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The environmental efficiency of Wanjiang demonstration area: A Bayesian estimation approach

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ABSTRACT

With the implementation of the strategic policy and the construction of Wanjiang demonstration area recently, the government cares more about the natural environment. To protect the environment of this demonstration area, a quantitative analysis of environmental efficiency and its influencing factors is needed. In this paper, we measure the environmental efficiency of the demonstration area, and then analyze the total factor productivity of the area by Malmquist productivity index through data envelopment analysis (DEA) approach. Through the index and its decomposition, we are able to reveal the changing trend of the environmental efficiency. Moreover, we apply Bayesian estimation approach to analyze the influencing factors of the efficiency and discuss the relationship between these factors and the environmental efficiency. Results show that the efficiency of Wanjiang demonstration area bares a significant difference among constituent cities. Each area should devise proper environmental policy according to its particular circumstance.

1. Introduction

On January 12, 2010, the State Council of China approved the Wanjiang City demonstration area program (Wanjiang Program for short in the sequel), which is an industrial shift demonstration area of the city cluster along Anhui-Yangtze River planning for the transfer of industries of coastal city. At present, the government's attention gradually shifts from the economic aspects of the area to the environmental aspects. As the first approved national level industrial transfer demonstration area, Wanjiang city cluster is the area for implementing the strategy of promoting the rise of the China's central region. The demonstration area, which plays a critical role in undertaking industrial transfer in the Midwest of the nation, is also an important part of the Yangtze River delta region. Additionally, the program is of great significance to the rise of Anhui province. It will certainly promote the growth of Anhui province by participating in the division of labor in the pan Yangtze River delta region. In the course of exploring the new pattern of undertaking industrial transfer in the central and western regions, the implementation of the Wanjiang Program will bring a new flavor to the development of central China.

According to the Wanjiang Program, Wanjiang city cluster includes nine cities plus three districts (or counties) in Anhui province: Hefei, Wuhu, Maanshan, Tongling and Anqing, Chizhou, Chuzhou, Xuancheng and Chaohu, and Jinan district and Shucheng County of Luan city.[1] We show these Wanjiang demonstration cities in Fig. 1. Altogether, it consists of 59 counties (city, district). It covers a land area of 7.6 square kilometers and a population of 30.58 million people. From 2009 to 2011, GDP of the cluster is 6733.16, 8406.81, and 1.035 trillion in RMB respectively, which accounts accounted for 66.91%, 68.02% and 67.63% of the province's total GDP.

The rapid development of the economy is accompanied with the increasing consumption of resources and the augment of environmental pressure in China. The Wanjiang Program requires the demonstration area to place resources conservation and environmental protection in an important position. Specifically, the development should combine the industrial transfer with the enhancement of ability to sustainable development, strengthen the ecological construction and environmental protection, focus on energy conservation and emission reduction, and promote the comprehensive utilization of resources.

Therefore, the program should improve the environmental efficiency when pursuing a rapid economic growth so as to improve the level of the sustainable development of the society. Necessary measures should be taken to ease the environment pressure to ensure that the environmental load is within a tolerable range. Wanjiang city cluster is a representative of an emerging

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[1] On October 22, 2011, the Chaohu city is officially split into three districts, which are incorporated into Hefei, Wuhu and Mannshan, respectively.

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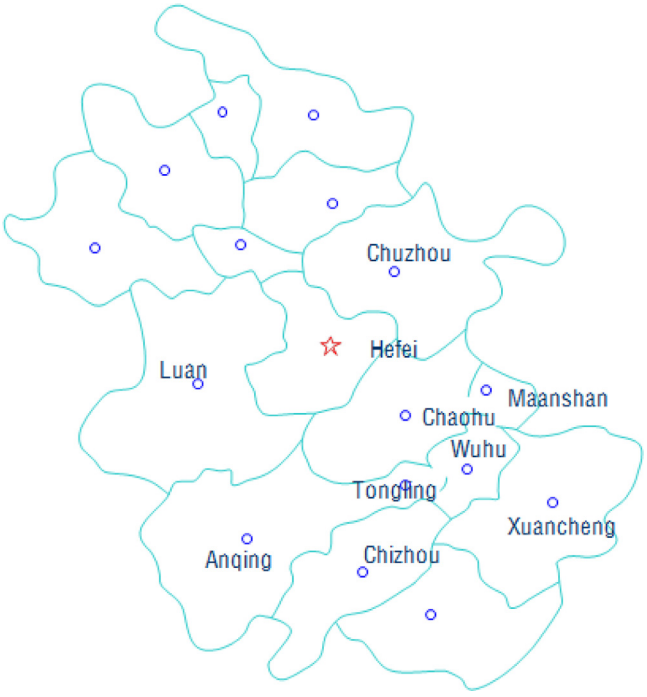

Fig. 1. Wanjiang demonstration cities in Anhui provinces.

economy. Its rapid development has a significant impact on the quality of the environment. Only do we hold good balance between economic development and environmental protection, can the program achieve real sustainable development.

The rest paper is organized as follows. Section 2 briefly reviews the related works about environment efficiency and Malmquist productivity index. Section 3 shows the super SBM model and calculates the environmental efficiency of cities in Wanjiang demonstration area. Section 4 gives the empirical analyses on the effect of various factors on the environmental efficiency of Wanjiang demonstration area by Bayesian statistical inference method. The conclusion is given at the last section.

2. Literature review

Recently, how to pursue rapid economic development subject to natural environmental constraint has attracted more and more scholar's interest and attention. As a comprehensive index for evaluating the impact of economic development on environment, environmental efficiency was first proposed by WBSCD (World Business Council for Sustainable Development, Sustainable Development Council) in 1992.[2] According to the definition, the environmental efficiency refers to the ratio of the economic value of products and services satisfying human needs to environmental load. This definition is well received in academia. The definition emphasizes that providing goods and services with price advantage to meet human demand for high quality life and at the same time, controlling the impact on the environment to the bearing level of the earth during the entire life cycle of the products and services.

Current debate about the relationship between environmental protection and economic benefit in academia still remains. There are two contradictory points about the relationship. Boyd and McCelland (1999) and Feichtinger et al. (2005) maintained that excessive restrictive environmental policy implemented by the government will disturb enterprise's normal business. For example, environmental protection will cause the enterprise to bare additional costs, lessen the profits, and eventually weaken the ability to compete in the market. In contrast, Mohr (2002) and Kuosmanen et al. (2009) argued that necessary environmental protection policies will reduce costs and increase their sales, resulting in efficiency promotion eventually. Rapid economic growth tends to reduce the efficiency in using the natural resources and increase the environmental pressure resulting in declining environmental quality. Though two viewpoints have their grounds on the relationship between environmental policies and enterprises, they both believed that the economy development impedes the environment. The deteriorating environment owing to serious environmental pollution and excessive development, in turn, hinders economic development.

The researches on the environmental efficiency have emerged since the environmental efficiency was put forward. A majority of them have been calculated based on data envelopment analysis (DEA) (Rogge, 2012). However, traditional environmental efficiency estimators include environmental protection factors, but do not include the undesirable outputs. Färe et al. (1989) was the earliest application of weak disposability to input and output indicators. The proposed model assumes that the reduction in undesirable outputs has a negative effect on desirable outputs. In other words, in the course of reducing the undesirable outputs, the desirable output will suffer accordingly. In addition, Färe et al. (1989, 1994a,b) transformed the theoretical Malmquist productivity index into empirical index. Thereafter, many DEA works based environmental efficiency appear continuously. Kumar (2006) used DEA to compute the directional distance function, and further derived Malmquist–Luenberger (ML) productivity index to examine conventional and environmentally sensitive total factor productivity (TFP) in 41 developed and developing countries over the period of 1971–1992. Zhang et al. (2011) also applied the Malmquist–Luenberger (ML) productivity index to measure China's growth in TFP. In their research, the undesirable outputs are incorporated. They showed that the average annual ML productivity growth is 2.46%, approximately half of the result from the traditional Malmquist productivity index. The authors also investigated the effect of the enforcement of environmental regulations on the improvement of ML productivity growth in China. Wu et al. (2012) studied the energy efficiency performance by environmental DEA models with CO_2 emissions. Moreover, that paper provided decomposition of the resulting energy performance indexes into contributing components. Lee and Zhang (2012) estimated the technical possible CO_2 reduction potential based on the input distance function. At the same time, they estimated the shadow price of CO_2 emissions. Mahlberg et al. (2011) investigated the drivers of TFP change in 14 countries of European Union during the period 1995–2004 based on an extended DEA model for eco-efficiency analysis. However, judging from the current literature, the major researches concentrate on the application of non-parametric DEA technique. In contrast, rare studies perform statistical analysis on the evaluation results (Song et al., 2012). Moreover, all these works only consider the improvement from output oriented or input oriented, that is, their models are radial. In this paper, super slacks-based measure model (super SBM) is applied to measure the environmental efficiency of Wanjiang demonstration cities. The super SBM model is firstly proposed by Tone (2002) based on the SBM model by Tone (2001). So far, SBM model has been applied in many areas (Rao et al., 2012; Zhang and Choi, 2013). But SBM model cannot discriminant the efficient DMUs which have the same efficiency of 1. Super SBM model by Tone (2002) not only can measure the input slacks and output slacks of cities to be efficient, but also can discriminate the efficient DMUs in SBM model by Tone (2001). That is, it has the advantages of both SBM model and super

[2] http://www.stat.yale.edu/cgi-bin/R/cpmain?iso=BRA%26view%3Dsummary%26thisind%3DEPI.