Urbanization Process and Population in Modern China

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Contents

1 Abstract

In this paper, an agent-based modeling approach is used to simulate the demographic changes in modern urbanization in China in order to infer the evolution of urban systems and patterns of demographic change. This article can shed new light and understanding on the theory of urban change. The article proposes that emerging cities should develop with a large inflow of population into the city center first, and then a portion of the population outflow after the population is saturated. The model shows that the distribution of the population after the equilibrium of population movements is very similar to the existing map of urban construction. The model also shows that the urban process leads to a widening gap between the rich and the poor. This paper can provide modeling and conceptual support for the urbanization process and population mobility.

2 Introduction

China is now the world's second-largest economy, but while many cities were not urbanized 20 years ago, in the short 20 years since then, China's urbanization has increased rapidly, and many of them have now completed the urbanization process and have developed into cosmopolitan cities. However, this has been followed by high urban housing prices and ecological damage [1], which has left ordinary people suffering.

More than half of the world's population lives in cities, and the urban population has been increasing in recent years. It is particularly important to explore how cities are changing in some developing country and wether its process is like European [2]. Cities tend to contain a large labor force, a large population, more modern facilities and higher consumption. The countryside tends to have a better natural environment and cheaper daily consumption. In general, as a country with a large population and has undergone a lot of urbanization in recent years, it is necessary and essential to investigate the relationship between urban systems and population and the change of population flow and residence in the urbanization process [3].

Through the study of CITS4403 and the review of related literature, the use of agent-based modelling has gained importance in social science research in recent years [4][5][6]. Through the study of CITS4403, I found that such models are often implemented in a bottom-up approach. the prototype of the Agent model is Schelling's segmentation model. In the course of learning, the Schelling model, although very simple, is of great significance in that a large number of changes at the micro level cause changes at the macro level. This is what we learn later that the whole has a property that the individual does not have-emergence.In this paper, we will use Agent-Based Modeling to explore the relationship between change and population in China's urban changes since modern times.

Three questions of research value are raised here and will be answered in full:

1. What is the trajectory of population movement when a city grows?
2. Is the distribution of population after reaching equilibrium similar to that of the present city building?
3. Will the gap between the rich and the poor increase in the process of urban development?

3 Overall Architecture

3.1 City Evolution Conception

For the conceptual model of urban evolution, I propose the conceptual model of the urban system as shown in the figure below. C is the current urban state at time t1, which is the basis of urban development; P is the urban construction plan to be realized at time t2, which can play a guiding role in urbanization development; E is the ecosystem, including various natural environments and agricultural land, which provides land for urbanization expansion [7]. which provides land for urbanization expansion. The three dashed arrows interact with each other, and the three solid arrows indicate that all three of them contribute to the urbanization process.

The above concepts are expressed in the figure below.

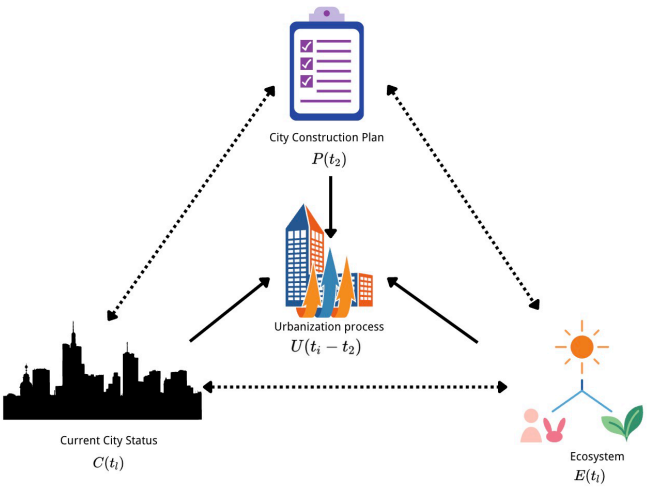

Figure 1: City Evolution Conception Map

3.2 Factors For Residents Affecting

For the residents themselves, there are multiple influences. The countryside and the city are two large areas that each have a different impact on the residents. People in the countryside initially leave the countryside and enter the city because of low income and poor infrastructure environment, and the city has higher income and better facilities environment, and many people enter the city. However, as urbanization progressed, people in the cities felt the negative effects of high consumption and high work pressure, and many people began to yearn for a peaceful life in the countryside with its good ecological environment and low life pressure, and many people returned to the countryside. Residents themselves also have children, but they need to be able to satisfy their own assets and age. The population is expanded by the births of the inhabitants.

The above concept is expressed in the figure below.

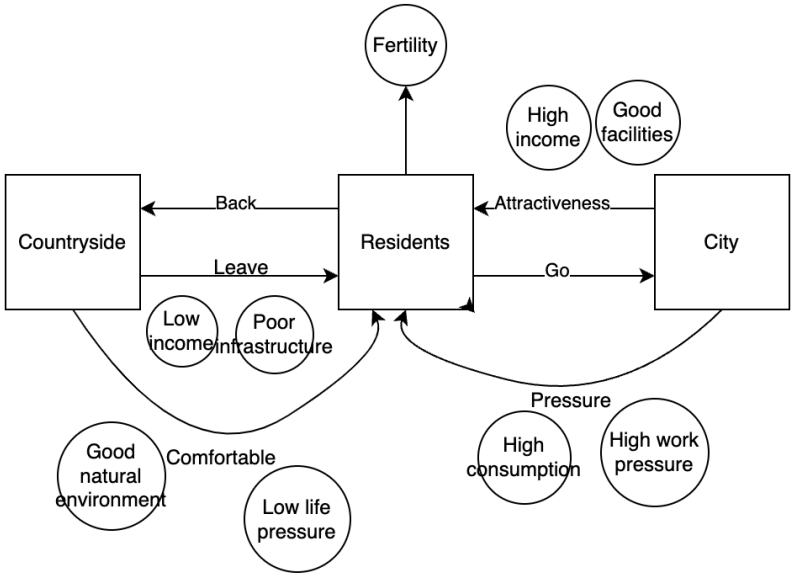

Figure 2: Factors For Residents Affecting

4 Methodology

We base our modeling on the two models mentioned above two conceptions .

We need to define our own different parameters to simulate based on the Agent model, object-oriented development, giving them different functions and impact factors for different parameters.

The space consists of a two-dimensional grid of N x N, and we set up parameters such as inhabitants, births and deaths, personal wealth, regions, income, consumption, etc.

The interaction of networked distributed factors affects the whole urban system. The subjects that control the urban system are highly decentralized and there is no complete dominant player. The structure of the urban system changes in response to economic, natural, and other changes. We will also explore what state of the distribution of urban residents is a more stable, balanced state with the outside world.

All methodologies can be found in the code.

4.1 Resident-Agent

The subject of Agent is the resident with independent will, and we deduce the evolution of the whole city by studying the movement trajectory of the residents as a whole. The study shows that the inhabitants are the key factor of urbanization [citation needed].

1. Residents have personal wealth and need to consume and live.

2. Residents have the ability to work, to create labor value and to earn income. The residents have the ability to work, create labor value and earn income. Companies give residents a place to work and pay them a wage.

3. Residents also have the ability to reproduce and produce new offspring

4. the inhabitants will die.

5. Residents also experience the beauty of the surrounding nature every day, so the surrounding environment will have some impact on them.

6. In addition to being affected by force majeure factors, residents will also be affected by government policies, and the government will enact many mandatory policies, which will be against the natural development of the city.

4.1.1 Areas

The area is divided into 5 parts and given 5 levels. The middle area has the highest rank and the rank decreases from the outside.

The area is divided into 5 parts, and from the inside to the outside, we assign 5 levels of 4,3,2,1,0 respectively.

```
agent_by_level = {0: [], 1: [], 2: [], 3: [], 4: []}
```

Figure 3: Areas

4.1.2 Wealth

People cannot exist independently at birth, and many people often need financial support from their parents until they are able to work. Some people are born rich and some are born poor.

The initial wealth of each person is not fixed, but randomly generated within a certain range.

We will also explore the gap between the rich and the poor, a serious social problem that is prevalent in many countries [8][9].

```
#Set the initial wealth for each resident
min_sugar = params.get('min_sugar', 10)
max_sugar = params.get('max_sugar', 100)
```

Figure 4: Wealth

4.1.3 Income

Every normal person has some ability to work, and the ability to work becomes the ability to earn an income. According to common sense, the more central the area, the higher the salary.

1. Wages are also linked to property, the more property the higher the wage, and there is some kind of coefficient in between.

$$Income = \left(1 + \frac{Wealth}{100}\right) \times AreaLevel$$

2. The central area is the most central business area, where companies pay the highest wages to residents, and the wages decrease in descending order by area.

```
#Incomes
#Income is linked to property and we are given the following coefficients
self.income = (1 + (self.sugar / 100)) * level
```

Figure 5: Income

4.1.4 Consumption

Consumption is something that every resident has to deal with, which may include daily food consumption, rent consumption, utility supply consumption, etc. The more central the area, the higher the consumption, and the more remote the area from the realized center, the lower the consumption.

1. We stipulate that consumption will increase year by year as the years go by, probably due to inflation and other factors, and I set up some sort of factor in between.

$$Consumption = \left(1 + \frac{Age}{25}\right) \times AreaLevel$$

2. The central region is the region with the highest consumption, and it changes accordingly to the regional rank.

```
#Consumption
self.consumption = (1 + (self.age / 25)) * level
```

Figure 6: Consumption

4.1.5 Fertility

Fertility is related to age, related to total population, and related to property.

1. The age of childbirth must be less than a certain age.
2. The birth must be based on a certain amount of property.

```
    #Fertility
def replication(self):
    #Property over 15 and age under 40 to have children
    if random.random() < self.replicate_prob and self.sugar > 15 and self.age < 40
```

Figure 7: Fertility

3. The total population of the city exceeds a certain amount and it is not suitable for childbirth.

```
#Maximum population limit
if len(env.agents) < 300:
```

Figure 8: Population Limit

4.1.6 Death

1. People die without any property on which they depend.
2. People will die after a certain age.

```
#Determine how long each person will live
min_lifespan = params.get('min_lifespan', 30)
max_lifespan = params.get('max_lifespan', 70)
```

Figure 9: Initial Life

```
    #Death
def is_starving(self):
    #1.Property less than 0 resident will death
    return self.sugar < 0

def is_old(self):
    #2.Death when maximum life expectancy is reached
    return self.age > self.lifespan
```

Figure 10: Death

4.1.7 Government

Governments tend to enact mandatory policies, which can lead to restrictions on some parameters.

4.1.8 Others

People will choose to leave their places when they cannot make ends meet, depending on income and consumption. The rule is that when income is less than consumption, people will move to outside areas.

```
#If income is less than consumption residents will move from their current area
  to other areas.
if agent.income < agent.consumption:
    i = np.argmin(t)
else:
    i = np.argmax(t)
```

Figure 11: Move to Other Areas

5 Statistics

5.1 Demo

The diffusion model demo demonstrates the entire process in two stages:
Step 1: The population grows and moves towards the city center.
Step 2: The population gradually spreads outward and stops growing.
Please see the code demo for details.

5.2 Initial State

The initial numbers are small and the locations are scattered.

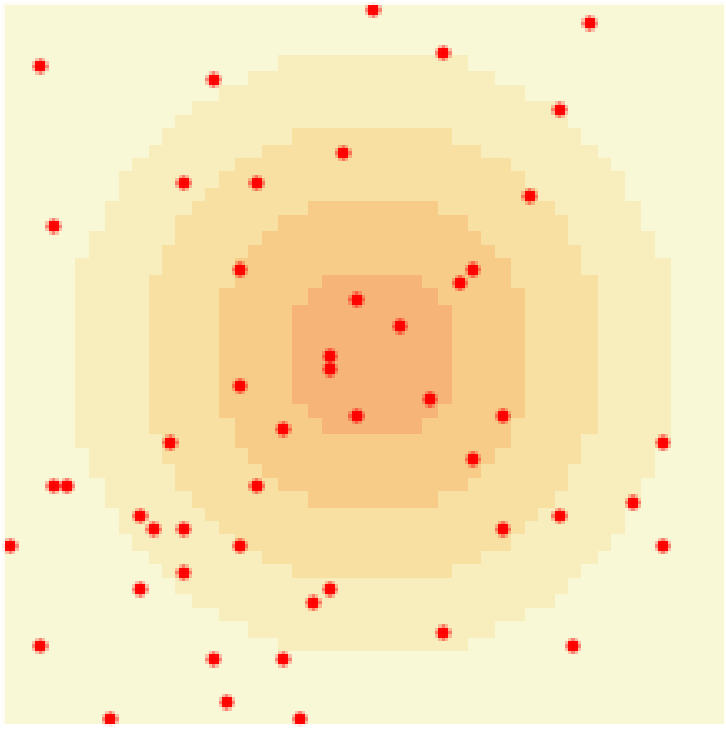

Figure 12: Initial State

5.3 Balance State

The number of people increases and flows back and forth between the different areas, eventually reaching a state of equilibrium.

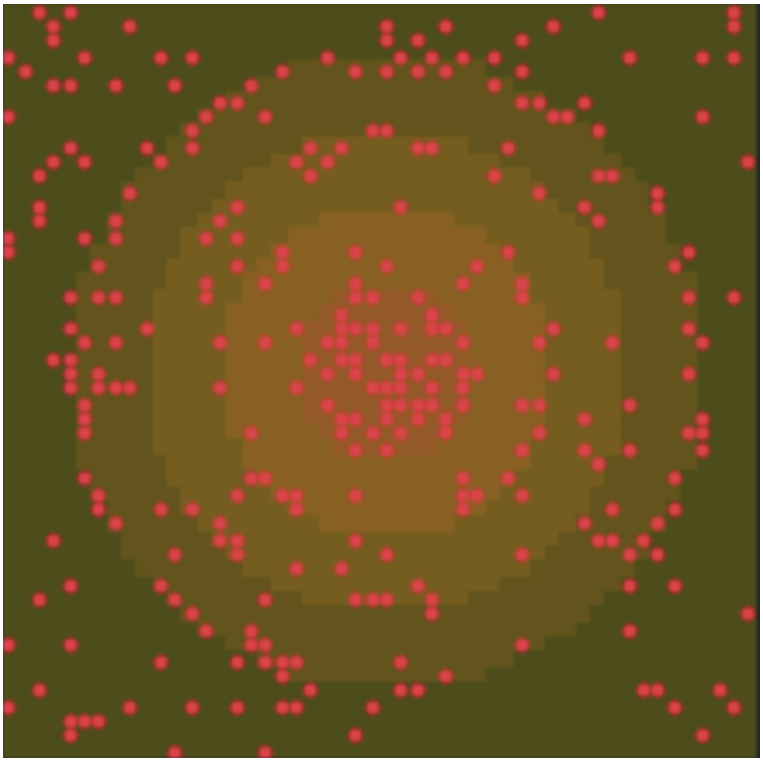

Figure 13: Balance State

5.4 Beijing Map

The following figure shows the current urban distribution and population distribution heat map for Beijing 2022.

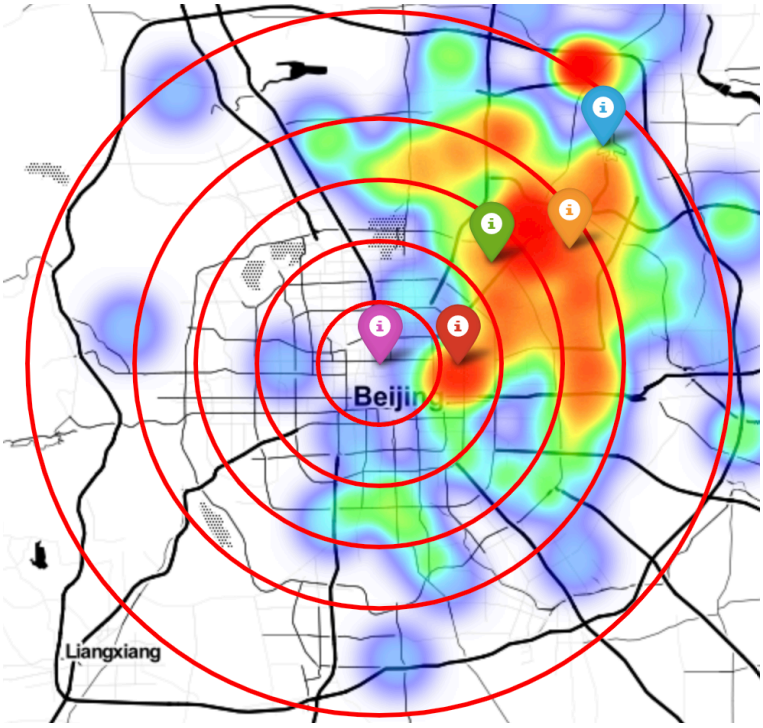

Figure 14: Beijing 2022

5.5 Population

As shown in the figure below, with urbanization, there is a significant increase in population in different areas at first, and people give birth to new population. However, as urbanization increases in areas 4, 3, people's stress and other negative factors increase, and people leave the downtown areas of 4, 3 to go to more outside areas. This process is what happens in the demo in step2 when people start to leave the city center for the countryside, and the two areas 0,1 have a significant increase. Eventually the four components reach an equilibrium state.

Figure 15: Total number of people/year in different areas

5.6 Average Wealth

As shown in the figure below, the wealth level of each region is similar at the beginning. With urbanization, the average wealth of residents in region 4, the downtown area, increases significantly. 0-40 represents step 1 in the demo, where residents are attracted to live and work in the city because of the urbanization of the downtown. 40-60 shows a significant decrease in wealth, which is a reflection of step 2 in the demo, where people move away from the downtown. However, as the picture shows, we find new information that the important reason for the significant drop in average wealth should be that many rich people are also leaving the city center because of the urbanization of the city center. Region 3 also has a significant increase and then converges to the same level as the other three regions.

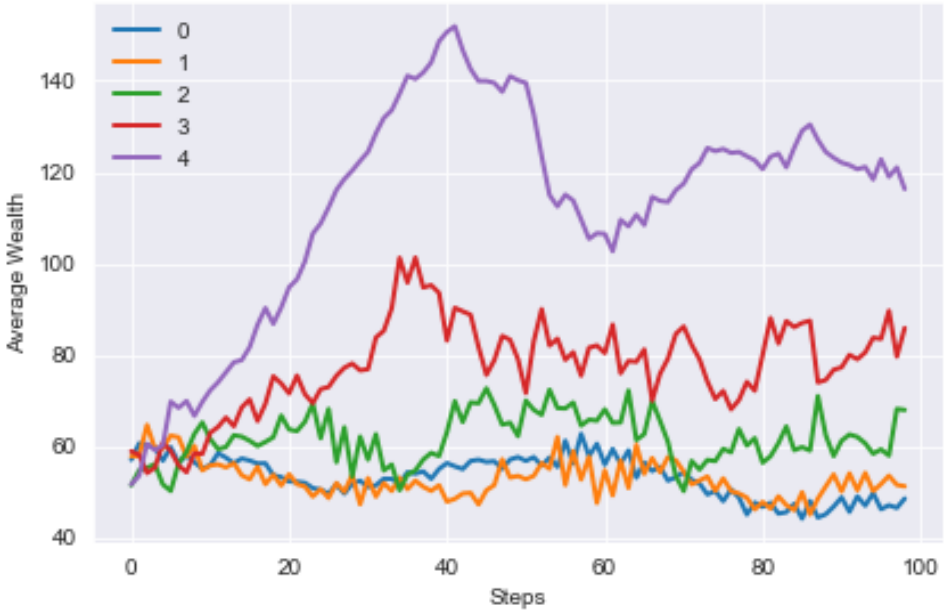

Figure 16: Wealth per capita/year in different areas

5.7 Highest Wealth

According to the graph below, the rich in region 4 are far richer than the rest of the population. The rapid decline of the latter line is due to the death of the rich.

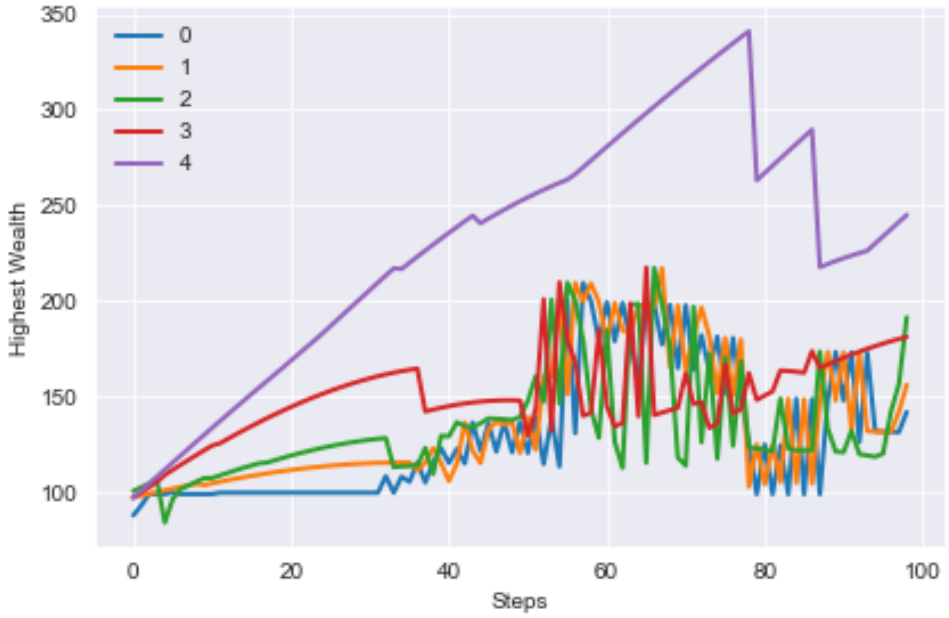

Figure 17: Highest resident wealth/year in different areas

5.8 Lowest Wealth

According to the chart below, a portion of the poor with very low initial wealth in all regions become poorer and poorer as time increases. While overall the lowest income people in regions 4,3 fluctuate more, the rest of the regions have little change.

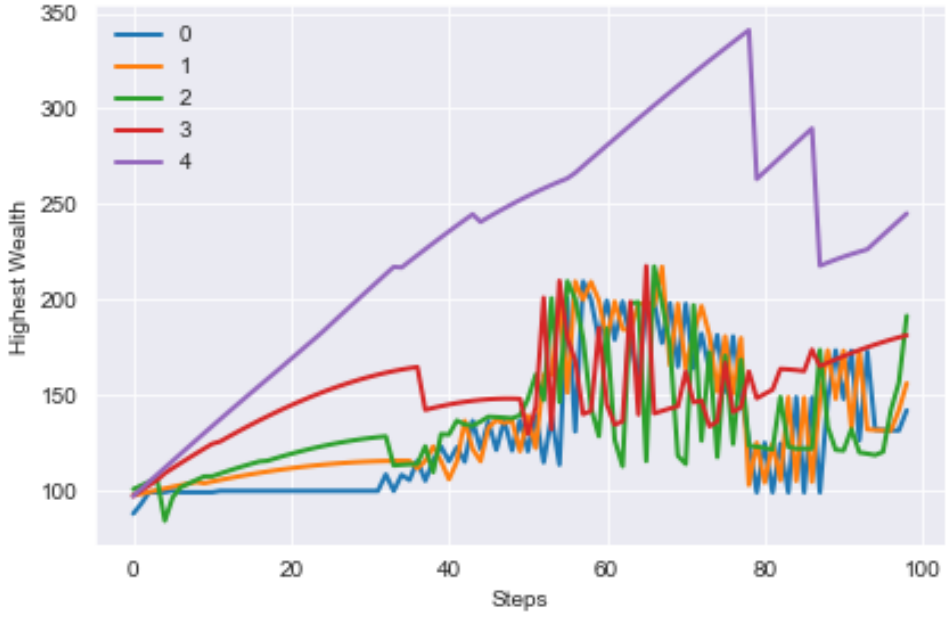

Figure 18: Lowest resident wealth/year in different areas

6 Conclusion

6.1 Realization Conception

With the resident model based on Agent-based Modeling, we find that residents first gather in the middle, then some gradually move away from the city center, and some even go back to the countryside.

This is consistent with the 3.2 conceptual diagram of residents that I proposed in the overall architecture.

6.2 Similar to Beijing Map 2022

According to the previous section 5.2, 5.3, and 5.4, the distribution of the final equilibrium state of my model is very similar to the distribution of urban construction and population in Beijing, a representative of modern urbanization in China.

6.3 The Gap between the Rich and the Poor

According to the previous section 5.6, 5.7, 5.8, it is shown that in the process of urbanization, the gap between the rich and the poor is increasing, the rich are getting richer and the poor are getting poorer. Although the graph shows that the wealth of the rich may be hundreds of times greater than that of the poor, in reality it may be greater than this value [10].

6.4 Reason for The Gap between the Rich and the Poor

According to the previous section 5.6, the gap between the rich and the poor is not obvious at the beginning of urbanization, but as many people seize the opportunity of urbanization and go to the city center, the wealth rolls up and they become richer and richer. The average wealth in the city center is much larger than in other areas.

7 Limitations and Future Works

1. We mentioned ecosystems inside the overall architecture at the very beginning , but did not implement them inside the model. Ecosystems have an interactive effect on the whole city and its inhabitants. Urbanization will pollute the environment, while residents will aspire to places with good natural environment, etc.

2. We have mentioned the government factor in the parameters, but we have not implemented it in the model. In reality, for example, if the government wants to build a reservoir or a mine, then the defined area cannot be inhabited. So the changes in the city system may have to be implemented in the direction specified by the government.

3. We will subsequently add the inheritance parameter that the property should be inherited by the children after the death of the parents.

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