



# China's regional sustainability and diversified resource allocation: DEA environmental assessment on economic development and air pollution



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## ABSTRACT

Environmental protection, including the prevention of air pollution and health hazard materials such as PM2.5 and PM10, is now a very serious policy issue in China after attaining the rapid economic growth and development. The PM stands for “Particular Matter”, indicating the size of both solid particles and liquid droplets found in air. Unfortunately, the economic development has produced a serious healthcare problem in not only China and other surrounding nations. To enhance people's healthcare and appeal a good national image to the world, China is recently looking for the new industrial and environmental policy direction to attain social sustainability in terms of economic development and environmental prevention. To discuss policy implications on the new policy direction, this study utilizes Data Envelopment Analysis (DEA) for assessment on its regional performance by incorporating PM2.5 and PM10 as undesirable outputs, along with two disposability concepts (i.e. natural disposability and managerial disposability). No previous DEA study has incorporated the amount of PM2.5 and PM10 in empirical investigation. Using a simulated data set for the period of 2013–2014, this study measures the efficiency of municipality cities under four different types of regional classifications. The empirical results indicate that the Chinese government should distribute its economic resources to cities, which locate in the northwest region (including Lanzhou, Xining, Yinchuan and Urumqi), and reinforce more strict regulation on energy consumptions for environmental prevention in major cities (e.g. Beijing, Tianjin, Shanghai and Chongqing). The industrial policy change from the economic growth to the environment protection is essential for the future of China, which is currently the second largest economic power in the world. The environmental protection can enhance the China's image of contributing in economics, industry and environmental protection to all other nations. It can be envisioned that the new policy effort reduces the regional imbalance and increases the social sustainability in China. The empirical findings and policy implications discussed in this study are applicable to not only China but also other industrial and developing nations and those are useful in guiding their industrial and environmental policy development.

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## 1. Introduction

China's environmental crisis is one of the most serious policy challenges. The crisis has emerged from the country's rapid industrialization. The economic rise, which was around 10 percent annual Gross Domestic Growth (GDP) on average, increased during the past decade and came at the expense of the environment and public health. Life expectancy has decreased by 5.5 years because of air pollution. According to a World Health Organization report ([http://www.who.int/phe/health\\_topics/outdoorair/databases/FINAL\\_HAP\\_AAP\\_BoD\\_24March2014.pdf?ua=1](http://www.who.int/phe/health_topics/outdoorair/databases/FINAL_HAP_AAP_BoD_24March2014.pdf?ua=1)), seven million people were killed by air pollution in 2012 and 40% of them were Chinese.

Health officials warn that exposure to particulate matters, known as PM2.5 (Particulate Matter with diameter of 2.5 micrometers or less) and PM10 (Particulate Matter with diameter of 10 micrometers or less),

may produce serious health problems, including lung cancer and other cardiopulmonary mortality. The Environmental Protection Agency (EPA) in the United States began regulating small particles separately from the larger PM10 in 1997. The PM2.5 may deeply penetrate into our lungs than the PM10 and the consequent threats to health are more serious. In 2013, a Danish study, involving 312,944 people in nine European countries, revealed that every increase of 10  $\mu\text{g}/\text{m}^3$  in PM10 increased the lung cancer rate by 22%. The smaller PM2.5 was particularly deadly along with a 36% increase in lung cancer per 10  $\mu\text{g}/\text{m}^3$ .

The purpose of this study is to discuss the current situation of Chinese industrial development and environmental protection, including the source of air pollution and related to health issues such as PM10 and PM2.5. No previous study has examined the influence of such particles. This study proposes the use of a holistic methodology (Data Envelopment Analysis: DEA), to evaluate the performance of Chinese cities from their social sustainability, or a simultaneous development of economic success and environmental protection.

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The proposed use of DEA, referred to as “DEA environmental assessment”, has three research concerns to be explored in this study. First, it incorporates two disposability concepts such as natural disposability and managerial disposability, where operational performance is the first priority and environmental performance is the second priority under the natural disposability. An opposite priority is found under the managerial disposability. Second, this study applies the proposed DEA approach, originated from the two disposability concepts, for performance assessment of Chinese cities. It is necessary for us to examine different disposability concepts and different methodologies to obtain useful policy suggestions for guiding a very large policy issue such as the Chinese economic development and pollution prevention. Finally, this study summarizes policy implications obtained from the proposed empirical study.

The remainder of this study is organized as follows. Section 2 provides a historical description on Chinese industrial development and environmental protections. Section 3 summarizes previous studies on DEA environmental studies on Chinese social sustainability. Section 4 discusses underlying concepts, which are incorporated into the proposed DEA approach. Then, the section describes radial models under the two different disposability concepts. Section 5 describes a data simulation process. Section 6 applies the proposed approach to evaluate the social sustainability (economic success and environmental protection) of Chinese cities. The section summarizes empirical results obtained from the proposed DEA study. Section 7 concludes this research, along with research tasks to be explored as future extensions.

## 2. Chinese industrial development and environmental protection

In 1972, Chinese representatives attended the first United Nations Conference held in Sweden on the Human Environment. On August 5, 1973, the Environmental Protection Leadership Commission was first established in the National Environmental Protection Conference of China. The members of this commission were leaders of more than 20 related national departments. By then, the country's environment was already in a serious situation that was further exacerbated by economic reforms of the late 1970s. Spearheaded by Xiaoping Deng in 1978, the reforms boosted China's industrial outputs at an average annual rate of more than 11.4 percent. At the same year, China has amended its constitution to add the following statement: “The state protects the environment and natural resources. It also prevents and controls pollution and other public hazards.” This amendment formed the constitutional foundation for the country's administrative framework for environment protection. In 1979, China passed the Environmental Protection Law for trial implementation. This law included a chapter on the governmental structure and responsibilities, which required all related departments under the State Council, as well as provincial and municipal governments, to set up specialized environmental protection and supervision institutes. China's environmental protection framework was thereby formally enacted into law.

China has conducted the first national administrative reform after the transformation of a market mechanism in the early 1980s. As part of these reforms, the Environmental Protection Leadership Commission was dissolved and the Environmental Protection Agency was set up as part of the newly formed Ministry of Urban Construction and Environmental Protection. Thus, the environmental protection belonged to the category of urban construction, making the government's responsibility to protect the environment as secondary. In 1983, the Chinese government announced that environmental protection became a state policy. The law of Air Pollution Prevention and Control was enacted in 1987. In 1989, the Standing Committee of the National People's Congress set up the administrative framework by making the 1979 Environmental Protection Law permanent. The decision strengthened the governmental responsibility and authority over environmental protection. Later on, more laws were enacted such as the Energy Conservation Law of 1997,

and several important international agreements, such as the Kyoto and Montreal protocols.

The legacy of decentralization characterized by Deng's reforms remained at the heart of China's environmental struggles. The reforms diffused authority to the provinces, creating a proliferation of Township and Village Enterprises (TVEs) to encourage development in rural industries. In 1997, TVEs generated almost one third of the national GDP (Gross Domestic Product). However, local governments had a difficulty in monitoring their performance, therefore seldom upholding environmental standards. Today, environmental policies remain difficult in these enforcements at a local level, where officials often retain their economic incentives and ignore their environment protections.

In 1998, the Chinese government upgraded the Leading Group to a ministry-level agency, which became the State Environmental Protection Administration (SEPA). However, although SEPA was directly under the State Council's control, it was still not at the cabinet level and did not have a voting power in the Council's decisions. The Clean Production Promotion Law, enacted in June 2002, established demonstration programs for pollution regulation in 10 major Chinese cities and designated several river valleys as priority areas for cleaning-up of pollution.

From 2001 to 2005, Chinese environmental authorities received more than 2.53 million letters and 430,000 visits by 597,000 petitioners who requested environmental redress. The number of mass protests caused by concerns over environmental issues grew steadily from 2001 to 2007. The increased attention on environmental matters caused the Chinese government to display an increased level of concern towards environmental issues and subsequently implemented strict environmental regulations. Consequently, subsidies for some polluting industries were cancelled, while other polluting industries were shut down. However, many internal environmental targets were still missed in China's industrial development<sup>1</sup>.

After the 2007 address, the influence of corruption was a hindrance to effective enforcement, as local authorities often ignored orders and hampered the effectiveness of central decisions. In response, the Communist Party of China (CPC) implemented the “Green” project, where China's GDP was adjusted to compensate for negative environmental effects. However, the program quickly lost an official influence due to unfavorable data.

On March 15, 2008, China's Eleventh National People's Congress passed the Super Ministry Reform (SMR) motion, which was proposed by the State Council, and created five “super ministries,” mostly combinations of two or more previous ministries or departments. The main purpose of the SMR was to avoid overlapping governmental responsibilities by combining departments with similar authority and closely related administrative functions. One of the highlights was the elevation of the State Environmental Protection Administration (SEPA) to the Ministry of Environmental Protection (MEP), which we also refer to as the environmental SMR. In the SMR, MEP was upgraded and was the only department to retain its organizational structure and governmental responsibilities. Since its status as a cabinet member is protected by law and cannot be changed by the State Council, the establishment of MEP demonstrates the strong political will and commitment of China's central government to environmental protection.

Citizen activism in government decisions increased in the 2010s<sup>2</sup> and more than 50,000 environmental protests occurred in China during 2012. In response to an increasing air pollution problem, the Chinese government announced a five-year, \$277 billion plan to address the issue in 2013. According to the Xinhua News Agency report, a policy effort including an investment of 950 million yuan was made by Chinese government to build an information broadcast system, referred to as

<sup>1</sup> Joseph Kahn and Jim Yardley “As China Roars, Pollution Reaches Deadly Extremes”. *The New York Times*, August 26, 2007.

<sup>2</sup> Keith Bradsher “Bolder Protests against Pollution Win Project's Defeat in China”. *The New York Times*, July 4, 2012.

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