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Will the land supply structure affect the urban expansion form?

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ABSTRACT

Existing studies have intensively discussed urban expansion, while relatively less attention has been paid to the impacts of the land supply structure. The aim of this study is to discuss whether diverse land supply structures for residential/commercial and industrial land affect the form of urban expansion by taking Yiwu City as a case. Land use data from 2006 and 2014 combined with multinomial logistic regression were applied to first detect the determinants of residential/commercial and industrial land conversion. Next, a cellular automata model was coded to forecast urban expansion with diverse land supply structures for residential/commercial and industrial land in 2020 by treating the regression results as conversion rules. We found that the determinants of residential/commercial and industrial land are distinguishable, and by considering such distinctions, we further found that Yiwu's urban expansion in 2020 will show diverse outcomes in the context of various land supply structures for residential/commercial and industrial land. More specifically, the more residential/commercial land that is supplied and the less industrial land that is supplied, the more clustered form of urban expansion will be, but the urban form variance is not very obvious. These findings inform a new dimension of decision-making for local government to manage urban growth both in China and in other regions.

1. Introduction

Urban expansion occurs in most parts of the world at different temporal and spatial scales (Feng, Lichtenberg, & Ding, 2015; Jat, Garg, & Khare, 2008; Seto, Fragkias, Güneralp, & Reilly, 2011; Verburg, Eck, Nijs, Dijst, & Schot, 2004; Weilenmann, Seidl, & Schulz, 2017) and is thought to be the comprehensive consequence of a growing population, rising economy and an evolving society (Brueckner, 2000; Kuang, Chi, Lu, & Dou, 2014; Zhang & Su, 2016). In return, urban expansion engenders some negative externalities on social, economic and environmental sustainability (Miller, 2012; Müller, Steinmeier, & Küchler, 2010; Pickett et al., 2001). Among these is a typical phenomenon: the fragmentation of land resources (Mckinney, 2002; Polyzos, Minetos, & Niavis, 2013), such as that caused by leapfrog development (Yue, Liu, & Fan, 2013), which is quite common and critical in many Asian countries (Su, Chang, & He, 2017; Tian, 2015). Thus, one challenge facing land use policy makers or city governors is to guide the form of urban expansion to be more compact. For this purpose, many spatial policies—such as the application of greenbelts, urban service boundaries (USBs) and urban growth boundaries (UGBs) (Brown, Page, Riolo, & Rand, 2004; Gennaio, Hersperger, & Bürgi, 2009; Ma, Li, & Cai, 2017)—have been adopted and work effectively to limit the fragmentation of urban expansion (Zhou, Zhang, Ye, Wang, & Su, 2016).

As the country experiencing the most extensive urban expansion worldwide (Seto et al., 2011), China has also implemented similar policies of space constraint for urban expansion, including general land use planning (GLUP) and the master plan (MP) (Long, Haoying, & Qizhi, 2009). Moreover, in contrast to the market-based land management system in Western countries, which primarily maintains efficient ecological outcomes by providing economic incentives to private landholders and has less quantity limitations (Moon, 2013), China further established the land supply quota (LSQ) regime, which provides another powerful tool to guide rational urban expansion from the perspective of quantitative restrictions (Chien, 2015; Ding, 2003). The land supply quota sets an upper limit for conversion of agricultural to urban land and is allocated from top to bottom in a planned manner (Tan, Beckmann, Berg, & Qu, 2009), e.g., the provinces' land quotas are allocated by the central government, and the cities' land quotas are distributed by provincial governments (Standing Committee of the National People's Congress of China, 2004, pp. 566–575). Meanwhile, the land quota calculation is mainly based on the predicted demand for economic development and population growth for a planned period (e.g., 15 years) as well as the historic land supply data (Zhang et al., 2016). Hence, the land supply for construction is nearly monopolized by governments (Tan & Zhou, 2015). Despite some market-oriented land policies developed to circumvent the stringent constraints of the land supply quota—such as the rewarded land conversion quotas (RLCQ) (Zhang, Wang, Li, & Ye, 2014), the transfer of development

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rights (TDR) (Wang, Wang, Tao, & Su, 2010) and the linkage between urban land taking and rural land giving (LUTRG) (Tan & Zhou, 2015)—land supply for construction is still primarily derived from the land use quota regime in reality. This fact means that the land quota may exert more significant effects on China's urban expansion.

Specifically, the upper-level government allocates the annual quota to lower-level governments in each year during the planned period (Wang et al., 2010). Thus, the total amount of land supply for construction is comparably fixed, whereas the use of the land is flexible. This land can be used for infrastructure, residence, commerce or industry, provided the total amount of land used does not exceed the quota. In China, therefore, given that the land supply quota is fixed and the types of urban land are various, an interesting research topic about the influence of land supply structure on urban expansion has emerged but has seldom been reported on before. However, to explore topic, it is necessary first to understand the urban expansion process and the determinants of various urban lands (Li, Li, et al., 2013, Li, Zhou et al., 2013; Verburg et al., 2004).

Massive amounts of literature have explored the process of urban expansion in global (Angel, Parent, Civco, Blei, & Potere, 2011; Arribas-Bel, Nijkamp, & Scholten, 2011; Hamidi & Ewing, 2014), and a growing interest is turning to developing countries (Chen & Song, 2014; Chen, Gao, & Chen, 2016; Gao, Huang, He, Sun, & Zhang, 2016; Thapa & Murayama, 2010; Vongpraseuth & Chang, 2015). Generally, satellite images of various resolutions, depending on the extent of the study area, are the primary basic data for information extraction about urban expansion (Liu, Yue, Fan, Liu, & Fan, 2011; Ma & Xu, 2010; Maimaitijiang, Ghulam, Sandoval, & Maimaitiyiming, 2015; Tsutsumida, Saizen, Matsuoka, & Ishii, 2015; Yue, Zhang, & Liu, 2016). By comparing certain time spans, the extent of urban expansion is easily derived, thus providing a financially efficient way to detect urban expansion in various periods (Bhatta, Saraswati, & Bandyopadhyay, 2010; Sun, Wu, Lv, Yao, & Wei, 2013). However, due to resolution limitations, the misjudgment or misinterpretation of urban expansion is inevitable, thereby reducing the reliability of urban expansion detection and further impacting the discussion of robust determinants. For the determinants, no sole comprehensive theory explains them, but a synthesis of interdisciplinary knowledge can help explore the driving forces of urban expansion (Verburg et al., 2004), and vast numbers of previous studies have contributed to this knowledge system by integrating information from the perspectives of the natural environment (e.g., the topology, soil quality) (Li, Li, et al., 2013, Li, Zhou et al., 2013; Xiao et al., 2013; You & Yang, 2017), socioeconomic characteristics (e.g., the population, economic growth, globalization) (Feng et al., 2015; Vongpraseuth & Chang, 2015; Weilenmann et al., 2017), accessibility (e.g., the cost to roads or ports) (Shafizadeh-Moghadam & Helbich, 2015; Shu, Zhang, Li, Qu, & Chen, 2014), the neighborhood situation (e.g., the push-pull between neighboring land uses) (Liu et al., 2011; Verburg et al., 2004), and policy (e.g., the plan, the prime cropland protection) (Shu et al., 2014; Yue et al., 2013). These findings comprise the diverse determinants of urban expansion and vary with regions and periods (Chen, Chang, Karacsonyi, & Zhang, 2014; Gao et al., 2016; Kuang et al., 2014; Shafizadeh-Moghadam & Helbich, 2015; Shu et al., 2014; Weilenmann et al., 2017; You & Yang, 2017). Nevertheless, the recognized determinants above are merely for urban land because previous research mainly focused on sole urban land as a whole, without subdividing it into types of urban land—e.g., industrial land and residential land—therefore, the divergence of various urban land determinants has long been ignored by prior studies (Braimoh & Onishi, 2007).

In this context, this paper focuses on the relationship between land supply structure and form of urban expansion in China. Specifically, we address two questions at the county scale: 1) Are the determinants of various urban land expansion the same? 2) Given different land supply structures among various urban land, which kind of urban form will changed to be? In other words, which type of land supply structure will lead to a denser urban form? This study takes Yiwu as an example and pays more attention to industrial and commercial/residential land, two land types that have engendered intensive discussion among experts and attracted great attention from local governments in China (Tao, Su, Liu, & Cao, 2010). This study uses historical land use data from 2006 and 2014 from the Land Administration Bureau; these data are more precise than the information interpreted from satellite images. Multinomial logistic regression combined with thirteen potential factors selected from the perspective of the natural environment and socioeconomic, neighborhood, proximity and spatial policies were applied to detect the effects of different determinants on various urban lands as well as the divergences among them. Furthermore, based upon the regression results, we move forward from determinant detection to simulate urban expansion and attempt to forecast it under various scenarios in 2020 with the creation of a cellular automata model, so as to discuss urban form change within different land supply structures. This study paradigm may thus advance the understanding of various urban land expansion and further provide insights for new-type urbanization processes as well as China's land use policy.

2. Data and methodology

2.1. Study area

Known as the world's largest small commodity wholesale market authorized by the United Nations and the World Bank, Yiwu lies between latitudes 119°49′ and 120°17′ and stretches between longitudes 29°20′ and 29°33′ in Zhejiang Province; the area is primarily characterized by terrain in the shape of a basin, with the main city located in the center, while the east, south and north are surrounded by mountains. The mountain areas are protected as ecological zones, and the construction activity primarily occurs in the central area; therefore, according to Yiwu's general land use planning during 2006 and 2020, which has planned construction prohibited areas, the study area is the rest of the city's territory (Fig. 1). As of 2014, Yiwu's gross domestic product (GDP) increased to 96.86 billion Yuan RMB, which is 5.2 times larger than that in 2006. Within this GDP, the economic sectoral composition changed from 4:52:44 to 2:39:58,[1] meaning the ratio of secondary industry decreased while tertiary industry increased quickly. On the other hand, according to land supply statistics,[2] more than 2000 ha of industrial, residential and commercial land were supplied during 2006 and 2014, and these three types of urban land accounted for a large proportion of past urban expansion. In addition, Yiwu's built-up area in 2014 reached 102 km^2, which is almost 2 times of that in 2006. In sum, the city's rapid expansion and massive increase in various urban land provide us with a good research example.

2.2. Data and preprocessing

This study's data are rich. The land use status data for the years of 2006 and 2014, in vector form, overlapped with each other to map land use change. This information can help us to identify the precise boundary of urban expansion during this period, yet it cannot assist in subdividing the expanded construction land into residential, commercial or industrial land. To do that, data on agricultural land converted to construction land (*Nong Zhuan Yong Data*[3]) from 2006 to 2014, also in

[1] Data from Yiwu's statistical yearbook.

[2] http://gtj.yw.gov.cn/.

[3] *Nong Zhuan Yong Data* provides data on agricultural land conversion to construction land. It records necessary attributes of conversion including the kind of construction land to which the agricultural land will be converted (e.g., commercial, residential, industrial or traffic land). Each parcel of agricultural land converted to construction land is strictly controlled by general land use planning because of China's cultivated land protection policy. If the conversion use of agricultural land is not consistent with the general land use planning and the master plan, the government will likely forbid the conversion, and