# Analysis of the regional differences between fixed assets investment and China's economic growth from the perspective of functional data

*Tianqi* Cheng[1,*], *Guici Chen*[1], *Zuo* Zhang[1], and *Feng* Jiang[2]

[1] Hubei Province Key Laboratory of Systems Science in Metallurgical Process, Wuhan University of Science and technology, Wuhan 430065, China
[2] School of Statistics and Mathematics, Zhong nan University of Economics and Law, Wuhan 430065, China

**Abstract.** Investment, consumption and export are the troika which promotes China's economic development. Investment is the most important factor and plays a vital role to drive economic growth. However, due to the differences in the geographical location, education level and infrastructure construction of various regions in China, the structure of economic development and the imbalance of growth still exist. This paper takes the fixed asset investment of 31 provinces, municipalities and autonomous regions in my country from 1999 to 2017 as the research objects in our country and uses functional data analysis methods to functionalize discrete data, uses Fourier basis functions to fit the smooth curve, and then uses FPCA analysis of the characteristics of the principal component function shows that the contribution rates of the first two principal components to the regional economy are 96.4% and 2.8% respectively, and the cumulative contribution rate reaches 99.2%, which can represent most of the sample information to a certain extent. Therefore, this paper uses the first two main components to analyse the overall change for law of China's regional economy, and roughly divides my country's 31 provinces and municipalities into 4 categories and adjust my country's economic development structure and promote coordinated regional development.

## 1 Introduction

Fixed asset investment is an important reference for economic development, economic structure, and economic growth, and an important indicator of national economic development. At present, there are large regional differences in my country's economic development. This deformity has caused a serious imbalance in the Chinese economy, and has brought serious hidden dangers to the future development of the Chinese economy.

Studying the fixed asset investment in various regions of our country can know the economic development trends of various regions, so as to optimize the investment structure and promote the coordinated development of various regions. For example, Xue Beibei

---

[*] Corresponding author: 1061556897@qq.com

established an ARIMA model based on time series analysis to study and predict the total fixed asset investment in Anhui Province in the next few years [1]. Chao Wang et al. used spatial econometrics to analyse the temporal and spatial characteristics of regional financial development and economic growth [2].

With the continuous development and maturity of the theory and practice of Functional Principal Component Analysis (FPCA), the application results involve medical diagnosis [3], mortality in demographics [4], Beijing industry population control analysis [5], stock market division [6] and other fields. In order to make up for the shortcomings of time series data model analysis methods and other statistical methods, this paper analyses the impact of fixed asset investment on regional economic growth from a functional perspective.

## 2 Model introduction

### 2.1 Functional data principal component analysis calculation method

First, the original data is converted into a function form, and the i-th observation value of the original data is converted into a function $X_i(t)$ defined at time t through this step. In order to do this, a set of basis functions must be selected and each function is expressed as a linear combination of basis functions. The given sample basis function $x_i$ is expanded as follows:

$$X_i(t) = \sum_{k=1}^{K} c_{ik}\Phi_k(t), i = 1,2,\dots,N. \tag{1}$$

Referred to as $X = (x_1, x_2, \dots, x_N), \Phi = (\Phi_1, \Phi_2, \dots, \Phi_K)^T, C = (c_{ik})_{N \times K}$.

Therefore, the sample basis function can be equivalently written in the following matrix form:

$$X(t) = C\Phi. \tag{2}$$

Set $N = n - 1$, then the estimate of the covariance function can be expressed as:

$$\hat{V}(s,t) = N^{-1}X^T X = N^{-1}\Phi^T(s)C^T C\Phi(t). \tag{3}$$

Since the Fourier basis function is used as the basis function in this paper, the Fourier basis function is a periodic function with a period of $\frac{2\pi}{\varpi}$, which is orthogonal. Its expression is as follows:

$$\hat{x}(t) = c_0 + c_1 \sin(\varpi t) + c_2 \cos(\varpi t) + c_3 \sin(2\varpi t) + c_4 \cos(2\varpi t) + \cdots \tag{4}$$

where $\phi_0(t) = 1, \phi_{2r-1}(t) = \sin(r\varpi t), \phi_{2r}(t) = \cos(r\omega t)$.

Expand by characteristic function:

$$\beta_j(s) = \sum_{k=1}^{K} b_k\Phi_k(s) = \Phi^T(s)b, \tag{5}$$

$b = [b_1, b_2, \dots, b_k]$ is the parameter vector to be estimated, and replace $V(s,t)$ with $\hat{V}(s,t)$, then we can know that $\int_0^T \hat{V}(s,t)\beta_j(t)dt = \lambda_j\beta_j(s)$, substituting (5) into the above formula:

$$\int_0^T \hat{V}(s,t)\beta_j(t)dt = \int N^{-1}\Phi^T(s) C^T C\Phi(t)\Phi^T(t)bdt = \Phi^T(s)N^{-1}C^T CWb. \tag{6}$$

Let the symmetric matrix $W = \int \Phi\Phi'$, and substitute (5) and (6) into (3):

$$N^{-1}\Phi^T(s)C^T CWb = \lambda\Phi^T(s)b. \tag{7}$$

Further :

$$\boldsymbol{N^{-1}C^T CW}\mathrm{b} = \lambda \mathrm{b}. \tag{8}$$

The eigenvalue problem of the matrix equation is the weight function $\beta(s)$, and the eigenvector corresponding to the largest eigenvalue is the weighting coefficient of the first principal component.

The first principal component function is obtained by calculating $V\beta_1(s) = \lambda_1\beta_1(s), \|\beta_1\| = 1$. Under the restriction conditions $\int x_j(s)x_k(s)\,ds = 0, \forall j < k$, by calculating $V\beta_k(s) = \lambda_k\beta_k(s), \|\beta_k\| = 1$ to get the k-th Principal component function.

## 2.2 The principal components of the fixed asset investment curve

Each sample curve $x_i(t)$ can be represented by a set of orthogonal basis functions $\{f_1, f_2, \dots f_n\}$, approximately expressed as:

$$x_i(t) \approx \hat{x_i}(t) = \sum_{m=1}^{n} \alpha_{im} f_m(t), \alpha_{im} = \int x_i(s)f_m(s)\,ds. \tag{9}$$

Minimize the objective function

$$PCASSE = \sum_{i=1}^{n} \|x_i - \hat{x_i}\|^2, \tag{10}$$

where

$$\sum_{i=1}^{n} \|x_i - \hat{x_i}\|^2 = \int_0^T (x(s) - \hat{x}(s))^2 ds, \alpha_{im} = \int x_i(s) f_m(s)ds, \tag{11}$$

Is the principal component score.

## 3 Functional principal component analysis

This paper selects 589 samples of fixed asset investment in 31 provinces, municipalities and autonomous regions across the country from 1999 to 2017 from the National Bureau of Statistics. Based on the above data, discuss the impact of fixed asset investment on my country's regional economic development.
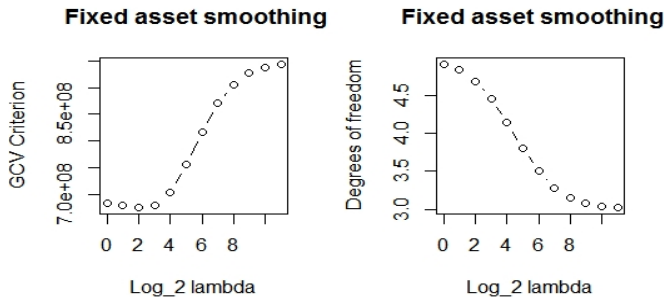


**Fig. 1.** The functional curve of fixed asset investment.

Based on R programming, the functionalized curve graph is drawn. It can be seen from Figure 1 that the GCV curve achieves the minimum value when $log_2 \lambda = 2$, that is, when the penalty factor is equal to 4, the fitting error of the model is small, which has a good model interpretation.
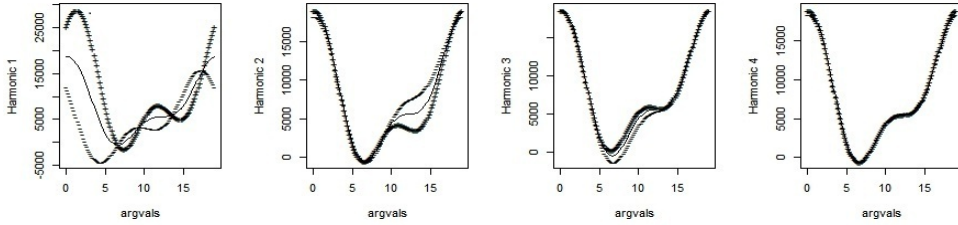
**Fig. 2.** The effect diagram of the deviation of the four principal components from the mean function

The first principal component function has a positive effect on economic development when the investment in fixed assets has a good momentum and stable economic development, and has a negative effect on economic development when the economic development is hot. The second principal component function has a negative effect on economic development when economic development is low. According to calculations, the contribution rates of the first two main components to the regional economy are 96.4% and 2.8% respectively, and the cumulative contribution rate reaches 99.2%, which can represent most of the sample information to a certain extent. Therefore, this paper selects the first two principal components to analyze the overall change law of China's regional economy.

Figure 3 is drawn according to the principal component score table. The abscissa represents the score of the first principal component function, and the ordinate represents the score of the second principal component function. The 31 provinces and municipalities in the country are divided into 4 categories.

The fixed asset investment in Fujian and Jiangxi in the first quadrant accounts for a larger proportion of the national fixed asset investment, and the economic development speed is higher than that of other provinces and cities, which has a greater impact on the national economy. Shaanxi, as a transportation hub connecting the eastern and central regions of China and its rich mineral resources and water resources, plays an important role in stimulating the economy of western my country. The 15 central and western provinces, municipalities and autonomous regions in the second quadrant, including Xinjiang and Ningxia, have undertaken a large number of industrial transfers and settlements in the eastern coastal areas, and their industrial investment has grown rapidly. Therefore, their fixed asset investment development has an increasing impact on national economic development. Inner Mongolia and Liaoning in the third quadrant have poor fixed asset investment due to the backward industrial structure. In the fourth quadrant, the developed regions along the central and eastern coastal areas such as Hunan and Hubei have entered the stage of industrial transformation and structural adjustment, and the growth rate of fixed asset investment has remained stable.
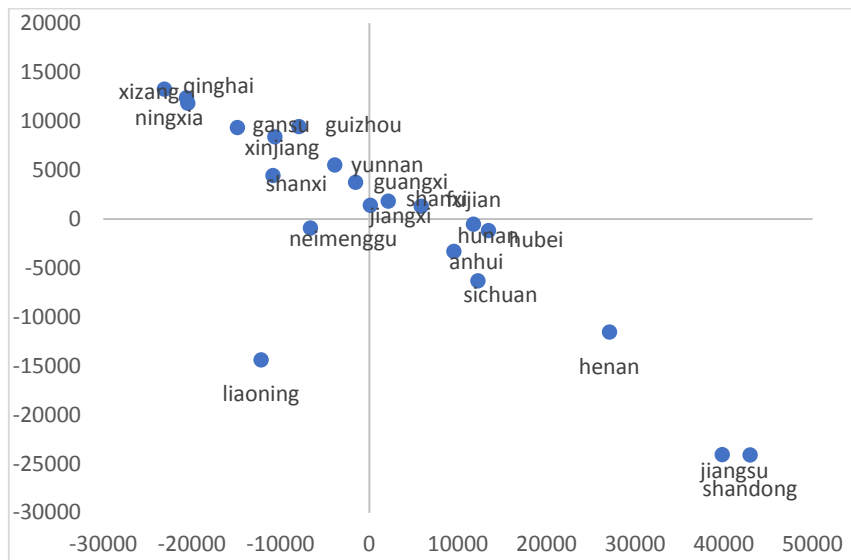
**Fig. 3.** The first and second principal component function score classification diagram.

## 4 Conclusions and recommendations

As we all know, China's economic structure shows the characteristics of high in the east and low in the west, strong in the south and weak in the north. Due to the regional differences in the level and structure of my country's fixed asset investment, to promote the coordinated development of my country's economy, we must improve macro-control and deepen the reform of the investment system. strengthen inter-regional cooperation and promote regional coordinated development, etc.

## References

1.  B. Xue. Based on the ARIMA model: the forecast of the total investment in fixed assets of the whole society, SD, **15**, 141-143(2014)
2.  C. Wang, X. Zhang, PezhmanGhadimi, Q.Liu, Ming K. Lim, H. Eugene Stanley, The impact of regional financial development on economic growth in Beijing–Tianjin–Hebei region: A spatial econometric analysis, Phys A: SMA, **521**, 635-648(2019).
3.  Y. Hu, X. He, J. Tao, N. Shi. Modeling and prediction of children's growth data via functional principal component analysis. SCSA: Mathematics, **52**, 1342-1350(2009).
4.  J. Wang, J. Zhu, R. Fu. Functional mortality prediction model. SR, **09**, 87-93(2013).
5.  Y. Liang, Q. Shen, L. Liu. Application of Functional Principal Component Analysis (FPCA) Model: Taking Beijing's Industry Population Regulation as an Example. RW, **02**, 29-33(2017).
6.  Y. Wang, C. Shang. Division of Stock Market Segments and Construction of Indexes Based on Functional Data Analysis. SM, **03**, 60-65(2019).