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Particulate air pollution and real estate valuation: Evidence from 286 Chinese prefecture-level cities over 2004–2013☆

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ABSTRACT

Whether, and to what extent the air pollutions depress the real estate prices in China have increasingly become to be important issues yet to be well addressed. By applying a very unique panel data set on $PM_{2.5}$ concentrations from 286 Chinese prefecture-level cities for 2004–2013, this study quantitatively assesses the impact of $PM_{2.5}$ concentrations on real estate prices in China. The preferred empirical results demonstrate that: (1) $PM_{2.5}$ pollutions have negatively significant effects on real estate prices in China. Specifically, 1 $\mu g/m^3$ increase in $PM_{2.5}$ concentrations is associated with a decrease of 46 RMB/m^2 in real estate prices on average. (2) The estimated effects differ widely across Chinese cities, with higher-ranking cities being more substantially impacted. Additionally, the negative effects become increasingly statistically significant and quantitatively large over time. (3) Finally, 1 $\mu g/m^3$ increase in $PM_{2.5}$ is responsible for about 5200 hundred million RMB losses in real estate valuations, approximately accounting for 0.9% GDP in 2013 of China. The findings are rather robust to various alternative settings.

This article is part of a Virtual Special Issue entitled 'Comparing Sustainable Energy Policies in Northeast Asia: toward the harmonized Public-Private Partnership'.

1. Introduction

The past one decade has seen enormous housing prices appreciation as well as air pollution soaring in China. During 2003–2013, China's housing prices have tripled on average. In Beijing, Shanghai, Guangzhou, and Shenzhen, the most economically important metropolitan cities of China, housing prices even had an average annual real growth rate of 13.1% during this decade, which is equivalent to that these cities' housing prices in 2013 are almost 4 times of the prices in 2003. This growth rate easily surpasses the housing price appreciation during the U.S. housing bubble in the 2000s and is comparable to that during the Japanese housing bubble in the 1980s (Fang et al., 2015). Unsurprisingly, the spectacular housing market boom enables housing assets to be the most important assets of the households in China.[1] Meanwhile, air pollution has increasingly become a major public concern for China. $PM_{2.5}$ (Particulate Matter 2.5), which is commonly considered to be an exceedingly pernicious air pollutant, spiked at unprecedented level and conventional measures were found to be "beyond index" in 2013 (The Economist, 2013). Although stringent environmental regulations are devised and enforced to combat air pollutions, China's air quality saw almost no improvement. In the capital of China, Beijing, for example, $PM_{2.5}$ concentrations for a time soared so far as to 1000 $\mu g/m^3$ in 2015, while the harmless level set by the World Health Organization (WHO) is only 10 $\mu g/m^3$.

Exposure to high levels of environmental pollutions, especially fine particulate matter $PM_{2.5}$, causes severe and costly health problems, such as heart attacks and hospitalizations for asthma (Chang et al., 2014), and day to day living quality is thereby dramatically impeded. This naturally predicts that real estate prices of polluted cities will be lower. In other words, environmental pollutions will reduce real estate prices (Gyourko and Tracy, 1991; Rosen, 2002; Zheng et al., 2014). As far as China is concerned, the related questions are as follows. Do these negative effects of environmental pollutions on real estate prices widely exist in China? How large are these effects from the quantitative perspective? To what extent do the effects vary across Chinese cities and periods? Furthermore, in terms of real estate valuations, how large are the welfare gains (or losses) of environmental pollutions reducing (or increasing)?

Addressing the previous questions systemically is crucial for at least two reasons. First, as mentioned earlier, housing assets have become

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[1] In 2011, housing assets account about 60% of total assets in China's households.

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the most important assets for the majority of the households in China, the factors that have adverse effects on real estate prices are therefore of great concern to both households and Chinese government nowadays. Second, in spite of the aspiration for improvements in air quality by citizens and the resolution of the central government to clean the air, the local governments are relatively inactive to improve the air quality, worrying about the adverse impacts of environmental regulations on the local economic performances. This is widely known as the dilemma between economic growth and environmental protections faced by China (Zhao et al., 2014). However, the values of clean air in terms of real estate valuations are traditionally failed to be taken into account. Under the circumstances that environmental pollutions significantly lower real estate prices, the economic losses imposed by environmental regulations will be overwhelmingly overrated. Because such costs can be partially or even completely offset by the real estate prices gains stemming from the improvement of air quality, which potentially induces the local governments to implement environmental protection policies more favorably.

Despite the relevance of investigating the existence and strength of environmental pollutions' negative influences on real estate prices in China, there are relatively few papers fully address these issues. Accordingly, this paper attempts to systematically explore these problems by taking advantage of a very unique and comprehensive panel data set including $PM_{2.5}$ and real estate prices from 286 Chinese prefecture-level cities for 2004–2013. Our preferred empirical results suggest that: (1) There are significantly negative impacts of $PM_{2.5}$ on the real estate prices in China. In particular, 1 $\mu g/m^3$ increase in $PM_{2.5}$ lower real estate prices by an additional 46 RMB/m^2. The results are relatively robust to different empirical model settings. (2) The negative effects differ widely across cities and periods. Specifically, in more populated and economically developed cities (or high-ranking cities), the real estate prices are much more sensitive to the increase in $PM_{2.5}$ concentrations. Additionally, the negative effects of $PM_{2.5}$ on the real estate prices become increasingly statistically significant and quantitatively large over time. For instance, the negative effects during 2010–2013 are about 2.3 times as many as the ones during 2004–2007. (3) In terms of real estate valuations, 1 $\mu g/m^3$ increase in $PM_{2.5}$ is responsible for about 5200 hundred million RMB losses, approximately accounting for 0.9% GDP in 2013 of China.

Our paper complements the existing literature in at least three ways. First, unlike most of the existing papers which have mainly focused on the effects of environmental pollutions on individual's health conditions (Chay and Greenstone, 2003; Neidell, 2009; Chen et al., 2013; Greenstone and Hanna, 2014; Tanaka, 2015; Bombardini and Li, 2016), or on economic performances (Grossman and Krueger, 1995; Copeland and Taylor, 2004; Broner et al., 2012; Hering and Poncet, 2014; Barrows and Ollivier, 2014), we instead study the effects of environmental pollutions on real estate prices, which has currently been a major concern for both households and the government in China. Second, to our knowledge, this is the first study to make use of a comparatively long (10-year) $PM_{2.5}$ panel data set from nearly all Chinese prefecture-level cities to qualify environmental pollutions' influences on real estate valuations. Previous work on this topic, such as Zheng et al. (2010, 2011), have only focused on regular air pollutants, like SO_2 or PM_{10}. In addition, while only 35 cities are used in Zheng et al. (2010) and 85 cities are used in Zheng et al. (2011), the number of cities in our study is as high as 286. The reason that our paper concentrates on $PM_{2.5}$ rather than other common atmospheric pollutants like SO_2, NO_2, and O_3 is two-fold. On the one hand, the miniscule size of $PM_{2.5}$–approximately one-thirtieth the width of a human hair–makes it particularly pernicious, which in turn renders it an especially important pollutant to study (Chang et al., 2014); On the other hand, due to the limited access to the long and comprehensive panel data sets on $PM_{2.5}$ concentrations, the effects of $PM_{2.5}$ have received remarkably less attentions than SO_2, NO_2, O_3, etc. Third, as previously claimed, this paper also sheds light on the heterogeneity in the effects of $PM_{2.5}$ on real estate prices across cities and periods.

The rest of this paper proceeds as follows. Section 2 describes the data sources and presents summary statistics on the main variables used in empirical analysis. Besides, in order to motivate the empirical model specifications below, the stylized facts with regards to the correlations between real estate prices and $PM_{2.5}$ concentrations are also presented in this section. Section 3 presents conceptual framework, outlines the econometric approach and reports the results. Robustness checks and economic losses analysis are conducted in Section 4. Section 5 concludes.

2. Data and stylized facts

To implement empirical analysis, in this study a very unique $PM_{2.5}$ concentrations panel data set spanning from 2004 to 2013 is complied for 286 prefectures of China, supplemented with real estate prices data and the regular prefecture-level demographic and socioeconomic data. One of the advantages of this current research over the previous ones is that a comprehensive data set on city level $PM_{2.5}$ concentrations over a decade is employed. This section mainly documents the data sources, provides descriptive statistics and presents some stylized facts that motivate the empirical analysis below.

2.1. Data

2.1.1. Units of analysis

The unit of analysis in this study is a prefecture, an administrative division ranking between province and county. Median land area and median population of the prefectures in China are 12,362 km^2 and 3.8 million in 2013, respectively. The size of the prefecture makes it a relevant unit of analysis (Bombardini and Li, 2016). Fig. 1 maps the locations of the prefectures covered in our data set, with the capital city of China, Beijing marked. It can be claimed from Fig. 1 that the prefectures in the panel data set are distributed across most parts of China,[2] and are thus nationally representative.

2.1.2. Real estate prices

Since this paper is especially interested in the quantitative effects of $PM_{2.5}$ concentrations on real estate prices in China, real estate prices are the dependent variable and $PM_{2.5}$ is the key independent variable. Real estate prices for 286 prefecture-level cities from 2004 to 2013 are directly derived from China Premium Database available in CEIC (Euro-money Institutional Investor Company). As Zheng et al. (2014), the real estate prices in this paper are represented by average sale price of newly-built commodity housing units, which account for the majority (more than 70%) of the housing transactions in Chinese cities. The real estate prices are rather diversified across cities. In 2013, for example, the real estate prices are available for 284 prefecture-level cities, with the mean of 4665 RMB/m^2, the median of 3963 RMB/m^2, the 10th of 2886 RMB/m^2, and the 90th of 7020 RMB/m^2.

2.1.3. $PM_{2.5}$ concentrations

Due to the fact that China's $PM_{2.5}$ concentrations data is not officially published until 2013,[3] researches concerning $PM_{2.5}$ concentrations are dramatically hindered. However, on the basis of Ma et al. (2015), a 10-year (from 2004 to 2013) long $PM_{2.5}$ concentrations panel data for 286 prefectures in China is constructed in this study. Ma et al. (2015) estimated monthly ambient $PM_{2.5}$ concentrations from 2004 to 2013 in China at 0.1° resolution (adjacent grid points are approxi-

[2] In some western provinces of China, like Tibet and Xinjiang, the cities are rather sparsely populated and few of them become prefectures. For example, in Tibet only the provincial capital, Lhasa, is prefectural city, only Urumqi and Karamay are prefectures in Xinjiang.

[3] Even in the year 2013, the $PM_{2.5}$ concentrations are officially published in only 74 cities, which are regularly considered to be more populated and economically important.