in Hangzhou, China

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Incineration plants and derelict industrial sites can have a number of adverse effects on the local environment and social welfare, including the diminution of property values. Although there are many incineration plants in China, there has been relatively little research done to quantify their negative externality effects. This study therefore considers the effects of three municipal incineration plants in Hangzhou city on residential property values. Hedonic pricing modeling of 2,200 residential transactions in over 70 multifamily buildings within ten kilometers of the incineration plants over a one year period including 2014 and 2015 is carried out. Generally, the results show that the neighboring properties show decreases in the initial listing price of up to 25%, declining until the effect is gone about three kilometers from the incinerator. The most consistent losses are approximately 10% between 1-2 kilometers from the nearest incinerator. These results are comparable to similar situations in the United States and Canada.

Keywords

Incinerator, Property Values, Regression Analysis, China

1. Introduction

The urban garbage crisis in large Chinese cities is growing, as substantial urban growth has forced municipalities to deal with rapid increases in solid waste and inefficient garbage treatment methods, and related pollution issues. Incineration is becoming widely used to reduce the burial of municipal solid waste, treat potentially infectious medical waste, and reduce the potential toxicity and volume of hazardous chemical and biological waste. The garbage incineration rate in China was 19.6% at the end of 2010. Furthermore, garbage incinerator projects are being installed at a faster rate in the current twelfth five-year plan of China. China had expected to incinerate up to 35% of its garbage nationwide and 48% in the eastern developing regions at the end of 2015 (Yang, 2013).

Whether incineration is the best way to manage waste has been debated across Asia. A major aspect of the debate is the potential risk to human health related to the emissions of potentially hazardous pollutants co-generated by the incineration process (Committee on Health Effects of Waste Incineration; Board on Environmental Studies and Toxicology; Commission on Life Sciences; Division on Earth and Life Studies; National Research Council, 2000). A major challenge in siting incinerators is local community opposition. Citizen action groups assert that incineration is associated with noxious odors, declining property values, and visual disamenities. Many studies have found a negative relationship between adverse environmental conditions, like air pollution, and economic effects on wages and lower property values. However, although there are many incinerators found in China, there has been very little research that evaluates the impacts of these negative externalities. This research therefore attempts to fill this research gap.

This study considers the effects of three incineration plants in Hangzhou city (located about 4 hours west of Shanghai, China) on residential property values. This paper is organized as follows: first, we review the academic literature on the impact of undesirable facilities, primarily incinerators, refineries, and other facilities of air pollution on property values. Next, a residential transaction data set of 2,200 observations is provided. After that, we present several hedonic pricing models in 70 neighborhoods within ten kilometers of the incinerators for 2014 and 2015. Consistent with expectations, we find that residential properties that are near (within three kilometers) the incinerators are more adversely affected than properties located further away from the site. The effects are nearly always negative within 3 kilometers, but the magnitude of the price reductions vary somewhat between the three incinerator locales. We then compare these results with those in the United States and Canada, and conclude with a discussion on future research topics.

2. Literature

Incinerators, like other municipal waste facilities, (i.e., landfills, material recovery facilities, recycling plants, etc.) are generally associated with the external cost of air pollutants such as particulates, nitrogen oxide (NO_x), dioxins, sulfur dioxide (SO_2), and other combustion byproducts (e.g., ash). On the other hand, they may offer some indirect benefits through the co-generation of electricity. Incineration plants are usually placed near or in large cities, close to both the source of garbage and the potential consumers of recovered energy. As a result, relatively more people are likely to be exposed to any negative effect. Disamenities associated with proximity to incinerators may include odor, dust, wind-blown litter, vermin, flies, visual intrusion, noise, traffic, and the focus of this paper, which is a negative effect on residential property values.

The conventional theory, which applies hedonic regression (Rosen, 1974), holds that the value of a house is determined by its characteristics, including neighborhood amenities or disamenities. Thus proximity to an undesirable facility is reflected by a price that is lower than that of an identical house that is not near such a facility, holding all else constant. Hedonic price models have long been used to value not only the physical attributes of housing units (e.g., square footage, number of bathrooms, and air conditioning) but also the surrounding location and environmental amenities (e.g., local school quality, crime rates, and air quality). Since the 1980s, many studies have evaluated the effect of hazardous or undesirable facilities, including the following: landfills (Hite et al., 2001; Akinjare et al., 2011), petroleum/gasoline storage and transport (Simons et al., 1997; 2001; Boxall et al., 2005), groundwater contamination (Rabinowitz and Page 1993) and waste sites (McCluskey and Rausser, 2001; Ihlanfeldt and Taylor, 2004), on nearby real estate.

2.1 Incinerators and Air Pollution Studies

As previously noted, there are relatively few studies that focus on the impact of incinerator facilities on property values. Zeiss and Atwater (1989) evaluate the impact of a landfill on property prices in Tacoma, Washington and an upcoming incinerator in Salem, Oregon on property prices. In the former, they used hedonic price regressions on three neighborhoods; that is, between 135 and 350 properties sold for the period of 1983 to 1986. In the latter, they also used hedonic regression analyses on between 25 and 90 properties sold for the period of 1983 to 1987. The results show that the landfill does not appear to affect property values in the host community. In terms of the incinerator, none of the facility impact variables is significant in explaining the variation in prices during any of the three siting phases.

Zeiss (1990) has used the listings and sales data of residential properties obtained by compiling a list of all street addresses within a 5-kilometer (about 3 miles) radius of a site between January 1982 and December 1988 to carry out a multiple regression analysis on property and facility impact characteristics of sold properties in a host community. He found that there is only a moderate effect on residential real estate sales because of the incinerator, and the incinerator does not cause community destabilization.

Kiel and McClain (1995a) have collected data on 2,593 single family home sales in North Andover, Massachusetts from January 1974-May 1992 to evaluate the effects of opening and operating an incinerator on residential appreciation rates in the Boston, Massachusetts area. They take into consideration sales during five stages: pre-incinerator (1974-1978); rumor (1979 -1980); construction (1981-1984); online (1985-1988); and ongoing operation (1989 -1992). They find that response to prices are related to distance from the incinerator site and over time. There are no observable effects during the pre-rumor and rumor stages, but adverse effects are evident during the construction ($2,283 per mile), online ($8,100 per mile) and operation ($6,607 per mile) phases.

In a related article, Kiel and McClain (1995b) evaluate the effect of opening and operating an incinerator on residential sales price in the Boston area. With the same time frame and data set from their previous study, they then use a hedonic regression analysis on a smaller subset of 310 sales- resales within several miles of the site. The distance variable from the facility shows no effect prior to construction. They find that housing appreciation rates fell by 2% during the construction phase, 3% during the operation phase and 3.5% during ongoing operations.

Eshet et al. (2005) summarize and analyze the valuations of externalities related to landfilling and incineration of municipal solid waste, and address both the values and methods conducted since 1990. Their results show that the reduction in housing prices is between 2.8% and 30% within 1 kilometer of the landfill and incinerator.

Several papers have provided the results of analyses carried out on the effect of other forms of air pollution on residential property values in the United States, namely hog barns and refineries.

For instance, Simons et al. (2014) examine the economic impact of a tightly clustered complex of hog barns, which is a type of concentrated animal feeding operation (CAFO), on residential property in a rural area near Benton, Kentucky. Based on over 200 sales, the results show price reductions of 23-32% for residential properties sold within 1.25 miles of the facility, and much larger losses northeast (downwind) of the facility.

Flower and Ragas (1994) study the effects of two petroleum refineries located 1½ miles apart in St. Bernard Parish, Louisiana, just east of New Orleans, on residential property values. They use hedonic regression models to analyze sales of 1,999 homes from 1979 to 1991 near the refineries, based on proximity and air pollution. Their analysis finds losses of 5% in the area near one refinery and 1.5% for homes within half a mile of the other refinery. Proximity, neighborhood prestige, and the quality of a buffer are found to contribute to differences in the losses experienced by homes near the refineries. The authors use distance rings to determine the affected areas.

Simons et al. (2015) study the effects of refinery air pollution on house prices near Houston, Texas. A total of 3,964 residential MLS sales from 2006-2011 are used to populate an ordinary least squares (OLS) model, a spatial model, and a spatial model with an additional endogenous variable. The findings indicate that residential properties in an affected area within about two miles of the refinery sold for 6- 8% less, holding all else constant. With the use of a spatial ring model, the negative effect was shown for one year to generally diminish with distance up to about two miles from the refinery.

2.2 Externality Research Papers in China

Even though there are numerous articles on the effect of various factors on real estate prices in Chinese property markets, the peer-reviewed literature has focused on the valuation of positive effects, such as green space, subway, views, and schools. Jiang (2006) uses a non-parametric regression model to assess housing price around West Lake in Hangzhou. The analysis finds that every 1% increase in distance from house to the lake leads to a value reduction of 16.4%. Shi et al. (2010) apply a hedonic pricing method to analyze the effects of the Huang Xing Park in Shanghai city on the surrounding residential prices, and the results show that its maximum impact radius is 1.6 kilometers, and the strongest impact location within 0. 3 kilometer. Nie et al. (2010) quantitatively analyze the spatial and temporal effects on the surrounding property value from 2001 to 2007 of the Shenzhen Metro Line Phase 1 with haplotype pattern mining (HPM), which is a statistical method. The results show that the transit line has a positive spatial effect on the property value within a radius of 700 m around the stations. The property value increment within the radius of 700 m and 100 m is 19.5 % and 37.8 % respectively.

However, almost no work in the Chinese literature has addressed negative property value effects produced by industrial factories, waste sites, landfills, or incinerators on home value. Furthermore, the only available papers are qualitative impact studies, such as whether contamination has had an effect on price. Wang (2005) provides a means to analyze the effect of gas stations on nearby houses by introducing methods and steps for the valuation of real estate, but does not actually analyze actual cases. Zhang (2007) studies residential units affected by electromagnetic fields, and collects sales, second-hand (existing resale) housing and rental prices, and compares them with Beijing housing price changes over the same period of time. The results show that these facilities can affect long-term sales prices through stagnation or even decline, and that sales price also fluctuates with media reports. Furthermore, a strong market and pollution control reduce negative effects on sales prices. However, Zhang (2007) only uses a comparison method to value the extent of the effects.

Zheng (2009) estimates the economic value of clean air in Beijing, and the results show that a decrease of 1 microgram per cubic meters in total suspended particulate (TSP) is associated with a 0.93 percent increase in property value.

Chen and Hao (2013) analyze the negative willingness of residents to pay for waste transfer stations based on a study of spatial differences for 25,200 second-hand house prices in Shanghai. They find that housing prices drop 3.6% for each kilometer closer to the waste transfer station.

Li et al. (2015) explore the impact of soil and groundwater pollution remediation on housing prices in Taiwan. First, they used hedonic regression analysis, but due to limited sales and the small number of sales near the polluted sites, it is very difficult to use this method to evaluate the effect. They then use a contingent valuation analysis to investigate the willingness of buyers to pay, and find that after a hypothetical pollution remediation, the study respondents are willing to pay an average of $1,168 per square meter, slightly higher than current price of $1,059 per square meter of the surrounding real estate. This equals to a clean-up premium of 10%.

Thus, with respect to the potential negative externalities on residential property value in China, there is a lack of quantitative research on ways to value the effects, research methods that should be used, and extent of the effects. This paper therefore addresses these shortcomings with three incinerator projects in Hangzhou, China.

3. Study Area

Hangzhou is the capital of Zhejiang Province and the local political, economic and cultural center with a registered population of 8.89 million in 2014. The sub-provincial city of Hangzhou is the core of the Hangzhou Metropolitan Area, and the fourth-largest metropolitan area in China. It comprises 9 districts, 2 cities, and 2 counties. In 2014, the GDP per capita in Hangzhou was RMB 103,757 (USD 16,900, according to the 2014 exchange rate) and the urbanization rate was about 74.3%.

According to the Hangzhou Statistics Yearbook (Hangzhou Municipal Bureau of Statistics 2014), investment in real estate development was 230.1 billion yuan, up 24.2% over the previous year. The average price of commercial housing sales was 15,700 yuan/square meters (265 yuan/square foot), down by 8.4%. Housing construction completed in the Hangzhou area was up 28.1 % over the previous year. Meanwhile, the amount of solid waste has also increased at a 10% annual growth rate in recent years (Hangzhou Municipal Bureau of Environmental Protection, 2014).

The three municipal solid waste (MSW) incinerator plants analyzed in this study are Hangzhou Nengda Green Energy Co., Ltd (Nengda), Hangzhou

Lvneng Environment Protection Power Plant (Lvneng), and Jinjiang Green Energy Co., Ltd (Jinjiang) plants (see Table 1). According to the Hangzhou Environmental Sanitation Planning (2008-2020) that was released by the Hangzhou Municipal Bureau of City Planning (2014), the Nengda plant is located in the Spain/Sanxin Industrial Park (formerly Qiaosi Spain Industrial Park) in the Yuhang District. It covers an area of 46,200 square meters (about 12 acres). It was phased into operation between 2001 and 2004. The facility burns up to 800 tons of municipal waste per day (an annual average of 220,000 tons), from its local service area. The Nengda plant is mainly responsible for part of the MSW disposal of the Shangcheng, Xiacheng, Yuhang and Jianggan Districts, Hangzhou Economic and Technological Development Zone, and the MSW disposal of Pengfu, Jiubao, Jianqiao and Qiaosi Towns, and Xiasha Street.

Table 1 Characteristics of Three Incinerator Facilities in Hangzhou, China

Incinerator plant	Area (m2)	Treatment Capacity (tons per day)	Collection Area
Nengda plant	46,200	800	Shangcheng, Xiacheng, Yuhang and Jianggan Districts Hangzhou Economic and Technological Development Zone, and the municipal solid waste disposal of Pengfu, Jiubao, Jianqiao, and Qiaosi Towns, and Xiasha Street
Lvneng plant	42,620	500-600 (current); 1050 (final)	Shangcheng District, Westlake District, Shangsi area, parts of Jianggan District, and all of Binjiang District
Jinjiang plant	58,667	800(current); 1,200(final)	Xiaoshan District and the southern towns of Hangzhou City

Source: Hangzhou Environmental Sanitation planning (2008-2020)

The Lvneng plant is located on Puyan Street East in the Binjiang District, and was put into use in August 2004. The Lvneng plant is responsible for the Shangcheng and Westlake Districts, Shangsi area, parts of the Jianggan District, and all of the Binjiang District. In the first phase, the treatment capacity was 450 tons /day, and the current capacity is now 500-600 tons /day, with the capacity of the final design being 1,050 tons / day.

The Jinjiang plant is located on Shushan Street in Panqiao Village in the district of Xiaoshan. It is 58,667 square meters in size (about 15 acres). The main project was put into use in August 2007, and the facility burns up to 800 tons of municipal waste per day, with a maximum daily capacity of up to 1,200 tons. It is responsible for the incineration of waste for the Xiaoshan District and the southern towns.

4. Residential Transaction Data Set and Models

Hedonic price modeling is the standard approach for estimating the effects of negative externalities on residential property value, and the dependent variable is typically transaction price. Our analysis of residential property sales uses standard hedonic regression techniques (see Rosen 1974; Simons et al. 2014; 2015). The dependent variable is the natural log of the original housing listed prices, and the independent variables include a number of housing-related control variables. The vectors of the independent factors include housing characteristics (typically for stacked-flat condominium sales), location, neighborhood characteristics, and proximity to the incinerator, and measured in various ways, including an approach that uses distance rings. The model takes the form:

$$HP = \beta 0 + \beta_1 HC + \beta_2 LOC + \beta_3 INCIN + \varepsilon \quad (1)$$

where:

HP = the initial listed sales price of each condominium unit sold: in either linear or log form;

β_0 = the model intercept;

HC = a vector of housing physical characteristics, including: livable floor area, number of bedrooms, living rooms, and bathrooms, floor, a high rise dummy, unit finishing/decor, and age at date of sale;

LOC = a vector of proximity variables for distance to: subway station, bus, central business district (CBD; Hangzhou government center), nearest shopping mall, school, main highway, and industrial park;

INCIN = the distance of the home from the nearest incinerator, measured by distance or in distance rings of 1 kilometer, as discussed below; and

ε = the model error term.

In general, data on second-hand (resale) housing transactions are difficult to obtain from government offices in China. Online listings of second-hand housing for sale are generally transparent and available in real time, but the actual final transactions prices are generally not readily available. The data collected for this paper originate from two sources. The housing resale listings data originate from "listings to sell" on http://hz.58.com/[1] , and information on the distance to all locational variables (including to the nearest incinerator) is found by using an electronic map (http://map.baidu.com).The authenticity and validity of these data sources are high and generally considered to be accurate.

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[1] 58.com is the leading and largest live classification information website in China. Its services cover all areas of life, such as housing rental, second-hand sales, job recruitment, car rentals, etc. and all of the large and medium-sized cities in China. It provides nearly one million daily rental and second-hand housing sales data points.

This paper uses original listing prices for residential condominium transaction data sold between September 2014 and April 2015[2]. Second-hand (resale) housing transactions originate from published information of a private real estate agency, and duplicate sales are eliminated. As mentioned above, the residential listing price is obtained from http://hz.58.com. The authors recognize that this variable is generally considered less desirable than the actual sales price as the dependent variable. Overall, the listing price is typically 3-5% higher than the eventual sales price, and this ratio is generally consistent across US markets. The difference is typically due to negotiation. However, in China, the use of listing price as a dependent variable is not uncommon, partly because of the lack of reliable public real estate data, and the cost of private sector sales data. Plus, due to a real estate transfer tax and potential capital gains tax, some buyers avoid taxes through side deals to reduce their tax liability. Thus, the use of the listing price as a dependent variable may actually be more reliable than

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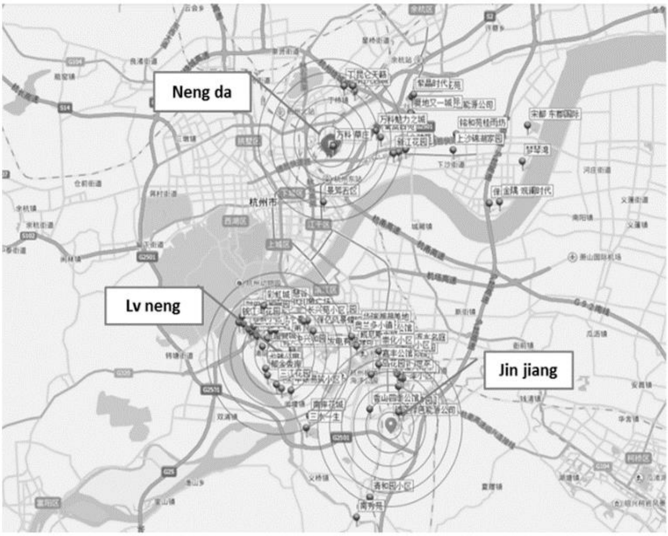
[2] Wen (2004) carries out a study on the stability of the listing-sales price ratio, analyzes the relationship between residential listing price and eventual transaction price based on a sample of 270 pairs of listing-sales price in Hangzhou City in 2004, and finds a significant linear relationship, in which transaction price = -1.196 + 0.930 * listing price, relative to the Chinese housing market, which is in the same city that the incinerators are located. A bivariate plot indicates that the adjusted R^2 which reflects the relationship between listing and transaction prices is 0.983, which is very close. Furthermore, the variance of the residuals of the cumulative probabilities of the observations and the expected cumulative probability is normally distributed (Wen (2004)). We have utilized this transformation for the current paper. Listing-sales price transformation in Haizhen has been previously used in the Chinese real estate literature. For example, Wu et al. (2008) analyze the impacts of lakes and landscaping on residential house values in Nanjing, and use the listing price as the dependent variable in a hedonic price model. As with the current case, it is acknowledged that the use of sales price is in theory, better, but reliable sales price data are difficult to obtain. The potential magnitude of error in the use of the listing data is small, as there is a correlation coefficient of 0.97 (listing-sales) based on a data set of sales in 2006 collected from a private real estate company in Nanjing (the sample size is 49). In China today, the on-line listing price by homeowners/sellers reflects the anticipated price to the seller in a competitive market with acceptably complete information. Hence, the seller's listing prices may be more sensitive to market fluctuations, and are often considered to better reflect the true market value (Pollakowski, 1995). Also, according to "The China Household Finance Survey Report 2012" published by the Southwestern University of Finance and Economics, the relationship between self-reported price by Chinese families and market price is 95%, thus indicating that self-reported home and market prices are closely related.

Furthermore, Hao and Chen (2014) investigate the level of residential segregation in 2010 in Shanghai and its impacts on neighborhood house prices. Listing price is again used as the dependent variable in the hedonic price model. They point out that ideal second-hand housing prices should be the actual transaction price, but because of the real estate transfer tax in China, with related capital gains tax liability, the reliability of the actual sales price may be low, because personal property or other valuable goods or services may be transferred to the seller in a "side deal", (off the record) in order to keep the registered sales price low and thus minimize the transfer tax. Thus, we conclude that residential sales prices tend to be systematically underestimated, consistent with Wu et al. (2008).

the sales price in China. Thus, we employ transformation of listing-sales price specific to Hangzhou per Wen (2004), while acknowledging the potential problems of utilizing the listing price as a dependent variable.

The data set yields 2,258 transactions. Table 2 shows the location of the incinerator and nearby residential neighborhoods, and the number of transactions in each neighborhood.

Table 2 Maps and Neighborhoods near all Three Incinerators in Hangzhou, China



Number	Neighborhood	Sales	Longitude	Latitude	Average Listing Price	Distance to the Nearest Incinerator
1	ZXHY	22	120.188079	30.16268	119.286	1.30
2	JSMC	23	120.161078	30.164881	113.727	1.60
3	DHYD	14	120.165448	30.17097	119.385	1.70
4	GYGY	20	120.163902	30.148214	125.789	1.60
5	LCXZ	32	120.165396	30.143607	191.632	1.90
6	SJHY	47	120.17343	30.136463	117.402	2.40
7	JNMK	49	120.178049	30.133277	116.727	2.80
8	BWY	22	120.172901	30.177605	158.619	2.20
9	CDZCH	25	120.168333	30.177043	144.271	2.20
10	RDXQ	46	120.155518	30.172929	134.400	2.50
11	ZLYZHU	13	120.186519	30.131965	118.417	3.20
12	JJXQ	63	120.152905	30.179743	123.206	3.20
13	LCQY	44	120.154614	30.174537	176.865	2.70
14	JNWY	45	120.150207	30.176051	136.511	3.10
15	ZXXQ	4	120.14845	30.177995	94.500	3.40

(Continued…)

(Table 2 Continued)

Number	Neighborhood	Sales	Longitude	Latitude	Average Listing Price	Distance to the Nearest Incinerator
16	XDYXGCH	28	120.178398	30.190139	59.370	3.60
17	CHXY	13	120.198285	30.18413	143.167	3.60
18	NAJD	36	120.201934	30.184309	148.114	3.90
19	BYFJDY	66	120.207167	30.176418	134.354	3.70
20	BSHHY	53	120.154981	30.188523	294.788	3.90
21	YTGCH	58	120.143919	30.182147	194.439	4.00
22	QHWHY	69	120.139503	30.182717	190.978	4.40
23	TYXQ	46	120.159941	30.193284	200.349	4.20
24	CHC	75	120.162188	30.195492	195.843	4.30
25	HTSHC	44	120.142546	30.186861	163.605	4.50
26	SHYHG	59	120.171202	30.19664	242.052	4.30
27	QHYXQ	11	120.25828	30.051994	104.260	7.50
28	NANHC	93	120.20319	30.11291	221.645	5.70
29	SSHYSH	101	120.200346	30.104131	118.311	7.40
30	ALDXZ	61	120.241346	30.172266	174.033	6.50
31	XHMD	40	120.24879	30.178721	160.846	7.40
32	LCDXY	36	120.251952	30.170416	143.371	7.50
33	HPKD	35	120.250885	30.173241	251.441	7.40
34	NCHJY	14	120.287951	30.115729	87.000	1.40
35	NCHJY	16	120.283843	30.116221	105.533	1.20
36	XSHSJ	45	120.258273	30.117752	56.568	2.20
37	GZXQ	4	120.28375	30.134964	97.667	3.20
38	SJHT	11	120.288155	30.140867	146.980	3.90
39	HDDJ	21	120.285586	30.141515	154.850	3.90
40	MMSHJ	13	120.282544	30.144271	172.167	4.20
41	BDHY	21	120.258953	30.143749	160.050	4.40
42	SJHCH	20	120.281492	30.150431	237.053	4.90
43	THHY	19	120.279142	30.152203	214.164	5.00
44	JFGG	11	120.266323	30.151345	72.304	5.00
45	HYHY	20	120.286524	30.155693	177.389	5.50
46	BSHMT	11	120.295934	30.163523	163.310	6.60
47	GQXQ	40	120.281794	30.158176	81.103	5.70
48	CHXQ	13	120.266243	30.161369	60.717	6.10
49	WNSSHC	53	120.245986	30.16528	161.173	7.10
50	NXY	4	120.245939	30.036909	64.167	8.30
51	FDGJLC	21	120.295486	30.340315	96.900	0.52
52	FDYYC	6	120.29481	30.339263	123.800	0.43
53	DGYJ	15	120.296033	30.35201	90.455	1.70
54	ZJSHD	11	120.29749	30.353755	87.800	2.00
55	JYY	19	120.290133	30.312626	113.000	2.60
56	LQMY	25	120.28403	30.310529	100.875	2.90
57	WKML	58	120.263707	30.326584	130.614	3.10
58	SCXY	9	120.267856	30.32148	150.750	3.20
59	XJHY	23	120.27956	30.309648	104.000	3.30
60	MHYGYF	21	120.336056	30.324293	94.830	4.11

(Continued…)

(Table 2 Continued)

Number	Neighborhood	Sales	Longitude	Latitude	Average Listing Price	Distance to the Nearest Incinerator
61	SHSHJH	20	120.333436	30.312415	92.026	4.41
62	YGYC	19	120.24424	30.356202	68.333	5.52
63	KLTL	13	120.242754	30.360292	104.250	5.85
64	BLMGW	46	120.366291	30.272235	87.833	9.90
65	SDDJGJ	48	120.400841	30.330878	74.212	10.00
66	MQW	130	120.395967	30.303974	108.457	10.10
67	JYGLSHD	57	120.375318	30.273436	129.929	10.30
68	JFWQ	19	120.215862	30.273529	124.278	10.30
69	DQDTY	20	120.2346	30.360237	104.421	6.60
70	WKCZ	18	120.224972	30.315291	201.235	7.30

Table 3 contains the descriptive statistics on the housing transaction data set used in this study. A typical unit in our data set has 2.8 bedrooms, 1.9 other rooms, 1.2 baths, on the 9^{th} floor of a multistory building, and 7.0 years old at the time of sale. The unit size is 116 square meters (about 1,250 square feet) and listed at 1.46 million yuan (about USD 235,500) prior to the sale. A school is typically located 0.4 kilometers away, with a shopping district within 1.5 kilometers (about 1 mile). About 10% of the sales (232 units) are within 2 kilometers of an incinerator. Since the incinerators are several kilometers apart, some of the units are within 5 kilometers of more than one incinerator.

5. Model Results

5.1 Baseline Model

After investigating three potential functional forms for the dependent and independent variables (linear, semi-log and log), and considering goodness-of-fit criteria across the three model specifications, a semi-log form is the best fit for the dependent variable in this analysis. The results of the first baseline model are shown below. This model includes 2,258 sales, and the dependent variable is the natural log of the original listing price. There are four objectives of the model: to have the highest R^2 and consistency of the main economic variables with those in the literature, maintain acceptable heteroscedasticity[3], and also to have reasonable levels of multicolinearity.

[3]To check for heteroscedasticity, we prepare a scatterplot of the dependent variable Ln of the sales price. We examine its studentized residuals, and standardized predicted values. No fanning effect or other anomalies are detected. Thus we conclude heteroscedasticity is not a problem for this data set.

Table 3 Descriptive Statistics

Variable	Description	Minimum	Maximum	Mean	Std. Deviation
List_price	Listing price(10,000yuan)	30.00	900.00	146.17	77.11
Sale_price	Sale_Price	26.70	835.80	134.74	71.71
Ln_sale_price	Ln of sale price	3.28	6.73	4.79	.46
Bedroom	Bedrooms	1.00	6.00	2.81	.88
Livingroom	Living rooms	1.00	5.00	1.89	.40
Bathroom	Bath rooms	1.00	5.00	1.16	.41
Area_size	Area(M2)	27.00	580.00	115.83	46.18
Dummy_sale_year	Sale at 2014=0,sale at 2015=1	.00	1.00	.74	.44
Age	Age at sale	.00	32.00	6.99	4.44
Decor	Dummy for level of finishing (0-rough，1-common，2-good, 3-great model)	1.00	4.00	2.56	1.37
Floor	Floor	1.00	41.00	9.20	6.59
Dummy_highrise	High rise (<=7 floor =1，>7floor=0)	.00	1.00	.27	.45
Dis_sh.center	Distance to shopping center (km)	.11	3.80	1.53	1.05
Dis_bus	Distance to bus (km)	.03	.75	.24	.15
Dis_school	Distance to school (km)	.02	1.40	.40	.29
Dis_CBD	Distance to CBD	5.20	28.10	14.72	4.41

(Continued…)

(Table 3 Continued)

Variable	Description	Minimum	Maximum	Mean	Std. Deviation
Dummy_dis_subway	Dummy of distance to subway (<1km, yes=1, no=0)	.00	1.00	.20	.40
Dummy_dis_highway	Dummy of distance to highway (<1km, yes=1, no=0)	.00	1.00	.12	.32
Dummy_dis_river	Dummy of distance to Distance to Qian Tangjiang River (<1km, yes=1, no=0)	.00	1.00	.36	.48
Dis_incinerator	Nearest distance to incinerator	.43	10.30	5.03	2.59
Dummy_dist1	Dummy of distance 0-1km	.00	1.00	.01	.10
Dummy_dist2	Dummy of distance 1.1-2km	.00	1.00	.07	.26
Dummy_dist3	Dummy of distance 2.1-3km	.00	1.00	.14	.35
Dummy_dist4	Dummy of distance 3.1-4km	.00	1.00	.21	.41
Dummy_dist5	Dummy of distance 4.1-5km	.00	1.00	.18	.38
Dummy_dist6[4]	Dummy of distance> 5km	.00	1.00	.39	.49
Size_incinerator	SM of incinerator land	42620.00	58667.00	45803.45	5434.96

[4] This variable is reference category

For the baseline model shown in Table 4, the adjusted R^2 (which shows the amount of variation in the dependent variable explained by all independent variables combined) is 81.9%, which is highly satisfactory. The F-statistic for this model is 570.27 which is also highly satisfactory. The current model has acceptable levels of multicolinearity, measured by the variance inflation factor (VIF) and all variables in the model have a score below 10. Table 5 shows the independent variables in their reduced form as described earlier, and also the key variable of interest, which is distance to the nearest incinerator, expressed in kilometers.

Table 4 Baseline Regression Model- All Transactions

Model	B	t	Sig.	Multicolinearity Statistics	
				Tolerance	VIF
(Constant)	3.787	69.963	.000		
Bedroom	.049	6.182	.000	.345	2.898
Livingroom	.130	10.150	.000	.651	1.536
Bathroom	-.082	-6.493	.000	.621	1.610
Area_size	.007	44.523	.000	.314	3.182
Dummy_sale_year	.206	11.890	.000	.294	3.407
Age	-.008	-6.599	.000	.617	1.621
Decor	.032	8.907	.000	.704	1.421
Floor	-.002	-2.202	.028	.649	1.540
Dummy_highrise	-.063	-4.915	.000	.515	1.941
Dis_sh.center	-.042	-8.294	.000	.603	1.659
Dis_bus	-.002	-.084	.933	.787	1.271
Dis_school	-.081	-4.303	.000	.547	1.828
Dis_CBD	-.038	-24.440	.000	.352	2.838
Dummy_dis_subway	.108	8.202	.000	.609	1.642
Dummy_dis_highway	.040	2.075	.038	.434	2.304
Dummy_dis_river	.039	3.429	.001	.555	1.802
Dis_incinerator	.032	13.360	.000	.434	2.304
Size_incinerator	.000	4.589	.000	.560	1.785
Adjusted R^2=0.819; F-Statistic=570.272					

The parameter estimates for independent variables typically found in a hedonic regression model for the most part conform to expectations. For example, bedrooms (.049, or a 4.9% increase in listing price for each additional bedroom), living rooms (0.13, or a 13% increase in listing price for each additional living room), unit area (.007, or a 0.7% increase in listing price for each additional square meter), and decor/level of finishing (.032, or a 3.2% increase in listing price for an extra level of decor on an index scale) are statistically significant at a 99% level of confidence. Age (-.008) and floor (-.002) are negative and significant at a 99% level of confidence, as expected. Unexpectedly, bathroom (-.082, or an 8.2% decrease in listing price for each additional bathroom) and high-rise (-.063 compared to a midrise structure) are both negative and significant at a 99% level of confidence. We assume that better views from higher floors are not important enough to offset the inconvenience of additional height and higher density. However, proximity to the Qian Tangjiang River has a significant increment in listing price of 3.9%, so the importance of a view of the river is captured by this variable.

With respect to the distance variables, the prices significantly declined with distance from the Hangzhou CBD at a rate of 3.8% per kilometer, nearest shopping center at 4.2% per kilometer, and school, at 8.1% per kilometer, which likely reflects the importance of schools that are convenient. As expected, the dummy variables for close proximity to a subway (.108) and highway interchange (.040) are both positive and significant at 95%. Distance to a bus (-.002) is not statistically significant.

Distance to the incinerator (the key variable in this model) is associated with an increase in listing price at a rate of 3.2% per kilometer, holding all other variables in the model constant, and this is statistically significant at a 99% level of confidence. Thus, consistent with the hypothesis, we conclude that incinerators have a negative effect on property value. However, the variable specification (in distance per kilometer) does not include information on the extent of the negative effect of the nearest incinerator but this is addressed in the model below.

5.2 Distance Rings from Incinerator Model

The model on the extent of the negative effect of the nearest incinerator can be determined in two ways. One is to use a separate regression for each of the distance rings, and the other is to use a model that can be estimated over the entire sample with the interaction terms of distance and time period indicators to measure the changing impact of the nearest negative disamenity (Gamble and Downing,1982; Kohlhase,1991; Kiel,1995). We use the first approach. The results of the model that uses distance rings are shown in Table 5. This model also has 2,258 sales, and the dependent variable is likewise the natural log of the listing price. The adjusted R^2 scores (for a distance ring less than 1 kilometer to over 5 kilometers, respectively) are in a narrow band between 80.5% and 81.7%, which are all highly satisfactory. The F-statistic for this model is likewise satisfactory, which closely ranges between 520 and 560. All six models likewise have acceptable levels of VIF for all of the variables in the model. The same dozen or so independent variables are included, with generally similar results with a few exceptions (floor, and distance to schools and highway are not always significant in all of the models, depending on the availability of the features in these local areas). The only substantial difference in the models is the key independent variable of interest, which is distance to the nearest incinerator, expressed here in a series of dummy variables of 1-kilometer bands. The reference category for distance is >5 kilometers from the nearest incinerator. There are 25 transactions for the inner distance band, and over 150 sales for all of the other bands, so sample size is not a concern.

Table 5 Distance Rings from Incinerator Model-All Transactions

Model	dist1		dist2		dist3		dist4		dist5	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
(Constant)	3.966	0.000	3.927	0.000	3.994	0.000	3.922	0.000	4.039	0.000
Bedroom	0.047	0.000	0.037	0.000	0.054	0.000	0.041	0.000	0.050	0.000
Livingroom	0.120	0.000	0.122	0.000	0.138	0.000	0.124	0.000	0.125	0.000
Bathroom	-0.039	0.002	-0.035	0.005	-0.050	0.000	-0.033	0.008	-0.018	0.135
Area_size	0.007	0.000	0.007	0.000	0.007	0.000	0.007	0.000	0.007	0.000
Dummy_sale_year	0.101	0.000	0.123	0.000	0.107	0.000	0.100	0.000	0.068	0.000
Age	-0.007	0.000	-0.008	0.000	-0.007	0.000	-0.007	0.000	-0.006	0.000
Decor	0.028	0.000	0.028	0.000	0.027	0.000	0.027	0.000	0.025	0.000
Floor	-0.001	0.167	-0.001	0.142	-0.001	0.342	-0.001	0.191	-0.001	0.166
Dummy_highrise	-0.027	0.035	-0.028	0.031	-0.032	0.010	-0.026	0.045	-0.012	0.347
Dis_sh.center	-0.043	0.000	-0.036	0.000	-0.046	0.000	-0.038	0.000	-0.050	0.000
Dis_bus	0.021	0.487	0.018	0.571	0.033	0.272	0.035	0.257	0.036	0.234
Dis_school	-0.028	0.137	-0.045	0.019	-0.005	0.768	-0.021	0.270	0.015	0.413
Dis_CBD	-0.034	0.000	-0.034	0.000	-0.034	0.000	-0.035	0.000	-0.030	0.000
Dummy_dis_subway	0.126	0.000	0.109	0.000	0.108	0.000	0.113	0.000	0.085	0.000
Dummy_dis_highway	-0.025	0.180	-0.025	0.193	-0.061	0.001	-0.055	0.003	-0.061	0.001
Dummy_dis_river	0.073	0.000	0.074	0.000	0.067	0.000	0.079	0.000	0.015	0.218
Size_incinerator	0.000	0.003	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.952
Dummy_dist_incin	-0.293	0.000	-0.105	0.000	-0.151	0.000	0.020	0.099	0.160	0.000
Adjusted R2	0.809		0.808		0.817		0.805		0.817	
F_statistic	531.862		528.712		560.989		519.771		559.455	

Note: *** Significant at 0.01 probability level; ** Significant at 0.05 probability level;* Significant at 0.1 probability level

The results show that the effect of proximity of any of these three incinerators on housing listing price could be measured as far as 3 kilometers from the incinerator (1.86 miles), holding all the other variables in the model constant. Within 1 kilometer, the coefficient for the corresponding variable shows a value of -0.293, or an estimated loss of 25.4% [5] (based on the transformation suggested by Halvorsen and Palmquist,1980). Within 1-2 kilometers, the coefficient is -0.105, which equals to an estimated loss of 10.1%, and within 2-3 kilometers, the coefficient is -0.151, which is an estimated loss of 14.0%. All of these figures are statistically significant at a 95% level of confidence. Other distance bands beyond 3 kilometers show positive or neutral effects relative to the nearest incinerator. Thus, consistent with the hypothesis, we conclude that incinerators have a negative effect on property value within three kilometers, although the effect does not appear to be monotonically decreasing, since it is hypothetically anticipated the third distance ring would have lower prices than the second one.

5.3 Spatial Autocorrelation Analysis

House price data are often spatially correlated. That is, properties with high values are generally located in close proximity to other properties of comparable value and low value properties are also clustered. This is not surprising since (according to a popular saying) the three most important factors in determining the price of real estate are location, location and location. Thus, we are concerned about potential spatial autocorrelation. but we only have neighborhood centroids, not the location of each of our 2,258 transactions. So we test for spatial autocorrelation by using Moran's I on these 70 neighborhoods, and the value of Moran's I is 0.063, which is close to 0, and means less spatial autocorrelation. The results are shown in Table 6, and indicate a potentially slight spatial autocorrelation problem. So, we replicate the classical OLS model with 70 neighborhood observations (by using average listing price). The adjusted R^2 is 80%, consistent with previous models (81.9%). Of course, with a smaller N, the F-statistic is much lower (17.23), as expected. The parameter estimates on distance to incinerator are about the same, but at .0398 not. 032. Both are statistically significant at >95%, so our main results remain unchanged.

For spatial autocorrelation, we run both spatial lag and spatial error models. Both are shown in Tables 7 and 8. The adjusted R^2 is 85.9%-86.3%, which is similar. The results for the main variable on distance to the incinerator is 0.039-0.041, and is statistically significant. We also test for heteroscedasticity in each spatial model. The model with the better fit is the spatial lag model, where there is no heteroscedasticity at a 90% level of confidence. For the spatial error model, some heteroscedasticity is present at about a 95% level of confidence, as shown in Table 9. In conclusion, spatial autocorrelation in this study does not affect the main results.

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[5] Percentage log transformation of dummy variables, [exp (-0.293)-1]*100=25.4%, repeated again below.

Table 6 OLS Estimation Results for Spatial Autocorrelation-70 Neighborhoods

Variable	Coefficient	Std. Error	t-Statistic	Probability
Constant	2.945	0.420	7.005	0.000
Bedroom	0.067	0.070	0.957	0.343
Livingroom	0.324	0.168	1.926	0.060
Bathroom	-0.146	0.102	-1.428	0.160
Area_size	0.008	0.001	5.732	0.000
Dummy_sale_year	0.198	0.078	2.558	0.014
Age	-0.010	0.008	-1.272	0.209
Decor	0.121	0.034	3.590	0.001
Floor	-0.006	0.010	-0.607	0.547
Dummy_highrise	-0.168	0.100	-1.687	0.098
Dis_sh.center	-0.021	0.027	-0.774	0.443
Dis_bus	0.103	0.132	0.783	0.437
Dis_school	-0.203	0.084	-2.408	0.020
Dis_CBD	-0.032	0.008	-4.236	0.000
Dummy_dis_subway	0.138	0.054	2.539	0.014
Dummy_dis_highway	0.044	0.080	0.544	0.589
Dummy_dis_river	-0.063	0.065	-0.960	0.342
Dis_incinerator	0.040	0.011	3.778	0.000
Size_incinerator	0.000	0.000	1.477	0.146

Table 7 OLS Estimation Results for Spatial Lag Model

Variable	Coefficient	Std. Error	z-value	Probability
W_lnsalepric	0.055	0.249	0.220	0.826
constant	2.677	1.250	2.141	0.032
Bedroom	0.065	0.060	1.086	0.277
Livingroom	0.324	0.144	2.257	0.024
Bathroom	-0.144	0.087	-1.645	0.100
Area_size	0.008	0.001	6.727	0.000
Dummy_sale_year	0.196	0.066	2.945	0.003
Age	-0.010	0.007	-1.501	0.133
Decor	0.121	0.029	4.208	0.000
Floor	-0.006	0.008	-0.711	0.477
Dummy_highrise	-0.166	0.085	-1.956	0.050
Dis_sh.center	-0.022	0.023	-0.963	0.336
Dis_bus	0.101	0.114	0.886	0.376
Dis_school	-0.205	0.072	-2.832	0.005
Dis_CBD	-0.032	0.006	-4.920	0.000
Dummy_dis_subway	0.137	0.046	2.955	0.003
Dummy_dis_highway	0.043	0.068	0.635	0.525
Dummy_dis_river	-0.066	0.058	-1.134	0.257
Dis_incinerator	0.039	0.009	4.301	0.000
Size_incinerator	0.000	0.000	1.749	0.080
R-squared: 0.858873; Log likelihood: 41.8128;Akaike info criterion: -43.6257; Sigma-square: 0.0177275; Schwarz criterion: 1.34421; S.E of regression: 0.133145				

Table 8 OLS Estimation Results for Spatial Error Model

Variable	Coefficient	Std. Error	z-value	Probability
W_lnsalepric	3.004	0.352	8.531	0.000
constant	0.075	0.060	1.260	0.208
Bedroom	0.327	0.141	2.314	0.021
Livingroom	-0.168	0.087	-1.936	0.053
Bathroom	0.008	0.001	6.489	0.000
Area_size	0.225	0.067	3.376	0.001
Dummy_sale_year	-0.010	0.007	-1.465	0.143
Age	0.120	0.029	4.164	0.000
Decor	-0.007	0.008	-0.846	0.398
Floor	-0.182	0.084	-2.157	0.031
Dummy_highrise	-0.009	0.024	-0.372	0.710
Dis_sh.center	0.079	0.111	0.716	0.474
Dis_bus	-0.200	0.072	-2.761	0.006
Dis_school	-0.034	0.006	-5.573	0.000
Dis_CBD	0.146	0.046	3.155	0.002
Dummy_dis_subway	0.056	0.069	0.821	0.412
Dummy_dis_highway	-0.060	0.054	-1.098	0.272
Dummy_dis_river	0.041	0.009	4.686	0.000
Dis_incinerator	0.000	0.000	1.582	0.114
Size_incinerator	-0.630	0.429	-1.468	0.142
R^2: 0.862966; Log likelihood: 42.419931; Akaike info criterion: -46.8399 Sigma-square: 0.0172135; Schwarz criterion: -4.11845; S.E of regression: 0.1312				

Table 9 Regression Diagnostics for Heteroscedasticity and Spatial Dependence for SLM and SEM Models

Test	DF	Value	Probability
Spatial Lag Model			
Breusch-Pagan test	18	25.3639	0.11522
Likelihood Ratio Test	1	0.0474	0.82765
Spatial Error Model			
Breusch-Pagan test	18	28.6547	0.05277
Likelihood Ratio Test	1	1.2616	0.26135

5.4 Comparison between Sales Near 3 Incinerators and All Sales

A sufficient sample size is used to populate separate models for each of the three incinerators, although only one (Nengda) has any residence that is offered for sale within a distance of 1 kilometer. We separately run transactions near the 3 incinerators (Tables 10-12), and for the baseline model, without distance rings. The R^2 values of the model are in the 0.79-0.85 range, with F statistics between 149 and 490. In terms of the main independent variable, that is, distance to the nearest incinerator, every additional kilometer further away from the Lvneng incinerator is associated with an increase in value of 2.3%, with an increase of 1.4% attributable to the Jinjiang incinerator, and a 4.1% increase further from the Nengda incinerator, holding all the other variables in the models constant.

The distance to the incinerator variable is statistically significant at over a 99% level of confidence. These results are consistent with the conclusion that incinerators have a negative effect on property value, in each case and all cases combined.

Table 10 Baseline Regression Model - Lvneng Incinerator

Model	B	T	Sig.	Multicolinearity Statistics	
				Tolerance	VIF
(Constant)	4.491	100.229	.000		
Bedroom	.068	7.669	.000	.285	3.512
Livingroom	.157	11.438	.000	.628	1.591
Bathroom	-.037	-1.943	.052	.415	2.410
Area_size	.006	34.174	.000	.264	3.786
Age	-.009	-5.167	.000	.587	1.703
Decor	.007	1.696	.090	.700	1.429
Floor	-.003	-3.122	.002	.591	1.693
Dummy_highrise	-.025	-1.773	.076	.485	2.064
Dis_sh.center	.011	1.220	.223	.247	4.049
Dis_bus	-.032	-.630	.529	.689	1.451
Dis_school	.097	3.867	.000	.401	2.493
Dis_CBD	-.066	-26.831	.000	.315	3.174
Dummy_dis_subway	.048	1.943	.052	.358	2.796
Dummy_dis_highway	-.076	-1.693	.091	.649	1.540
Dummy_dis_river	.071	5.095	.000	.425	2.352
Dis_incinerator	.023	5.188	.000	.307	3.260
Adjusted R^2=0.852; F-statistic=490.160					

Table 11 Baseline Regression Model -Jinjiang Incinerator

Model	B	t	Sig.	Multicolinearity Statistics	
				Tolerance	VIF
(constant)	4.386	25.030	.000		
Bedroom	.075	4.959	.000	.360	2.779
Livingroom	.123	4.855	.000	.538	1.859
Bathroom	-.070	-2.662	.008	.547	1.827
Area_size	.007	23.433	.000	.267	3.739
Age	-.013	-6.472	.000	.512	1.952
Decor	.057	8.108	.000	.787	1.270
Floor	-.003	-1.204	.229	.562	1.780
Dummy_highrise	.019	.736	.462	.421	2.377
Dis_sh.center	-.127	-9.232	.000	.351	2.847
Dis_bus	-.738	-7.495	.000	.578	1.731
Dis_school	.017	.615	.539	.678	1.474
Dis_CBD	-.031	-4.231	.000	.221	4.527
Dummy_dis_subway	.024	.721	.471	.270	3.699
Dis_incinerator	.014	2.016	.044	.392	2.553
Adjusted R^2=.839; F-statistic=240.959					

Table 12 Baseline Regression Model–Nengda Incinerator

Model	B	t	Sig.	Multicolinearity Statistics	
				Tolerance	VIF
(Constant)	3.994	70.217	.000		
Bedroom	.028	1.971	.049	.317	3.155
Livingroom	.014	.748	.455	.774	1.293
Bathroom	.008	.423	.672	.377	2.650
Area_size	.006	20.447	.000	.273	3.662
Age	.000	-.263	.792	.656	1.524
Decor	.029	5.097	.000	.786	1.272
Floor	.000	-.424	.671	.716	1.397
Dummy_highrise	-.134	-5.472	.000	.647	1.546
Dis_sh.center	.007	1.155	.249	.608	1.644
Dis_bus	.221	6.259	.000	.581	1.722
Dis_school	-.325	-6.321	.000	.431	2.322
Dis_CBD	-.036	-19.225	.000	.309	3.240
Dummy_dis_subway	.176	7.773	.000	.340	2.945
Dummy_dis_highway	.108	4.858	.000	.283	3.537
Dis_incinerator	.041	10.132	.000	.176	5.687
Adjusted R^2=.794; F_statistic=149.392					

Similarly, we also run transactions for the six 1-kilometer distance rings for each of the 3 incinerators separately (Tables 13-15). Although all six 1-kilometer distance bands are tested, there are no data within 1 kilometer of the Lvneng and Jinjiang incinerators. Again, the R^2 value of the models (for a total of 18 models respectively) is in the 0.76-0.85 range, with F-statistics between 121 and 499. Overall, the results show that the effect of the 3 incinerators on housing price in terms of proximity could be generally measured as far as 3 kilometers from the incinerator (1.86 miles), but no further, holding all the other variables in the model constant. There is one exception: the model of the distance rings for the Lvneng incinerator shows a reduction of 3.4% up to 4 kilometers away.

Table 16 summarizes the key results for the 18 models. Eight of 9 data points within 3 kilometers are negative and statistically significant. For the Nengda incinerator within 1 kilometer, (the only facility to have sales within a distance band that is so close in proximity), the coefficient for the corresponding variable shows a value of -0.203, or an estimated economic loss of 18.3% after the log transformation as shown in Footnote 5. Within 1-2 kilometers, the coefficient value is -0.097 (Lvneng), -0.097 (Jinjiang), and -0.065 (Nengda), which equal to an estimated loss of 9.2%, -9.2%, and 6.3% respectively. Finally, within 2-3 kilometers, the coefficient value is -0.37 for Jinjiang and -0.12 for Nengda. Lvneng has a parameter estimate of -0.018, but it is not statistically significant. The other distance bands show a positive or neutral value relative to more than 4 kilometers away from the incinerator. These results are generally consistent with the regression results for all sales.

Table 13 Distance Rings from Incinerator Model-Lvneng Incinerator

Model	dist1		dist2		dist3		dist4		dist5	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
(Constant)			4.532	0.000	4.529	0.000	4.579	0.000	4.452	0.000
Bedroom			0.061	0.000	0.063	0.000	0.063	0.000	0.065	0.000
Livingroom			0.154	0.000	0.158	0.000	0.154	0.000	0.152	0.000
Bathroom			-0.023	0.224	-0.021	0.258	-0.024	0.208	-0.026	0.163
Area_size			0.006	0.000	0.006	0.000	0.006	0.000	0.006	0.000
Age			-0.013	0.000	-0.011	0.000	-0.011	0.000	-0.010	0.000
Decor			0.007	0.065	0.006	0.113	0.007	0.081	0.008	0.035
Floor			-0.003	0.001	-0.003	0.001	-0.003	0.000	-0.004	0.000
Dummy_highrise			-0.032	0.022	-0.025	0.074	-0.029	0.037	-0.024	0.084
Dis_sh.center			0.037	0.000	0.029	0.001	0.030	0.000	0.010	0.240
Dis_bus			0.034	0.471	0.042	0.406	0.064	0.180	-0.047	0.355
Dis_school			0.069	0.009	0.105	0.000	0.092	0.000	0.065	0.012
Dis_CBD			-0.062	0.000	-0.064	0.000	-0.066	0.000	-0.054	0.000
Dummy_dis_subway			0.088	0.000	0.092	0.000	0.081	0.001	0.092	0.000
Dummy_dis_highway			-0.076	0.091	-0.168	0.000	-0.173	0.000	-0.133	0.001
Dummy_dis_river			0.087	0.000	0.081	0.000	0.065	0.000	0.010	0.568
Dummy_dist			-0.097	0.000	-0.018	0.250	-0.034	0.007	0.118	0.000
Adjusted R^2			0.852		0.849		0.85		0.853	
F_statistic			488.752		479.493		481.895		494.568	

Table 14 Distance Rings from Incinerator Model-Jinjiang Incinerator

Model	dist1		dist2		dist3		dist4		dist5	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
(Constant)			4.678	.000	4.393	.000	4.616	.000	4.674	.000
Bedroom			.074	.000	.093	.000	.066	.000	.073	.000
Livingroom			.125	.000	.102	.000	.126	.000	.115	.000
Bathroom			-.084	.002	-.061	.015	-.077	.004	-.036	.174
Area_size			.007	.000	.007	.000	.008	.000	.007	.000
Age			-.012	.000	-.013	.000	-.012	.000	-.009	.000
Decor			.056	.000	.055	.000	.055	.000	.054	.000
Floor			-.003	.249	-.001	.557	-.003	.162	-.003	.278
Dummy_highrise			.035	.162	-.018	.460	.033	.186	.056	.024
Dis_sh.center			-.126	.000	-.105	.000	-.115	.000	-.111	.000
Dis_bus			-.726	.000	-.344	.001	-.738	.000	-.595	.000
Dis_school			.038	.183	.044	.096	.015	.598	.059	.036
Dis_CBD			-.045	.000	-.034	.000	-.041	.000	-.051	.000
Dummy_dis_subway			.001	.965	.051	.101	.020	551	-.057	.098
Dummy_dist			-.097	.056	-.370	.000	.063	.186	.177	.000
Adjusted R^2			0.839		0.853		0.839		0.844	
F_statistic			240.786		267.867		239.917		250.244	

Table 15 Distance Rings from Incinerator Model-Nengda Incinerator

Model	dist1		dist2		dist3		dist4		dist5	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
(Constant)	4.087	.000	4.137	.000	4.145	.000	4.066	.000	4.139	.000
Bedroom	.077	.000	.054	.001	.056	.000	.065	.000	.061	.000
Livingroom	-.001	.960	-.001	.945	.013	.548	-.005	.805	.004	.836
Bathroom	.001	.972	.005	.787	.004	.850	.005	.802	.003	.883
Area_size	.006	.000	.006	.000	.006	.000	.006	.000	.006	.000
Age	.000	.852	.000	.856	.000	.865	-.001	.517	.000	.947
Decor	.033	.000	.033	.000	.034	.000	.036	.000	.033	.000
Floor	.000	.702	.000	.906	.000	.861	.001	.591	.000	.845
Dummy_highrise	-.064	.014	-.078	.004	-.089	.001	-.046	.102	-.089	.001
Dis_sh.center	-.003	.645	.005	.468	.017	.019	.002	.809	.005	.454
Dis_bus	.229	.000	.267	.000	.340	.000	.242	.000	.284	.000
Dis_school	-.063	.167	-.004	.936	-.074	.113	.021	.659	-.011	.830
Dis_CBD	-.027	.000	-.030	.000	-.033	.000	-.027	.000	-.031	.000
Dummy_dis_subway	.047	.008	.016	.379	.038	.037	.017	.294	.002	.890
Dummy_dis_highway	-.009	.630	-.038	.040	-.053	.004	-.055	.003	-.048	.013
Dummy_dist	-.203	.000	-.065	.020	-.128	.000	.097	.000	.026	.045
Adjusted R^2	0.769		0.758		0.763		0.764		0.757	
F_statistic	128.917		121.214		124.905		125.359		120.726	

Table 16 Comparison between Transactions of 3 Incinerators and All Transactions

	All sales	Lvneng	Jinjiang	Nengda
Baseline Model				
Effect /kilometer further away	.032***	.023***	.014**	.041***
Adjusted Model R2	0.779	.865	.839	.794
F –Statistic	454.386	428.221	240.959	149.392
Distance Rings Model				
Dummy_dist1	-.293*** .809/531.862	No data	No data	-.203*** .769/128.917
Dummy_dist2	-.105*** .808/528.712	-.097*** .852/488.752	-.097* .839/240.786	-.065** .758/121.214
Dummy_dist3	-.151*** .817/560.989	-.018 .849/479.493	-.370*** .853/267.867	-.128*** .763/124.905
Dummy_dist4	.020* .805/519.771	-.034*** .85/481.895	.063 .839/239.917	.097*** .764/125.359
Dummy_dist5	.160*** .817/559.455	.118*** .853/494.568	.177*** .844/250.244	.026** .757/120.726
Number of transactions: All sales=2,258,Lvneng=1,361, Jinjaing=645, Nengda= 578.				

Note: *** Significant at 0.01 probability level; ** Significant at 0.05 probability level;* Significant at 0.1 probability level/. Figures below of parameter estimates are adjusted R^2 and F-statistics.
Reference category is >5 kilometers away from nearest incinerator.

6. Conclusions and Discussion

The primary aim of this paper is to examine the impacts of three waste incinerators on property value in terms of proximity to residential units for sale in the city of Hangzhou, which is located in Zhejiang Province, China. We have applied several hedonic pricing models, with a total of 2,258 valid observations, where the dependent variable is the natural log of the original housing listed prices (Ln) during 2014 and 2015.

Our results show that the presence of an incinerator has a statistically significant negative effect on the value of residential properties within 3 kilometers, with the 1 kilometer band which is most close in proximity showing a 25.4% reduction, and the furthest affected band (2-**3** kilometers away) showing a 14% reduction. A comparison between the sales among the listings within proximity of the 3 incinerators and all sales show a consistent pattern, although in one case the negative effect is found up to 4 kilometers away. Even if a potential error band of 3%-5% related to the listing-sales price ratio is accounted for, all of the results clearly show a negative effect on price due to the incinerator.

In terms of the individual plants, we find a common result in that there is no negative externality on housing price after 4 kilometers. However, at the edge of the negatively affected zone, which is about 3-4 kilometers to the incinerator, the results are not exactly the same, especially for the Lvneng plant where there is still a negative effect of -3.4%, while for the other two plants, a positive effect is found, which means that the influence of the incinerator is reduced. We hypothesize that distance to the river is the special factor that differentiates the Lvneng plant from the other two plants. The houses beyond 3 kilometers from the Lvneng plant are near the Qian Tangjiang River, and there may be an interactive effect from the influence of the river on housing price.

As mentioned in the literature review, there is virtually no quantitative research on China that addresses negative amenities, so this research is among the first to quantify the effect of incinerators on residential property values, as determined by the original listing price. Our results are generally consistent with those of research work on incinerators and waste facilities in the United States, including Kiel and McLain (1995a) and Eshet et al. (2005). The magnitude of loss (in excess of 20% within a mile) is also consistent with work by Simons et al. (2014) on hog farm odors in CAFO in Kentucky, US.

The results can help real estate developers to make comprehensive pricing decisions, both in acquiring development sites and pricing units for sale, therefore potentially leading to fairer prices and more efficient markets. The models also provide parameter estimates for regional accessibility, traffic conditions, schools, transit and other proximate factors. For local governments, since incinerators are a component of local public services, the efficiency of housing markets would improve if negative externalities attributable to public services can be internalized. Thus, this would create a more intact environment for residents. This research would therefore to a great extent provide municipal government with the means to more rationally plan their urban areas and create related policies.

Our findings have some limitations. In contrast to most previous hedonic pricing studies, our dependent variable is the listing price, rather than the sales price. This is the best and most consistent sales-related data available in China, and the ratio of the sales price to listing price is known. We acknowledge that residential listing price is complex, and determined by factors such as the reference price of the seller, house specific circumstances, professional opinion of real estate agents, and market conditions. Overall, the listing price of a unit is often typically higher than the transaction price (Wen 2004). We assume that this ratio has remained stable over the past ten years, and that houses near the incinerator have similar listing-sale ratios as those of the control properties.

Also, wind direction is known to affect air pollution, including emissions from an incinerator. If the wind is blowing towards an urban area from an industrial area, then pollution levels are likely to be higher in the town or city than if the air is blowing from another direction. In the related literature on the effect of air pollution from CAFOs on housing price, Isakson and Ecker (2008) and

Simons et al. (2014) all find substantial price reductions in terms of the wind direction, while other and closer-in areas have more limited price reductions. In a study by Kiel (1995), the effect of incinerators on housing price is also affected by wind direction, but the results are inconclusive. In the current paper, we have attempted to model wind direction, but applicable data are hard to find, and the results are also inconclusive and therefore omitted from this paper. Given the importance of air pollution in China these days, more research is needed in this area, as wind is generally not considered to be a factor in transaction prices in the current urban housing markets.

In closing, with rising income levels in China and concurrent with substantial economic growth and maturing housing markets, people are becoming more concerned about their present and future living environments, and demanding higher quality of not only the internal structure of the house, but also of the external environment. Thus, as more people strive to avoid or minimize living around landfills, incinerators, or brownfields, information, such as the results of this research, is a good source of guidance to them.

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