Land Use Policy 75 (2018) 518–529

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Spatial-temporal disparities, saving potential and influential factors of industrial land use efficiency: A case study in urban agglomeration in the middle reaches of the Yangtze River

Hualin Xie[a,b,*], Qianru Chen[a], Fucai Lu[a], Qing Wu[a,b], Wei Wang[a]

[a] Institute of Ecological Civilization, Jiangxi University of Finance and Economics, Nanchang 330013, China
[b] Co-innovation Center of Institutional Construction for Jiangxi Eco-civilization, Jiangxi University of Finance and Economics, Nanchang 330013, China

ARTICLE INFO

Keywords:
Industrial land
Land use efficiency
SGDDF
Land management
Malmquist index
Urban agglomeration
Yangtze River

ABSTRACT

Based on the sequential generalized directional distance function (SGDDF) and Metafrontier non-radial Malmquist index (MNMI), the dynamic changes, saving potential, efficiency decompositions, and influencing factors of industrial land use efficiency are analyzed. This paper is a case study on the urban agglomeration in the middle reaches of the Yangtze River focusing on the years between 2003 and 2012. The results show that (1) potential for significant improvement in industrial land use efficiency exists, and the saving potential of industrial land shows a rising trend. With the least saving potential, the Poyang Lake city group enjoys the highest efficiency. With the greatest saving potential, the efficiency in Wuhan city group is the lowest. (2) A positive catch-up effect and technological progress can be observed in industrial land use efficiency in the examined region, but the lack of technology innovators inhibits the promotion of industrial land use technology. (3) The analysis of the influencing factors shows that the relationship between per capita GDP and industrial land use efficiency follows an "N" shape. With the further economic development, industrial land use efficiency will decline slightly. Enhancing industrialization and land investment policies is thus conducive to increasing industrial land use efficiency, while industrial labor surplus and the governance of "Land Finance" have the opposite effect. Specific countermeasures to promote industrial land use efficiency are as follows: optimize industrial structure and improve labor skills; expand local industrial economy size properly to absorb surplus labor; perfect the land circulation system, and give full play to the resource allocation function of the land market; promote cross-regional flow of production factors; and strengthen regional cooperation among cities in the middle reaches of the Yangtze River.

1. Introduction

The *industry* forms the pillar of China's national economy; industrial land is the input factor of industrial production, but also an important carrier of activities of industrial production (Zhang and Lu, 1999). Since the reform and opening up of China's economy, its industrial economy has remarkably developed, as well as the increase in demand for industrial land (Tu et al., 2014; Zhang, 1997). In 2012, China's urban industrial land area reached 8712.44 km^2, accounting for 20% of the total built-up area of the city, far greater than the proportion of other productive land (Jia et al., 2010; Siciliano, 2012). The large-scale expansion of industrial land has not only led to the loss of a large number of arable land resources, exacerbating the problem of food security in China, but has also contributed to extensive use of land resources (Gong et al., 2014; Huang et al., 2009a, b). According to incomplete statistics, nearly 5% of China's land resources in the city comprise idle land, and about 40% of urban land in China are inefficiently used, aggravating the effects of loss of arable land (Wu and Qu, 2007). In addition, excess pollutants from industrial production processes are not only a direct threat to the health of local residents, but considerably damage the ecological environment (Wang et al., 2015).

The Chinese government has long been concerned about land use. Since 1985, a series of land use plans have been promulgated. In 1998, the land management law was revised, and it effectively curbed the encroachment of cultivated land by rapid urbanization and industrialization (Ding, 2003; Li and Yeh, 2004). In 2006, industrial lands were publicly transferred in an attempt to improve industrial land use efficiency through approaches such as establishing an open market and promote healthy competition (Zhao et al., 2014). In terms of environmental protection, a series of laws and regulations, such as Water

* Corresponding author at: Institute of Ecological Civilization, Jiangxi University of Finance and Economics, Nanchang 330013, China.
E-mail address: xiehl_2000@163.com (H. Xie).

https://doi.org/10.1016/j.landusepol.2018.04.027
Received 22 December 2017; Received in revised form 3 April 2018; Accepted 10 April 2018
Available online 24 April 2018
0264-8377/

Pollution Prevention Law, have been promulgated to limit the emissions of industrial pollutants and improve ecological environment (Du, 2014; Gao and Yu, 2007). However, considering the current situation, extensive use of industrial land, coupled with serious environmental pollution, remains fundamentally unresolved. The industrialization of urban agglomeration in the middle reaches of the Yangtze River is relatively backward, and industrial land use efficiency is lower than that of other developed provinces in eastern China (Gao and Li et al., 2014; Guo and Xiong, 2014). In addition, the impact of human activities on ecological land over time has been increasing (Xie et al., 2017). Due to preference for heavy industry and absence of environmental protection measures in the process of industrial development, the ecological environment is under great pressure; and environmental pollution is rife.

For sustainable development of the social economy, building a resource-saving and environment-friendly society ("two-oriented society") is a key strategy and rational pursuit (Sun, 2009). In December 2007, the Wuhan and Chang-Zhu-Tan urban agglomerations were approved as "national comprehensive reform pilot areas of two-oriented society construction"; in December 2009, the construction of Poyang Lake Eco-economic Zone was officially upgraded as a national strategy. Naturally, urban agglomerations in the middle reaches of the Yangtze River have become key areas in the construction of a two-oriented society. With the approval and implementation of "Development Planning for City Groups in the Middle Reaches of the Yangtze River", urban agglomeration in the Middle Reaches of the Yangtze River constitute an important stage of growth in central China. With a population of about 120 million, these regions include Wuhan urban agglomeration, Chang-Zhu-Tan urban agglomeration, Poyang Lake urban agglomeration, and their surrounding cities (Fig. 1), all covering an area of about 317,000 km^2; in 2004, its economic aggregate exceeded 4.5 trillion Yuan. As per the plan's proposal, per capita GDP and urban per capita disposable income were aimed to be promoted to 75,000 Yuan and 43,000 Yuan, respectively, in the next five years, envisioning that rapid economic development in the short term in the aforementioned urban agglomeration.

In terms of geographical location and economic spatial distribution pattern, the Yangtze River city group plays an important role in linking the eastern and western regions and connecting the south and north areas. In the middle reaches, urbanization has been accelerating under blind spatial expansion. According to incomplete statistics, the urban built-up area in the urban agglomeration of middle and lower reaches of the Yangtze river has expanded by 2.5 times between 2000 and 2010, while the population size has only increased by 1.48 times. Thus, urban space expansion has outgrown the demand of population and industrial agglomeration[1]. The rapid expansion of urban built-up area, mainly due to the occupation of surrounding high-quality cultivated land, is coupled with accelerating urbanization.

Since 1978, China has experienced a rapid loss of arable land (Zhong et al., 2017). The regions we examined are one of the main grain-producing areas in China. Thus, loss of arable land is a serious threat to national food security. The economic structure in the urban agglomeration of the river's middle reaches is dominated by industry. Being an important part of urban built-up area, extensive industrial land use, combined with severe food insecurity, requires the improvement of industrial land use efficiency; that is, shifting from "outward expansion" to "exploiting internal potential." Influencing the effect of industrial land use and management, the intensive use of industrial land is conducive to food security. Hence, analyzing the spatial and temporal disparities, saving potential, and influencing factors of industrial land use efficiency in urban agglomeration of these middle reaches not only provides references for optimal allocation of land resources and intensive industrial land use pattern, but also has theoretical and practical significance for nation food safety issues and acceleration of industrial transformation and upgrading.

Related literatures from across the world mainly focus on urban and rural residential areas from the aspects of building density and plot ratio (Denhise and William, 1996). There is dearth of literature on industrial land use efficiency or corresponding concepts abroad. In general, the more intensive the city is, the higher is its land use efficiency (Huang et al., 2009a). Outside China, intensive use of urban land has always been perceived through urban economics, land economics, land use planning, and policies and regulations thereof (Wang and Shao, 2008; Wang and Zhang, 2006). Investigating land use efficiency was initially limited to economic perspectives; for example, Stull (1974) proposed "social optimum economic benefit in land use," following which, Eric (2000) claimed that "not only economic but also social and political connotations should be taken in account," which enriches the principle of land use efficiency. The study on industrial land originated from the systematic description of industrial enterprise location selection in the early twentieth century (Fetter, 1924; Losch, 1954; Webber, 1964), and scholars expanded the research from aspects of economics and ethology afterwards. In recent years, land use efficiency in China has aroused wide concern both home and abroad. In terms of evaluation index system, the single-element evaluation method for resource efficiency originally applied in agriculture are introduced in the study of China's land use efficiency, (Hu et al., 2006), namely, use the number of resources, such as labor and capita per unit area, to represent the intensities of inputs (Huang et al., 2009a; Li et al., 2014; Xie et al., 2018), or use economic output value per unit area to represent the economic efficiency of land (Liu et al., 2003). Some scholars also noticed the negative impact of industrial pollution on the ecological environment, so they use the industrial pollution emissions per unit area of land to represent the intensity of pollution. However, as production is complex process, being a part of input factors, land cannot produce output alone. Therefore, a multi-index evaluation system taking social, economic, and environmental factors into account has been gradually incorporated into the evaluation of China's industrial land use efficiency. In terms of research methods, data envelopment analysis (DEA) is favored because it can objectively determine the weight of the parameters, and evaluate efficiency scientifically and systematically. (Guo and Xiong, 2014; Wu et al., 2011; Xiong and Guo, 2013). However, as the DEA model ignores the existence of slack variables, and it is constrained by static analysis (Sun et al., 2012), scholars developed a sequential generalized directional distance function (SGDDF), so they can obtain an unbiased and dynamic efficiency evaluation results (Zhang and Xie, 2015). In addition, the Malmquist index is also a widely-used dynamic efficiency evaluation method. It can decompose efficiency into catch-up effect and technological progress to explore the specific reasons for efficiency changes. However, these two indexes do not take into account the differences in industrial structure and production technology in different areas, which is an important factor that influences resource use efficiency. To overcome this shortcoming, some scholars put forward the Metafrontier Non-Radial Malmquist Index (MNMI) to further explore the dynamic changes of resource use efficiency differences in different areas, and propose the concepts of technological innovators in the framework of Metafrontier and group frontier, which helps deeply and meticulously understand the utilization status of regional resources (Zhang and Choi, 2013). In terms of influencing mechanism, the degree of economic development, industrial structure, and land policy are commonly considered important factors that influence the efficiency of industrial land use (Guo and Xiong, 2014; Xiong and Guo, 2013).

The study constructs a comprehensive efficiency evaluation index system including economic and environmental factors. Then, based on SGDDF model, the study analyzes the dynamic change of industrial land use efficiency in the middle reaches of the Yangtze River in 2003–2012, and calculates the industrial land saving potential according to the actual scale of industrial land. Next, using the MNMI method, the dynamic change of industrial land use technology and regional differences are analyzed to determine technological innovators that promote

[1] http://www.amr.gov.cn/ghbg/qyjj/201707/t20170720_65553.html.