Research Article

Should big cities grow? Scenario-based cellular automata urban growth modeling and policy applications☆

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A R T I C L E   I N F O

A B S T R A C T

The formation of 'Urban Networks' has become a wide-spread phenomenon around the world. In the study of metropolitan regions, there are competing or diverging views about management and control of environmental and land-use factors as well as about scales and arrangements of settlements. Especially in China, these matters alongside of regulatory aspects, infrastructure applications, and resource allocations, are important because of population concentrations and the overlapping of urban areas with other land resources. On the other hand, the increasing sophistication of models operating on iterative computational power and widely-available spatial information and analytical techniques make it possible to simulate and investigate the spatial distribution of urban territories at a regional scale. This research applies a scenario-based Cellular Automata model to a case study of the Changjiang Delta Region, which produces useful and predictive scenario-based projections within the region, using quantitative methods and baseline conditions that address issues of regional urban development. The contribution of the research includes the improvement of computer simulation of urban growth, the application of urban form and other indices to evaluate complex urban conditions, and a heightened understanding of the performance of an urban network in the Changjiang Delta Region composed of big, medium, and small-sized cities and towns.

1. Metropolitan regional management and controls

In both the study and management of metropolitan regions there are competing and different views about the influence of environmental, economic and cultural factors, particularly with regard to urban settlement and land use. Among these, at least three broad categories emerge and stand out. The first involves regulation, typically of the spread and composition of urbanization within a host environment (Fishman, 1995; Munizzo & Musial, 2010; Spool, 2014). Sometimes this is done with regard to perceptions of rightness of scale, i.e., the encouragement of smaller-scale settlements at the expense of larger ones, for instance (Bertaud, 2014; Hall, 2000). At other times it is pursued with regard to limits on the extent of urban or land-use characteristics, such as buildable area ratios and the like. The second category involves the use of infrastructure as a guiding hand in development. It is well known, for instance, that a doctrine of highest and best use often follows or correlates highly with spatial proximities and accessibilities (Turner, Houghwout, & Klaauw, 2014; Fischel, 2015). The presence or absence of vital resources, such as water and energy, not to mention flood control and other aspects of natural disaster mitigation, are strongly influential with regard to urban development and such dependencies can be used to guide urban growth and change. A third category concerns balancing resource allocations and scales of

# Exceptional Quality of China's regional urban networks
The Changjiang Delta Region and its spatial charateristics

1. Strong bi-polar distribution. Nationwide, there are over 600 designated cities plus over 20,000 designated towns. Roughly split among the population of China.
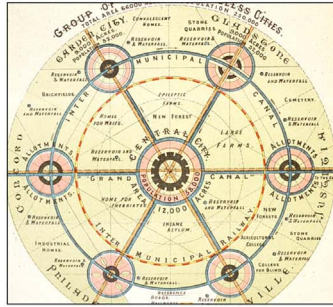
2. City-clusters are made up of multiple centers, with large and medium-sized cities surrounded by smaller communities.
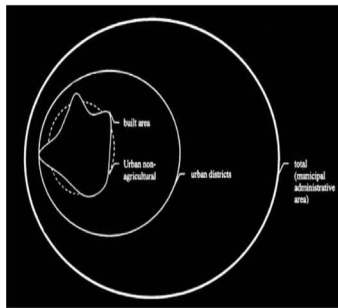
3. Core and peripheral models. For example, Hangzhou is a core and Guali, among other smaller towns, is located on the periphery of the broader metropolitan area.
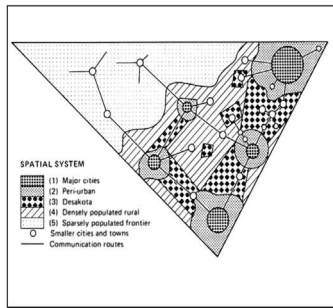
4. Peri-urban and other conditions (Desakota regions) since the 1980s.

Fig. 1. Exceptional quality of China's regional urban networks.

development into virtuous arrangements with respect to production, environmental consumption, and socially equitable outcomes (Goulias, 2007). This may well involve both regulation and infrastructural guidance, but also fundamentally uses economic and social incentives to achieve results. Here, lending practices and different levels of investment have formed stimulants favoring certain outcomes over others.

2. China's regional urban networks with their own exceptional qualities

China's regional urban networks have their own exceptional qualities. The first characteristic is a strong bi-polar distribution of cities and towns (Pu et al., 2009). There are over 600 sizable designated cities plus over 20,000 designated towns, roughly split among the population of China. The second quality is city-clusters that are made up of multiple centers, with large and medium-sized cities interacting with and surrounded by smaller communities (Rowe & Guan, 2016). For the Changjiang Delta Region, there are two additional qualities: one involves core and peripheral models of development (Marton, 2000). For example, Hangzhou, the provincial capital city of Zhejiang Province, is a core and Guali, among other smaller towns, is located on the periphery of the broader metropolitan area (Guan & Rowe, 2016). The other describes a peri-urban condition, or a Desakota region as observed by McGee et al. (McGee et al., 2007a, 2007b). (Fig. 1). Within this region several questions emerge regarding regulatory control, infrastructure development, and resource allocation. For instance, should big cities grow bigger/smaller? Should medium-sized cities growth bigger/smaller? And should small cities grow bigger/smaller? To address these questions, the Changjiang Delta Region, one of the most developed urban networks in China, was selected as a case study.

3. The study area

The study area of the Changjiang Delta Region covers an area of 75,900 km^2 of territorial land area and 10,200 km^2 of water bodies. It includes 16 regional-level cities, 28 county-level cities, and some 1700 towns. The total population was about 65 million in 2010. The average annual precipitation is between 1000 and 1500 mm, and the average annual temperature is between 14 to 17 °C. The region is composed of an alluvial flat land located in a transitional zone between the Changjiang and the East China Sea. The study boundary was drawn to include 62 regional level cities and counties from three provinces, Jiangsu, Zhejiang, and Anhui, and one municipality, Shanghai. Additionally, there were no large cities within a buffer zone of 100 km beyond the study area. This helps to rule out the possibility of other significant influences on the internal structure of the urban network.