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The persistence of air pollution in four mega-cities of China

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ABSTRACT

This paper analyses long range fractional dependence of China pollution in four major cities, namely Beijing, Shanghai, Guangzhou and Shenzhen from September 28 of 2013 to December 12 of 2015. Unit roots hypotheses are tested by using fractional integration methods using both uncorrelated and autocorrelated errors. The results reveal that the pollution is persistent, meaning that it will continue until strong anti-pollution measures are adopted. Policy implication is derived.

1. Introduction

After more than three decades of rapid development since 1978, China is nowadays experiencing very severe air pollution, especially where there is accelerating urbanization in (Wei, Huang, Li, & Xie, 2016; Zheng, Yi, & Li, 2015). Due to the concern regarding health effects caused by the deteriorating air quality, China's air pollution has become a hot topic for both the public and scholars (Chen, Ebenstein, Greenstone, & Li, 2013; Feng & Liao, 2016; Matus et al., 2012; Shi, Wang, Huisingh, & Wang, 2014). At present, there is little disagreement that air pollution poses a major environmental risk to human health (Guo et al., 2016; Tanaka, 2015). Moreover, the poor air quality also undermines the long-term sustainable development of China (Liu, Wang, & Zhu, 2015; Zheng et al., 2015). According to the estimation of the World Bank, the annual economic loss caused by air pollution could approach as much as 1.2% of China's GDP (Zheng et al., 2015). The degraded air quality also plays a very significant role in causing a significant amount of immigrants to flee China. However, how to effectively reduce the air pollutants remains an important question yet to be answered.

During recent years, sharply increasing empirical research on China also verifies the conclusion on the detrimental health effects of air pollution (Almond, Chen, Greenstone, & Li, 2009; Chen et al., 2013; Fung & Lee, 2011; Tanaka, 2015). However, the existing literature rarely pays attention to the persistence of the air pollution (Liu et al., 2015), namely the time characteristics of air pollution, which will shed light on the persistence of air pollution and the differences between the different regions of China. Meanwhile, a strong understanding of the persistence will also provide important policy implications for the government authorities with regard to regulation on the emissions of pollutants. Depending on the degree of persistence, including mean reverting, unit roots and long memory, different policy measures may also be adopted, and this degree of persistence is determined by the model associated to the data (Smyth, 2013; Barros, Gil-Alana, & Chen, 2015, Barros, Gil-Alana, & Wanke, 2016). This is the second important motivation of our paper. As Beijing, Shanghai, Shenzhen and Guangzhou are the top mega-cities in China, which also plays as engines of economic growth in China, we first investigate the persistence of air pollutant emission in these four mega-cities of China, and adopt the innovative fractional integration and autoregressive models to analyze the time series during the period from 2013 to 2015. With allowing for fractional values, a much richer degree of flexibility in the

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dynamic specification of these series will be displayed.

Despite air pollution being a great threat to human health as well as to long-term development, most previous research focuses solely on certain kinds of pollution, such as particulate matter 2.5 (PM 2.5) or sulfur dioxide (SO_2), without differentiating the different kinds of air pollutants and making a systematic analysis on all of them. Furthermore, it also ignores that the dynamics of different kinds of air pollutants varies both over time and from region to region. As the air pollution levels are determined by the concentrations of a complex mixture of air pollutants, SO_2, NO_2, CO, O_3, PM 2.5 and particulate matter 10 (PM10) are defined as the six criteria pollutants around the world in quantifying air pollution levels. In this paper, we will fill the gap in the existing literature and examine these different air pollutants in different regions of China, respectively.[1]

The remainder of the paper is organized as follows: Section 2 introduces the background of China's air pollution in four different mega-cities in China. Section 3 presents the literature review, followed by Section 4 that introduces the methodology and models. Section 5 displays the data and empirical results and Section 6 concludes.

2. Contextual setting of China's air pollution

2.1. The air pollution in China

According to the National Bureau of Statistics of China (www.stats.gov.cn), the energy consumed by the whole country amounted to the equivalent of 3.84 billion tons of coal in 2014, which is as much as 6.74 times of the total energy consumption in China in 1978. Meanwhile, coal consumption reached 2.47 billion tons in 2014, which is about 6.11 times the volume of coal consumption in 1978. As China has always relied on traditional fossil fuel energy in the last three decades, it produces plenty of byproducts of "economic miracles", which are regarded as the major anthropogenic contributors to air pollution in China (Chan & Yao, 2008; Chen et al., 2013).

Although the government had promulgated the Environmental Protection Law as early as 1979 (more details can be seen in Feng and Liao (2016)), the legislation for air pollution in China has significant defects (Feng & Liao, 2016; Wang & Hao, 2012; Zhang & Wen, 2008), especially in the context of a slowdown of economic growth. Recently, as the serious haze pollution began to blanket many Chinese cities in 2013, the government announced an unprecedentedly more restrictive standard on pollutant limits, which had previously been revised twice before in 1995 and 2000 (i.e. GB3095-1995, GB3095-2000), in order to prevent and control air pollution in China (See Table 1). Moreover, comparing to the former standards in 2000, the new Chinese National Standards for Ambient Air Quality also brought the pollutant PM 2.5 into its scope. This is also much higher than the air quality standard in the Europe and United States (Wang & Hao, 2012).

Despite there being an established system of legislation, plans and policies on air pollution in China which has played a significantly important role in controlling air quality (Wang and Hao, 2008; Feng & Liao, 2016), the air pollutants emission, including the SO_2, Soot and NO_x (Nitrogen oxides), remain at a high level, resisting any significant decline following several years of regulation (See Fig. 1).

Moreover, Soot emissions have sharply increased since 2010, which may explain why severe smog has consistently occurred in many cities of China. Meanwhile, compared to other countries in the world, China's mean annual exposure to PM 2.5 has been much higher since 1990 (See Fig. 2), increasing to more than 50 mg/m^3 since 2010 and is well above the historical level.

Table 1
Concentration limits for basic pollutants in the Chinese National Standards for Ambient Air Quality "GB3095-2012"(unit: mg/m^3).

Pollutant	Frequency	Grade-I	Grade-II
SO_2	Daily	0.05	0.15
	Annual	0.02	0.06
NO_2	Daily	0.08	0.08
	Annual	0.04	0.04
CO	Daily	4	4
	Hourly	10	10
O_3	Daily	0.1	0.16
	Hourly	0.16	0.2
PM 10	Daily	0.05	0.15
	Annual	0.04	0.07
PM 2.5	Daily	0.035	0.075
	Annual	0.015	0.035

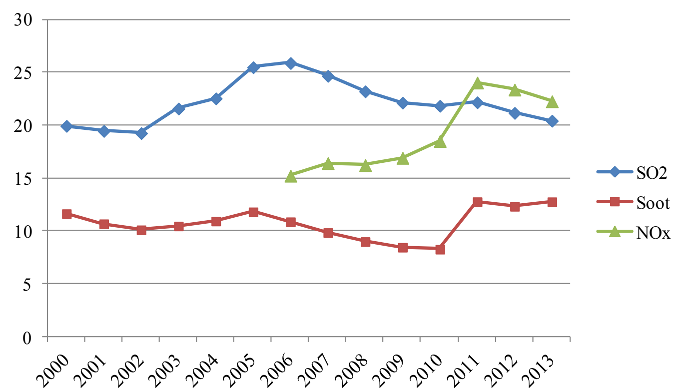

Fig. 1. The SO2, Soot and NOx emissions in China during 2000–2013 (unit: billion tons).
Sources: China statistical yearbook on environment

2.2. The development of four mega-cities in China

As is well known, Beijing, Shanghai, Guangzhou and Shenzhen are the top notable mega-cities in China (See Fig. 3). They not only play the role of the engine of economic growth in China, but also have a much larger population than other cities. The GDP of Beijing, Shanghai, Guangzhou and Shenzhen reached 3.72 trillion Yuan in 2014, which is about 58.48% of the GDP of the whole country. Meanwhile, their total population was 69.64 billion in 2014. All

Fig. 2. The mean annual exposure of the PM 2.5 in China and World (unit: mg/m^3).
Sources: The World Bank Database.

[1] As the data on O_3 is unavailable, we have not make analysis on it.