Application of Logistic Model in City Development Forecast

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Abstract. It is well known that the Logistic model is mainly used in epidemiology. The more common situation is to explore the risk factors of a disease and predict the probability of occurrence of a disease according to the risk factors. However, we found that the Logistic model is not only significant in epidemiology, but also plays an important role in city development prediction through our research. This paper selects six factors (Growth Rate of Population; Environmental Performance Index; Per Capita Disposable Income; Unemployment Rate; Engels Coefficient; Geordie Coefficient). These factors are indexes of city development. Then we use the Logistic model to predict the value of these indexes in decades. And according to the prediction values, we can judge the development degree and provide references for city development.

1 Introduction

Logistic model is mainly used in epidemiology. According to the model, we can predict the probability of occurrence of a disease or a situation under different independent variables. For example, to explore the risk factors of gastric cancer, you can choose two groups of people: one is the gastric cancer group, the other is non-gastric cancer group. Two groups of people must have different signs and lifestyle. The dependent variable is whether it is "yes" or "no", and the independent variable can include a lot, such as age, sex, eating habits, etc.

In this paper, we choose six reasonable indexes from the aspects of economy, population, environment and so on. It should be emphasized that these six indexes can be used to reflect the development of the city. Because these indicators are selected according to the principle of smart growth which is about helping every town and city become a more economically prosperous, socially equitable, and environmentally sustainable place to live.[1]

2 Symbols and Definitions

Table 1 variable description

Abbreviation	Meaning
GRP	Growth Rate of Population
EPI	Environmental Performance Index
PCDI	Per Capita Disposable Income
UR	Unemployment Rate
EC	Engels Coefficient
GC	Geordie Coefficient

Explanations of the reason why we selected indicators:

GRP: We believe that all the growth in demand can be attributed to population growth. Environmental pollution, demand for jobs and polarization between rich and poor are caused by the growth of the population. So, we select GRP as the only dynamic index.

EPI: It is surveyed by Yale every two years, including PM2.5, concentration of sulfur dioxide

and many other indicators.

PCDI, UR: The closer to people's lives, the more important.

EC, GC: They are easy to find in the indicators used to measure social equality.

3 Logistic Model

3.1 Our preparations

Firstly, we select an American city and a Chinese city, respectively, Orlando, Florida and Zouping City, Shandong Province. Secondly, we find the current growth plans of the two cities. Finally, according to the plan, we find the corresponding index value.

3.2 Overview

First of all, we use the model for non-linear fitting at intervals of ten years (1960-2010). [1]- [12] But it is difficult to obtain the undetermined coefficient in the model. So, we use the particle swarm optimization to find coefficient. In particular, the values of EPI are based on data from 2010 to 2015, because there is no EPI before. Later we use the particle swarm optimization to determine each undetermined coefficient in the model.

3.3 Steps of Logistic Model

The stepsofLogistic Model are as follows:

- Model of differential equations:

$$\begin{cases} \dfrac{dx}{dt} = r\left(1 - \dfrac{x}{x_m}\right)x \\ x(t_0) = x_0 \end{cases} \tag{1}$$

- Solving the equation:

$$\mathbf{x(t)} = \frac{x_m}{1 + (\frac{x_m}{x_0})} e^{-r(t-t_0)} \tag{2}$$

- Programming and drawing with MATLAB: according toLogistic Model, we obtain the predictive value of each metric. Later, drawing them.

3.4 Metrics Prediction

According to Logistic Model, we get the figures below:

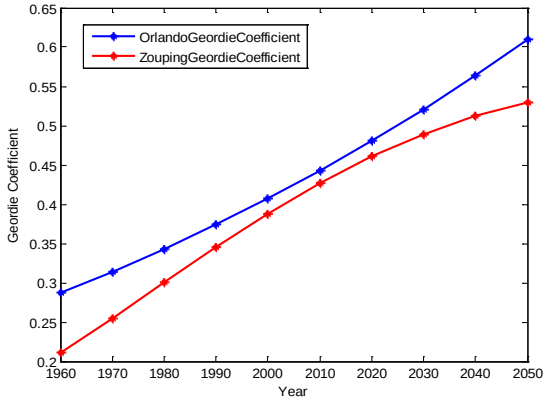

Figure 1 GC Prediction

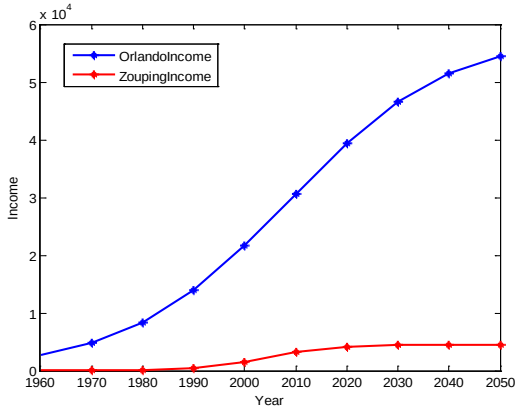

Figure 2PCDI Prediction

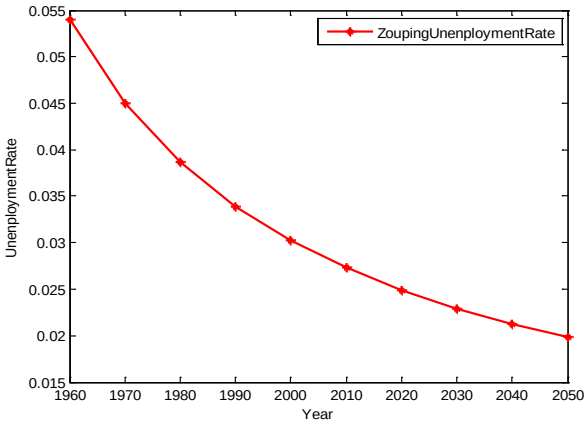

Figure 3 UR Prediction

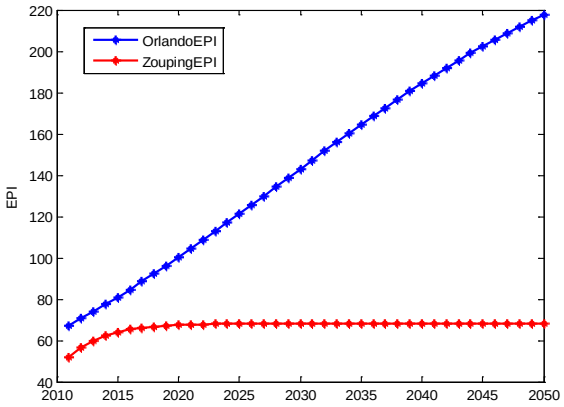

Figure 4 EPI PredictionPrediction

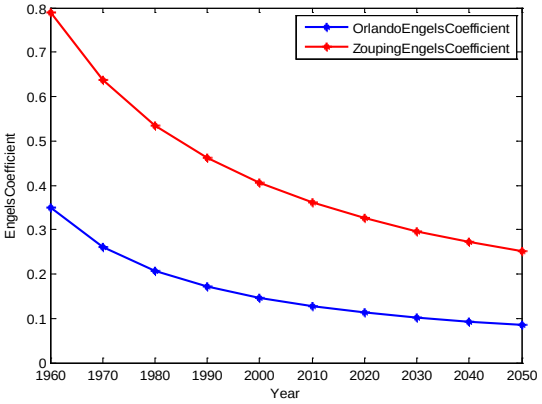

Figure 5EC Prediction

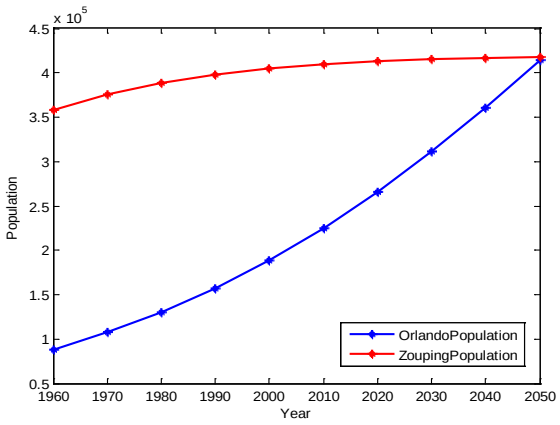

Figure 6 Population Prediction

3.5 Conclusions

From the six pictures above, we can see:

Orlando's GC, PCDI and EPI grew fast and EC fell quickly, reflecting Orlando's economic and environmental have a good development trend. Because of the 2008 world financial crisis, Orlando's unemployment rate fluctuated significantly. So, it does not fit the logistics model

Zouping's PCDI and EPI grow slowly, which is a bad phenomenon. It reflects his economic development is not enough, the lack of awareness of environmental protection. But its UR and EC decline faster, reflecting a relatively stable society, the gap between rich and poor reduced gradually.

- **Orlando, USA:**
  - Under the current development plan, Orlando's GC will eventually converge at 2.8 or so. Obviously, Orlando's Geordie coefficient growth is not realistic. It shows that the polarization between rich and poor will be out of control in Orlando. And the government did not make effective regulation. Therefore, Orlando should improve the tax on the rich and achieve welfare reallocation.
  - In addition, PCDI will eventually converge at around $ 58,500. It's a high level. So, Orlando should continue to maintain the current plan.
  - Because of the 2008 world financial crisis, Orlando's unemployment rate fluctuated significantly. So, it is difficult to predict. But Orlando's current unemployment rate is high. Therefore, the government should encourage entrepreneurship and make more arrangements for career guidance.

- Orlando's EPI will eventually converge at around 272. Clearly, it is not realistic. So, it is indicated that Orlando is working to improve the environment and have achieved remarkable results. Orlando need to keep trying.
- As for EC, it is on the decline. This is a good news for Orlando.
- Orlando's population will eventually converge at 1.04 million or so. Orlando should control the number of immigrants and improve immigration standards.

- **Zouping, China:**
  - Zouping GC will eventually converge at 0.58 or so, indicating that a wide gap between rich and poor. But it is still within the controllable range. We should do the same things as Orlando to decline GC.
  - Zouping PCDI will eventually converge at about $ 4550. Clearly, it is low compared with Orlando. Zouping needs to vigorously develop the economy and encourage enterprises to transform.
  - Less affected by the global financial crisis, the UR of Zouping will converge at 2.5 per thousand. We believe that its development plans for the resolution of the unemployment rate is very effective.
  - EPI will eventually converge at 68 or so. It seems that the environment has been improved, but it can't be satisfactory because of the low degree. Thus, Zouping needs to develop environmental protection policies and environmentally friendly industries.
  - As for EC, it is on the decline. This is also a good news for Zouping.
  - The population of Zouping will eventually converge at 0.43million or so. Although it is almost two times that of Orlando, due to the implementation of Family Planning and other policies, Zouping's population has been effectively controlled.

4 Summary

Based on Logistic Model, the paper selected six indicators of urban development. According to the development of the city's past data, we predict the development index of the next few decades。On the above, we describe six development trends and find it in conformity with the actual situations. Therefore, using the Logistic Model to predict urban development indicators is reasonable. So, it can help us to determine the degree of development and the development of various aspects of city based on the forecast curve. It can provide reliable development plans for a city. Of course, the prediction method we provide should be applied according to local conditions, to determine the final results reliably.

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