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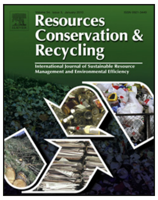

Full length article

Health-related benefits of air quality improvement from coal control in China: Evidence from the Jing-Jin-Ji region

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ABSTRACT

The excessive coal consumption plays an important role in the city haze in the Jing-Jin-Ji region. In this study, we evaluate health benefits resulting from coal control and air pollutants abatement in the Jing-Jin-Ji region employing the dose-response function. The estimation of total valuation has a range of 366.64–810.48 billion RMB for the whole region from 2015 to 2025 and the coal contribution to the economic benefits of air pollution mitigation is more than 50%. The considerable economic value of benefits makes it more attractive for the government to set stringent pollutants reduction target and the results are strong enough to provide air pollution control policy guidance.

1. Introduction

Coal is the main energy resource in China, accounting for almost 70% of the energy structure. About 80% of electric energy, 70% of chemical energy, and 60% of civilian commercial energy are provided by coal (Han et al., 2016; NBSC, 2015; Qi et al., 2012). Coal burning can produce sulfur oxides (SO_x), nitrogen oxides (NO_x) particulate matter (PM) and other harmful pollutants, which affect the life of human, animals and plants directly. The smog sweeping across most northern Chinese cities in recent years is considered to be caused by the massive use of coal (Yuan, 2016). There are some growing epidemiological evidences on the effects of air pollutants on human health in China (Chen, 2008; Zhao et al., 2014; Shen, 2015). The coal control strategy helps to decrease almost health-related pollutants emission as less coal was used and air quality can be improved hugely (Yuan et al., 2016). It will be possible for the Chinese government to take more rigorous coal use limits.

From the perspective of human health, we focus on qualification of benefits resulting from air pollutants abatement providing policymakers with the reference of coal control and environmental policies as well as clearing business organizations. As a matter of fact, the environmental externality of coal use has been widely concerned worldwide. Externalities distort incentives leading to suboptimal resource allocations and monetizing and internalizing of external costs have always been a challenging and debatable issue. Previously, coal externality investigations have centralized on thermal power generation because it generated the biggest problem of environmental pollution, in particular air pollution (Chen and Xu, 2010; Czarnowska and Frangopoulos, 2012). Associated with the external health damage of coal-fired plants, most of quantitative methods are adopted by the impact pathway approach (IPA) of ExternE project, which developed an accounting framework for the externalities of each fuel cycle including coal use (ExternE-Pol, 2004).The internalization has offered a reference for various electricity generation options in coal-fired electricity industry and an incentive of renewable energy development (Galetovic and Munoz, 2013).

All above studies reveal that external environmental costs of coal which incorporates all impacts on crop, building materials, forests and ecosystems should be included by electricity price. But the health-effect damage has not been emphasized or evaluated particularly. In addition, there are few studies on the monetization of health impacts from various air pollutants and for different regions. Matus et al. (2012) evaluated health impacts on ozone and particulate matter with 112 billion USD in 2005. Rodriguez et al. (2010) and Machol and Rizk (2013) presented an estimation of health damage in Mexico City metropolitan area and in United States respectively. Further study conducted by Longo et al. (2008) showed that the human health impacts comprised 100% of the external costs from particulates, and death impacts accounted for

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at least 80% of those health impacts. Concerning the issue of air pollution in China, Chen (2008) estimated the health damage costs of atmospheric particulates (PM10) in Pearl River Delta region. It cost 567.48 million RMB in 2006 accounting for 2.62% of GDP of that district. Based on corrected human capital method, Zhao et al. (2014) focused the premature death losses from by air pollution in Beijing in 2011. Yang and Teng (2016) carried out an analysis oneffect of coal control strategy to energy system and local pollutant reduction. A bottom-up model of China-MAPLE is developed, linking the carbon emission and local pollutant emissions to the coal controlpolicy scenarios.

In this study, we extend time span by setting two scenarios or targets and evaluate economic benefits of coal control from the perspective of human health. The rest of the paper is organized as follows. In Section 2, we describe the social-economic status and local air pollution level of the Jing-Jin-Ji region. Section 3 presents data and methodology. Section 4 provides empirical results and makes a discussion. The paper concludes on the basis of the results with some policy implications in Section 5.

2. The Socio-economic status of the Jing-Jin-Ji region

The heavy smog mainly resulted from coal excessive use could pose significant public health risks due to its deeper penetration into respiratory and lung areas, as well as cause huge enormous economic losses(Platt, 2007; Pan et al., 2012; Matus et al., 2012). Moreover, these pollutants are able to travel great distances and affect populations hundreds of kilometers from the source (Rodriguez et al., 2010), thus it is necessary to take some measures to mitigate air pollution within some regions.

The Jing-Jin-Ji region is one of the most overpopulated city clusters as well as the seriously polluted area in China. Besides Beijing and Tianjin, the region covers Baoding, Langfang, Tangshan, Zhangjiakou, Chengde, Qinhuangdao, Cangzhou, Hengshui, Xingtai, Handan and Shijiazhuang which are located in Hebei province (Fig. 1). As China's northernmost metropolitan region, the region accounts for 2.2% of China's land. Data from 2011 shows that this area accounts for 7.5% of China's population, yields 10% of its total GDP and consumes 10% of its coal (China Statistical Yearbook, 2012). Heavy industries play a significant role in the economic development of this region; these industries include petroleum processing and coking, the smelting and pressing of ferrous metals, and the production and supply of power and heat. They are also energy-intensive and high polluters contributing correspondingly to the severe air pollution.

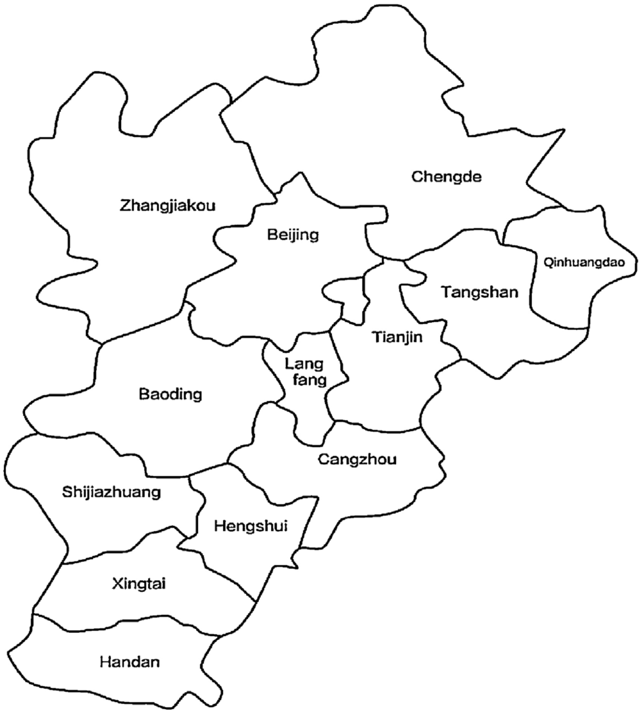

Fig. 1. The spatial location of the 13 cities in the Jing-Jin-Ji region.

The demographic and economic importance of the region makes it attractive to assess the economic valuation of potential health gains of pollution mitigation.Our study enters on analyzing and obtaining the health-related benefits of coal control strategy.

3. Methodology

The quantification of health-related gains carried out in this research is based on the impact pathway approach (ExternE-Pol, 2004) with the beginning of identification of relevant pollutants emitted in the Jing-Jin-Ji region. In this section, we provide information on data sources, estimate the reduced health effects because of the coal use control and monetize health benefits with various valuation approaches during the period of 2015–2025.

3.1. Data sources

The Impact Pathway Approach (IPA) is a traditional methodology of calculating site-specific health benefits from emissions reduction on condition that meteorological data, population distribution and pollutant emissions are available. A dataset obtained from the Data Center for Ministry of Environmental Pollution, can be used to demonstrate the relationship between air pollution and cardiovascular- and respiratory-morbidity and mortality between 2015 and 2025.

Sulphur dioxide (SO2), nitrogen dioxide (NO2) and particulate matters combined with NH_3 are essential pollutants to reduce contribution of power generation to future air pollution in China (Hu et al., 2016). Therefore,the explanatory variables of air pollutants included in our analysis are SO_2, NO_2 and PM_{10}. These pollutants are daily monitored by the monitors in 13 different cities and the population density of each city is various as the vast area of the Jing-Jin-Ji region. Comprehensive changes in pollution and population have prompted us to separate the regional population and pollution by city levels in order to analyze the impact and benefits of emission reduction in a more detailed analysis. Here, we incorporate the differences in pollution exposure to identify the exposure level of population in the region. The population figures for each city come from National Bureau of Statistics (NBSC, 2014) and pollution and population levels by cities are shown in Table 1 and Fig. 2.

In testing the data in Table 2, we find that some cities had serious pollution problems. Xingtai had the highest values of SO_2 and PM_{10} among these cities and Tangshan was severely affected by NO_2. By contrast, Zhangjiakou and Chengde had relatively high quality of air all year around and this may be related to geographic location. Table 2 also demonstrates that the pollutants concentration in the region generally has not yet met either the Ambient Air Quality Standards Grade 2 (*AAQS2*) (Ministry of Environmental Protection, 2016) or the World Health Organization (*WHO*) standards (World Health Organization, 2005).

After analyzing the situation of pollution and population in different cities, benchmark mortality and morbidity can be acquired for diseases as to apply the dose-response functions. Due to the difficulty of obtaining baseline death number of respiratory and cardiovascular cases for specific cities, we replace it with nationwide death rate of cardiovascular and respiratory diseases by using the China Health Yearbook (2014) which reports information

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