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JLUP-2692; No. of Pages 12
ARTICLE IN PRESS
Land Use Policy xxx (2018) xxx–xxx
Contents lists available at ScienceDirect
Land Use Policy
journal homepage: www.elsevier.com/locate/landusepol

Efficiency of construction land allocation in China: An econometric analysis of panel data

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ARTICLE INFO

Article history:
Received 19 January 2017
Received in revised form 22 March 2017
Accepted 23 March 2017
Available online xxx

Keywords:
Allocative efficiency
Construction land use
Cobb-Douglas production function
Econometric analysis
Panel data

ABSTRACT

The optimal allocation of land resources is an important prerequisite for sustainable land use and for synergic development of regional resources-environment-economy. The question on how to optimize and allocate the regional land resources has become a hotspot in land use and land cover change studies. However, the allocative efficiency of China's construction land is currently a rather rudimentary and subjective issue. This study used an extended Cobb-Douglas production function to measure the allocative efficiency of construction land at the national and regional levels using balanced provincial panel data from the 1985–2014 period. The results showed that China's construction land has exhibited a significant increasing trend over the past three decades, and its growth rate in the central region was relatively higher than that in the eastern and western regions. There is little or no available arable land that can be occupied by construction uses in China's economically developed provinces. Further investigations demonstrated that capital, labor and land investment all contributed to the non-agricultural GDP growth in China. The allocative efficiency of construction land in the eastern region was greater than that in the central and western regions. The efficiency of construction land allocation in China needs to be further improved, and the intensive utilization of land resource is necessary, particularly in the context of China's "new normal" economy. Because of the regional disparities in the efficiency of construction land allocation, formulating specific region-oriented land use planning may be more urgent. These findings can provide policymakers with a sound basis for land use and urban planning.

1. Introduction

Land resources are the material basis of survival and development for humans as well as the carrier of social and economic development. China is a mountainous country, with two-thirds of its total land area covered by mountains, hills and plateaus, but it has created a miracle with less than 7% of the world's arable land feeding 22% of the world's population (Lam et al., 2013). China has experienced an unprecedented industrialization and urbanization process, particularly since the reform and opening in 1978. Under the premise that the total amount of land resources remains unchanged, some of the arable land for agricultural production purposes is released to meet the needs of newly added construction land (Chen, 2007; Wang et al., 2012; Liu et al., 2014a; Li et al., 2015). Most of the newly added non-agricultural construction land in China was mainly converted from cultivated land, followed by forest land, grassland and unused land (Zhao et al., 2004; Song and Pijanowski, 2014). China has tried to use the most stringent farmland protection systems and policies to suppress the rapid reduction of arable land, which, to some extent, curbs the rate of farmland conversion (Lichtenberg and Ding, 2008; Wang et al., 2012; Long et al., 2009, 2010, 2012; Liu et al., 2008, 2014a; Li et al., 2014, 2015).

Despite this, China's cultivated land was significantly reduced over the past two decades, and the trend of rapid expansion of construction land has not changed (Wang et al., 2012; Song and Pijanowski, 2014; Liu et al., 2014a). China's rapid urbanization and economic growth mainly depend on low-cost land supply (Liu et al., 2014a), which has resulted in a large amount of cultivated land loss (Long et al., 2009; Song, 2014; Deng et al., 2015). Total arable land acreage has been shrinking and is approaching the warning limit

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https://doi.org/10.1016/j.landusepol.2017.03.030
0264-8377/

Please cite this article in press as: Liu, Y., et al., Efficiency of construction land allocation in China: An econometric analysis of panel data. Land Use Policy (2018), https://doi.org/10.1016/j.landusepol.2017.03.030

or red line of 1.8 billion mu (1.2 billion ha) (Xiao et al., 2017). More importantly, a great deal of high quality cultivated land was converted to developed land and low quality cultivated generated from unused land over the past decades (Liu et al., 2014b). Of the available arable land in China, only approximately 30% is classified as the highest grade (most suitable for crop production), with much of the remaining area subject to environmental stresses such as drought and high salinity content (MOA, 2014). Over 40% of Chinese cultivated land has been degraded, and 19.4% of the arable land has been contaminated through the overuse of fertilizers (MOA, 2014; Zhao et al., 2014; MEP and MLR, 2014). Furthermore, China's high-quality farmland and population distributions, as well as urban gathering areas, are highly overlapped in space (Yun et al., 2009; Si et al., 2010). China's sustainable development has long been facing the contradiction among food security, economic growth and ecological protection (Yang and Li, 2000; Chen, 2007; Bai et al., 2016). The incremental allocation of construction land has become the focus for policymakers to address the dilemma between economic development and ecological protection (Li et al., 2009). However, the formulation and implementation of China's general land use planning involve a top-down, administrative indicator decomposition, which lacks scientific analysis and prediction of land use types and uses for each province and region. This fails to fully consider the imbalance of regional socio-economic development and leads to the inefficient allocation of land resources. Furthermore, the incremental allocation of construction land cannot be linked with the regional cultivated land resource endowment and comparative advantage. The shortage of land supply makes it difficult to achieve effective equilibrium of the market (Li et al., 2009). These factors have resulted in remarkable spatial mismatch between grain production and farmland resources in China, which is becoming increasingly evident (Li et al., 2017).

Under the constraints of the shortage of cultivated land resources, how to allocate the limited land resources to the multiple land users in China considering various political, environmental, ecological and economic conditions has become a research topic (Zhou et al., 2015). Optimal allocation of land resources is the key to land use planning and an important tool of national macroeconomic regulation (Verburg et al., 2013; Zhou, 2015). However, optimizing land use allocation is a challenging task, as it involves multiple stakeholders with conflicting objectives (Liu, 1999; Liu et al., 2012). Much pioneering work has been attempted to optimize land use allocation (Liu, 1999; Verburg et al., 2002; Masoomi et al., 2013). Usually, sustainable development ideology is the theoretical basis of the optimal allocation of land use (Wang and Shao, 2016; Ligmann-Zielinska et al., 2008; Lou et al., 2009; Cao and Ye, 2013; Haque and Asami, 2014). The theories related to spatial optimal allocation of land use include location theory, growing pole theory, center place theory and comparative advantage theory (Liu, 1999; Liu et al., 2012; Hyde, 2013; Li et al., 2014). Linear programming, system dynamics and the Pareto front model, as well as genetic algorithms, are often used to optimize land use allocation (Liu, 1999; Verburg et al., 2002; Stewart et al., 2004; Zhang et al., 2011; Masoomi et al., 2013; Gong et al., 2012; Zhou, 2015). As we known, the Pareto front could provide valuable information on land-use allocation by revealing the possible trade-offs among multiple, conflicting objectives (Gong et al., 2012; Huang et al., 2013). However, seeking the Pareto front of land-use allocation is much more difficult than finding a unique optimal solution, particularly when dealing with regions of large area (Huang et al., 2013).

Some improved artificial models have been applied to solve complex multiple land-use allocation problems (Liu et al., 2012; Huang et al., 2013; Lu et al., 2014; Yang et al., 2015; Zhou et al., 2015). Multi-agent systems and genetic algorithms have also been widely used to simulate land use allocation optimization at various spatial scales (Li and Parrott, 2016; Liu et al., 2013; Masoomi et al., 2013; Zhang et al., 2016a,b). The hybrid models can help generate desired policies for land-use allocation with a maximized economic benefit and a minimized environmental violation risk (Cao and Ye, 2013; Zhou et al., 2015; Zhou, 2015). In addition, the Cobb-Douglas (C-D) production function was widely used to detect the efficiency of land use allocation. The related studies cover farmland conversion, enterprise land, and urban construction land (Chen et al., 2004; Zhang, 2011; Zhang et al., 2016a,b). The C-D production function has been gradually applied to allocate land resources because it can synthetically measure the economic efficiency of land, the labor force and capital investment and avoid multicollinearity among variables.

These existing studies mainly focus on the optimal allocation of land use quantity and spatial structure, which provides beneficial references for China's land use planning. However, few studies have focused on the allocative efficiency of land use, particularly construction land. Full knowledge of the allocative efficiency of land use is essential for verifying the effect of land use planning and is also the basis for optimizing land use allocation. Using a balanced panel dataset covering 31 provinces in China over the period 1985–2014, this study analyzed the status quo of construction land and then applied an extended Cobb-Douglas production function and econometric model to measure the economic efficiency of construction land allocation at both the national and regional levels. These findings will provide policymakers with a sound scientific basis for regional land use planning.

2. Data and methods

2.1. Data source

In this study, an extended Cobb-Douglas production function was used to measure the efficiency of construction land allocation, and data on the labor force, land and capital investment, as well as non-agricultural GDP, were included in the model. The dataset covers China's 31 provinces over the period 1985–2014 (Hong Kong, Macao and Taiwan are excluded because of the lack of data). The data of the provincial non-agricultural GDP added value and labor force for the secondary and tertiary industries were collected from the China Statistical Yearbook (http://tongji.cnki.net/kns55/index.aspx). The data on capital stock for the secondary and tertiary industries were obtained from a previous study, which estimated the capital stock for the primary, secondary and tertiary industries based on the perpetual inventory method (Zong and Liao, 2014). In this study, the construction land data mainly include three types of land use, i.e., land for residential and industrial/mining sites, land for transport, and land for water conservancy facilities.[1] The data on provincial construction land during the periods 1985–2005, 2006–2009 and 2010–2014 were obtained from a previous study (Zhang, 2011), the National Land Use Change Survey Report (2007–2010) and the China Land and Resources Statistical Yearbook (2011–2015), respectively. Based on the method of Zhang (2011), the data of construction land are converted and made comparable for the different periods. In addition, to eliminate the influence of the price index, GDP is calculated at a

[1] To measure the efficiency of construction land allocation more scientifically, this study used large balanced panel data including a long time series. Based on the national land classification that has been implemented since January 2, 2002, we included only three types of construction land in the model to ensure comparability of construction land data in different periods. In addition, the three types of construction land are the main body of construction land in China. More importantly, since 2009, the publicly available construction land data only include the three types, i.e., land for residential and industrial/mining sites, land for transport, and land for water conservancy facilities, and are available from China Land and Resources Statistical Yearbook 2015.