Counterfactual Analysis of the Spontaneous Generation and Evolution of Innovative City Based on Multi-agent Simulation

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Abstract: Good government regulation and system design are necessary for the generation and evolution of innovative cities. From the perspective of evolutionary rationality, can innovative cities spontaneously emerge and evolve without considering government regulation and institutional design? Based on the hypothesis of counter-facts, this paper uses Netlogo 5.0 as the analysis tool, adopts the method of multi-agent simulation, and simulates the generation and evolution of innovative cities at the macro level by analyzing the multi-agent simulation interaction at the micro level. Based on the analysis of the simulation results, we can find that: firstly, without considering the government regulation and system design, innovative cities can spontaneously generate and evolve. Secondly, the rapid rise of factor costs will restrict the development of innovative cities. Finally, in the spontaneous formation and evolution of innovative cities, the income gap will continue to expand, and there is no convergence trend.

1. Introduction

Under the background of accelerated urbanization, shortage of resources and restructuring of economic structure, cities play an increasingly important role in promoting regional economic development and transformation. Although the definition of innovative city has not yet been unified in academic circles, it has reached a consensus in some aspects that the formation and evolution of innovative city requires a good government regulation and system design. However, in the perspective of evolutionary rationality, if we do not consider government regulation and institutional design, can innovative cities spontaneously emerge and evolve? With the analysis of spontaneous generation and evolution of innovative cities, we will find the focus of government regulation and system design in the generation and evolution of innovative cities, which has a certain practical significance for the development of innovative cities.

2. Basic Assumptions and Key Variables

2.1 Basic Assumptions

This model adopts agent-based simulation analysis, uses Netlogo 5.0 as analysis tool, and uses counterfactual analysis method for theoretical deduction. The basic assumptions are as follows:

1) Counterfactual hypothesis of spontaneous generation and evolution of innovative cities. The counterfactual hypothesis of this paper is to consider the spontaneous generation and evolution of innovative cities without government regulation and system design.In reality, governments at all levels are influencing or restricting the generation and evolution of innovative cities in different ways. The counterfactual hypothesis in this paper seems to violate the basic realistic basis, but government regulation and system design are controllable variables. The influence of government on the generation and evolution of innovative cities is enough to constitute the realistic basis of this counterfactual hypothesis.

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2) Assumption of land supply unchanged. According to international practice, the warning line of the intensity of territorial development in a region is 30%. If the intensity exceeds, the living environment will be affected. In many urbanized areas of China, the intensity of development has greatly exceeded the international warning line. The development intensity of Shanghai has reached 36.5%. If we deduct the areas that are not suitable for large-scale development, the development intensity will be nearly 50%. The development intensity of Beijing is 48%.In this context, many cities in China have begun to make land reduction planning, and the report of the 18th National Congress also clearly put forward that the intensity of land development should be strictly controlled.

3) Migration tendency hypothesis. In this model, Agent decides whether to migrate to other areas according to its surroundings and individual characteristics. There are two main factors to consider: one is segregation threshold. Each agent wants to have a similar neighbor with no less than the isolation threshold. When the number of similar neighbors is less than the isolation threshold, the agent is not satisfied with the status quo and moves to an unoccupied unit area. According to Schelling's research, the isolation threshold is set at 30%.The second is the threshold-tent-income threshold. It is generally believed that the ratio of rent to income is within the affordable range of 25% to 30%. Once it exceeds 30%, it indicates that the pressure of rent is too high. Considering the Rent-to-Income ratio in the United States and the Rent-to-Income ratio in Wuhan city, this paper sets the threshold value of Rent-to-Income ratio at 30%, that is, if the Rent-to-Income ratio exceeds 30%, residents will choose to move to other regions because they can not afford it.

2.2 Key Variables

The key variables in this paper are as follows:

1) Ratio of high creative population. From the statistical point of view, there is a clear correlation between innovation and academic qualifications. In some official documents, highly educated talents are usually directly defined as innovative talents. According to Wuhan Medium and Long Term Talents Planning 2010-2020, the total number of business management talents reached 480,000 in 2015, so the initial value of the proportion of highly innovative talents was set at 10%. At the same time, the proportion of middle-innovative talents is set at 50%, and the proportion of low-innovative talents is set at 40%.

2) Proportion of people receiving higher education. This study divides education into higher education or not. According to Wuhan Medium and Long Term Talent Planning 2010-2020, the proportion of people with higher education is expected to reach 31.2% in 2020, so the proportion of people with higher education is set at 30% in this paper.

3) Per capita income. According to the data released in 2016 by Wuhan Statistical Bureau and the Wuhan Investigation Team of the National Bureau of Statistics, in 2015, the per capita disposable income of urban permanent residents was 36,436 yuan, and the annual income of the highest 10% of the population was about 120,000 yuan. Therefore, the average annual income variable is set at 36440 yuan, and the annual income of the highest 10% of the population is set at 120 000 yuan.

4) Annual population growth rate.The annual population growth rate is the sum of natural population growth rate and population migration rate. According to the statistical yearbook of Wuhan in 2015, the natural population growth rate of Wuhan in 2014 is 7.25%, and the population migration rate is 0.04%. Therefore, the annual population growth rate can be set at 7.2%, and the population migration rate can be neglected.

5) Innovative value.In this paper, the innovative ability of the high innovative group is assigned to 10, while the middle-innovative group and the low-innovative group are assigned to 5 and 1 respectively. Then the sum of innovation ability of population in a region is defined as the innovation value of the region.

6) Average rent.According to the "2013 Rent Market Report" published by Catching Market Network in 2013, the average rent in Wuhan in 2013 was 907 yuan per month. Considering the rising rent in recent years, this paper sets the average rent at 1000 yuan per month. This rough estimate does not hinder the discussion of the problem.

3. Model and Technology

3.1 Initialization Environment

This model creates a 41*41 empty ring with von Neumann neighbors and 1681 tiles. This paper refers to the data of Wuhan City in Hubei Province to set the initial environment. According to the Statistical Yearbook of Wuhan in 2015, the population of the downtown area of Wuhan is 64.073 million, and the initial agent can be set to 2000, that is, each agent represents 3,203 people. According to "Wuhan Land Use Planning 2010-2020", tiles are divided into five categories: residential area accounts for 50%, commercial and industrial area accounts for 10%.

3.2 Simulation Process.

1) Location mobility of agent pursuing self-satisfaction.Each agent moves its location constantly in pursuit of its own satisfaction. Satisfaction depends on two factors: one is the rent-income ratio, that is, the rent-income ratio must be less than 30%; the other is the isolation threshold, each agent hopes to have no less than the isolation threshold of the same kind of neighbors. When the number of similar neighbors is less than the isolation threshold, the agent is not satisfied with the status quo and moves to an unoccupied unit area.

2) The change of regional innovation value caused by agent location mobility.Due to the existence of isolation threshold, with the operation of the program, there will be a concentration of high or medium-innovative talents in geographical location, but at the same time, it will lead to the rapid rise of rent costs in the region, which will lead to the trend of differentiation in the region. Because some regions can not attract innovative talents, the value of innovation in this region will decline rapidly.

3) Changes in income and rent.According to the data of Wuhan Statistical Yearbook 2012-2015, the growth rates of income and rent are set as follows:

Table 1 Annual Income Growth Rate and Rent Growth Rate in Different Neighborhood Regions

Sum of Innovation Value Density in Neighborhood Areas	Annual Income Growth Rate	Annual growth rate of rent
Greater than 30	12%	15%
20-30	9%	10%
Less than 20	6%	5%

4. Simulation Results and Conclusions

4.1 Conclusion 1

In the state of natural evolution, innovative regions will spontaneously emerge, and the formation process is about 10-15 years. At the same time, the location of innovative regions is random. As time goes on, there are more and more innovative areas, but it is difficult to continue to increase after reaching a certain level.

4.2 Conclusion 2

Innovative regional layout is constantly changing. An innovative region will lose its attraction to high- or medium-innovative groups and gradually lose its innovation potential if it does not last too long. The reason is that while innovative areas attract innovative people, the rent will continue to rise. When the rent rises to a certain extent, the attractiveness of the region will gradually decline, thus losing the potential for innovation. In May 2016, Huawei will move out of Shenzhen city. Although it was confirmed to be false, it also highlights the reality that the pressure of rising rent in Shenzhen city will affect regional development.

4.3 Conclusion 3

With the evolution and development of innovative regions, the regional income gap continues to expand. In a typical simulation, the Gini coefficient reached 0.342 at 190 time step in the state of spontaneous evolution of innovation region, and rapidly climbed to 0.475 at 350 time step. In repeated simulations, Gini coefficients may rise faster and have no tendency to converge.

4.4 Conclusion 4

Relaxing the assumption of land supply unchanged has no significant impact on the simulation results. The assumption that land supply remains unchanged includes two levels: (1) the total amount of land supply remains unchanged; (2) the structure of land use remains unchanged. The relaxation of these two assumptions has different results.

5. Conclusions

Combined with simulation analysis, we can find that:

1) Innovative cities can spontaneously generate and evolve without considering government regulation and system design. This conclusion does not mean that in the construction of innovative cities, government regulation and system design can be ignored. Firstly, the spontaneous formation of innovative cities takes a long time. Secondly, if government regulation and system design are not considered, innovative cities will be stagnated after a certain stage of evolution.

2) The rapid rise of factor cost represented by rent will restrict the development of innovative cities. At present, this phenomenon has been obvious in Beijing, Shanghai, Guangzhou and Shenzhen city, but this study raises it to a general conclusion, and reveals the mechanism that the rapid rise of factor costs restricts the development of innovative cities. Therefore, governments at all levels should pay close attention to the rise of factor costs in the development of innovative cities. A key factor is the cost of housing rent. The real estate bubble has a certain crowding out effect on industry, and ultimately affects the development of innovative cities. In the development of innovative cities, the rise of factor costs such as rent is an inevitable phenomenon. The government needs to do two things: first, to control the rapid rise of factor costs such as rent, so that the rise of factor costs can be maintained in a reasonable range; second, to maintain the rapid growth of income, which requires more institutional dividends. Therefore, governments at all levels need to release more institutional dividends through the comprehensive use of demand-side and supply-side institutional design, so as to offset the constraints of the rapid rise in factor costs on the development of innovative cities.

3) In the generation and spontaneous evolution of innovative cities, the income gap will continue to expand, and there is no convergence trend. Under this background, how to redistribute income by leverage such as tax has become an unavoidable problem in the development of innovative cities.

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