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Canonical Correlation Analysis of Fixed Assets Investment and Economic Growth

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Abstract

This paper uses the National Research Network database on fixed asset investment and economic growth indicators in various industries. Through the use of typical correlation analysis methods, 19 fixed asset investment variables and 11 economic growth categories from 31 regions across the country. The relevant relationships are determined in the indicators, and the tests and economic principles are analyzed to obtain the efficiency of fixed assets investment in different industries. Through data analysis, I hope to provide some reference for future fixed asset investment in different industries in China.

Keywords

Fixed asset investment; Economic growth; Canonical correlation analysis.

1. INTRODUCTION

Investment, consumption and exports are the three carriages that drive the economy. As an important part of investment, fixed asset investment is self-evident. The purpose of this paper is to study the typical correlation between fixed asset investment and economic growth in various industries in China in 2016.

The correlation analysis between fixed asset investment and economic growth is mainly analyzed by regression analysis. If the autoregressive model is used to study the relationship between fixed asset investment and economic growth, it is considered that economic growth rate has a negative correlation with fixed asset investment, and there is a positive correlation between economic aggregate and fixed asset investment. Fan Qiaoli and Wang Jianzhong used SAS software to empirically analyze the relationship between GDP and fixed asset investment in 31 provinces, municipalities and autonomous regions in China, and proposed corresponding countermeasures. In the selection of variables, the use of fixed assets investment It is divided by composition, and the GDP is divided into three industries. The conclusion is that the construction and installation project is the main influencing factor of fixed assets. The fixed assets investment has a significant pulling effect on the first, second and third industries. Among the graduate students of fixed assets investment and economic growth, Liu Jinquan and Yinzhong used time series data for analysis, using Granger test in VAR model, and believed that China's fixed asset investment growth rate has a one-way positive impact on economic growth rate.

This paper mainly analyzes the typical correlation between the two groups of fixed asset investment and economic growth in various industries in China in 2016 by means of typical correlation analysis methods in R language software. The typical correlation between fixed asset investment and economic growth requires the application of macroeconomic theoretical analysis and the empirical analysis of typical correlation analysis methods in multivariate

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statistical analysis. Therefore, this article is a combination of macroeconomics and multivariate statistics.

This paper mainly adopts the fixed assets investment volume of each industry in 31 provinces, municipalities and autonomous regions in 2016 and the GDP of each major industry and other variables reflecting economic growth. Based on the use of R language software, the typical use of multivariate statistics Correlation analysis methods are used to analyze the linear dependence between fixed asset investment and economic growth, and to determine the composite indicators of the representative indexes of the two groups of variables. The two groups of variables are reflected by studying the relationship between the two sets of comprehensive indicators. Establish the relationship between fixed asset investment and economic growth in different industries, and conduct specific analysis. Depending on the industry, different industries will invest in fixed assets, and while driving economic growth, they can achieve efficient use of resources.

2. OVERVIEW OF FIXED ASSET INVESTMENT AND ECONOMIC GROWTH

Before the typical correlation analysis of fixed assets investment and economic growth, in order to facilitate the analysis later, the key concepts are first explained, and appropriate indicators are considered to measure the relevant concepts according to the actual needs of the study.

2.1. The Concept of Fixed Asset Investment

Fixed assets investment refers to the general term for the amount of work performed on the construction and purchase of fixed assets and the related expenses, which are measured in monetary terms and completed in a certain period of time. Including enterprises for capital construction, renovation, overhaul and other fixed asset investments. Fixed asset investment is the basis of social and economic production activities.

2.2. Selection of Measurement Indicators For Fixed Assets Investment

There are many kinds of fixed assets investment measurement indicators. According to industry, there are fixed assets investment in primary industry, secondary industry and tertiary industry, and it can also be divided according to the source of funds. According to the research needs of this paper, we mainly adopt the method of dividing the fixed assets investment according to the industry. The fixed assets investment indicators mainly include: agriculture, forestry, animal husbandry, fishery, mining, manufacturing, construction and other 19 indicators.

2.3. Economic Growth Concept

Economic growth usually refers to the continuous increase of a country's per capita output (or per capita income) over a long period of time. The economic growth rate reflects the growth rate of the total economic volume of a country or region in a certain period of time. It is also a sign to measure the growth rate of the overall economic strength of a country or region. The direct determinants of economic growth are investment, labor and productivity. GDP calculated at present price can reflect the scale of economic development of a country or region. GDP calculated at constant price can be used to calculate the speed of economic growth.

2.4. Indicators of Economic Growth

In view of the research on the relationship between economic growth and fixed assets investment, this paper chooses economic growth indicators, on the one hand, considering economic growth indicators that can reflect different industries, on the other hand, considering the impact of fixed assets investment on economic growth comprehensively, and chooses other

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general indicators reflecting economic growth. In view of the former, the gross domestic product of different industries is adopted: gross agricultural, forestry, animal husbandry, fishery, industrial, construction, transportation, storage and postal, wholesale and retail, accommodation and catering, real estate and financial industry. Considering the latter, we adopt general indicators that can reflect economic growth, such as per capita GDP, per capita disposable income and unemployment rate.

3. THE THEORETICAL BASIS OF TYPICAL CORRELATION ANALYSIS

In statistical analysis, simple correlation coefficient is used to reflect the linear correlation between two variables, and complex correlation coefficient is used to reflect the linear correlation between one variable and multiple variables. In 1936, Hotelling extended linear correlation to the discussion of two groups of variables and proposed canonical correlation analysis. The basic idea of canonical correlation analysis is similar to that of principal component analysis. It transforms the study of multiple linear correlation between one set of variables and another set of variables into the study of simple linear correlation between a few pairs of comprehensive variables, and the information of linear correlation contained in these few pairs of variables is almost covered. It covers all the corresponding information contained in the original variable group.

3.1. Typical Correlation Analysis Concept

Canonical correlation analysis is a multivariate statistical analysis method that studies the correlation between two groups of variables, and is one of the main contents in multivariate statistical analysis. It can truly reflect the interdependent linear relationship between the two sets of variables. Let two sets of variables x 1 , x2 , ⋯, xp , and y 1 , y2,⋯, y p represent, using a method similar to principal component analysis, select several representative among each set of variables The comprehensive index of sexuality (linear combination of variables), the relationship between the two groups of variables is reflected by studying the relationship between the two groups of comprehensive indicators. The basic principle is: first find the linear combination of the variables in the two sets of variables, so that they have the greatest correlation, then find the second pair of linear combinations in each set of variables, so that they are not related to the first pair of linear combinations, respectively. And the second pair of linear combinations itself has the greatest correlation, and so on, until the correlation between the two sets of variables is extracted.

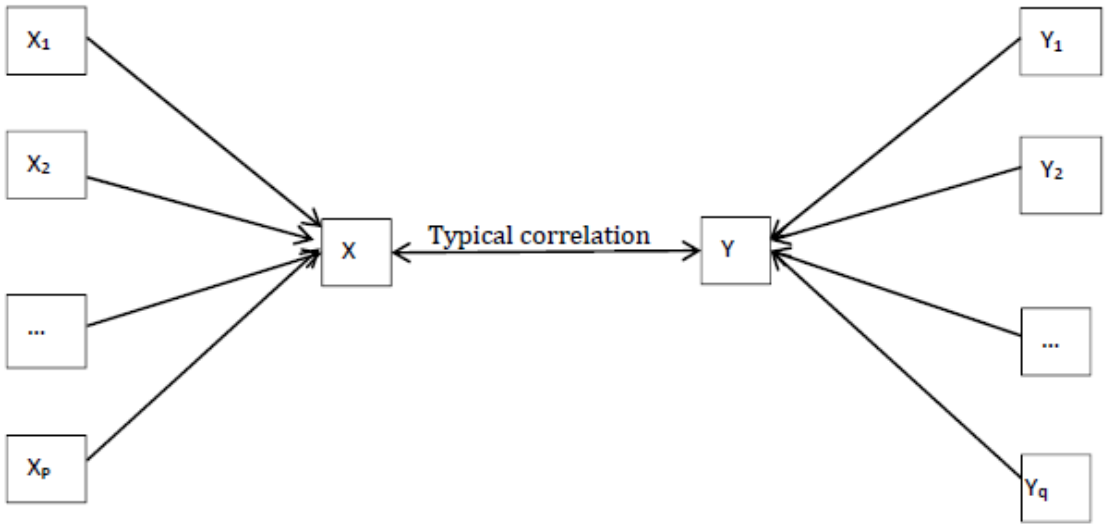

Figure 1. Typical correlation

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Canonical correlation analysis is an important analytical method in multivariate statistical analysis. Its basic purpose is to use comprehensive variables to describe the overall correlation between the two groups of variables. That is, the relationship between the two groups of variables is grasped as a whole, and two sets of representative two comprehensive variables U1 and V1 are extracted from the population, and the correlation between the two comprehensive variables is used to reflect the two sets of variables.

3.2. Modeling theoretical Steps for Canonical Correlation Analysis

First, the data is mathematically processed. Suppose there is a set of p-dimensional x variables and another set of q-dimensional y variables to generate evidence for data normalization; secondly, the normalized correlation coefficients and variables are calculated using the normalized data; finally, the significance test of typical correlation coefficients is performed.

There are two sets of random vectors x (p dimension), y (q dimension), The linear correlation between x and y, respectively, selects several representative integrated variables u k in two sets of vectors And v k , which are a linear combination of the original variables :

uk=a1kx1+a2kx2+L+apkxk,

vk=b1ky1+b2ky2+L+bpkyk,

In theory, the logarithm of a typical variable and the corresponding number of typical correlation coefficients can be equal to the number of fewer variables in the two sets of variables. The correlation coefficient ρ1=λ1 of u1 and v1 reflects the most relevant component, which is called the first typical correlation coefficient; the correlation coefficient of u2 and v2 is the second correlation coefficient of λ2 reaction, which is called the second typical correlation coefficient; analogy. In practical applications, you only need to keep a few of the previous pairs of typical variables. The principle of retention is based on the significance test results of typical correlation coefficients, as well as the actual interpretation. If the first pair of typical variables already reflects enough information, it is desirable to keep only the first pair of typical variables. The significance test of a typical variable is performed after the "removal of the influence of the first k typical correlation coefficients" and whether the remaining p-k typical correlation coefficients can reach a significant level. In general, when examining the significance of the r-th (r<k) canonical correlation coefficient, the test statistic approximates the χ2 distribution with a degree of freedom of (p-k+1)(q-k+1).

3.3. Calculation of Typical Correlation Coefficients and Variables

Let the observed objects come from the samples of the normal population. Each sample measures two sets of indicators , which are respectively recorded as X=(x 1 , x x,..., x p) ' , Y=(y 1 , y 2 , ... , y q) ' , the original data matrix is:

$$XY=[X,Y]=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} & y_{11} & y_{12} & \cdots & y_{1q} \\ x_{21} & x_{22} & \cdots & x_{2p} & y_{21} & y_{22} & \cdots & y_{2q} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{n2} & y_{n1} & y_{n2} & \cdots & y_{nq} \end{bmatrix}$$

1. calculates a correlation coefficient matrix R, and R is split:

$$R=\begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix}$$

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Where R 11 and R 22 are the correlation coefficient matrices of the first set of variables and the second set of variables, respectively, R12 and R21 (R12 =R21 ') are the correlation coefficient matrices of the first set of variables and the second set of variables .

2. Calculate typical correlation coefficients and typical variables

First ask for A=$R_{11}^{-1}R12R_{22}^{-1}R21$ Characteristic root of $r_1^2>r_2^2>\cdots>r_p^2>0$, and determining ther1, r2, ..., rp eigenvectors corresponding to a1, a2, ..., ap; then seek B= R_{22}^{-1} R21 R_{11}^{-1} R12 Characteristic root of $s_1^2 > s_2^2 >\ldots> s_p^2 >0$, and determining the s1, s2, ..., sp corresponding eigenvectors b1, b2, ..., bp, where $r_i^2=s_i^2$.

3. Write a typical variable of the sample

U1=a1'x, v1=b1'y

U2=a2'x, v2=b2'y

⋮ ⋮

Up=ap'x, vp=bp'y

Where a and b are the typical loads of the variables x and y, respectively.

4. Perform a hypothesis test on the typical correlation coefficient to determine the number of correlation coefficients. The following is the significance test of the canonical correlation coefficient of λ.

Test hypothesis H0:λ_r=0

When the significance of the r (r < k) canonical correlation coefficient is tested, statistics are made:

$Qr\text{-}1 = -[n - r - \frac{1}{2}(p+q+1)] \ln\Lambda r\text{-}1 \sim \chi 2[(p - r + 1)(q - r + 1)]$

Among then, $\Lambda r\text{-}1 = (1 - \lambda_r^2)(1 - \lambda_{r+1}^2) \cdots (1 - \lambda_p^2) = \prod_{i=r}^{p}(1 - \lambda_i^2)$

5. Perform a typical correlation analysis of the data based on the correlation coefficients.

4. BASED ON TYPICAL CORRELATION EXAMPLES

Fixed assets are the basis of economic production activities. The correlation analysis of fixed assets investment on economic growth has existed for a long time, but it is mainly about empirical analysis based on simple correlation analysis, or even about typical correlation analysis, but from the perspective of fixed assets investment based on the division of three major industries. From the perspective of industry division, this paper studies the typical correlation between fixed assets investment and economic growth, explores the investment with high return in fixed assets investment, prevents excessive investment and achieves effective utilization of resources.

4.1. Source and Processing of Data

Using macroeconomic data in the database of National Research Network, this paper compares the statistical yearbook of the National Statistical Bureau in 2017. The data sources are reliable, and the fixed assets investment index adopts the total fixed assets investment of 19 industries in 31 regions of the country divided by industry; the economic growth index chooses the main national economic accounting divided by industry. The indicators are combined with several other major economic indicators reflecting the economic situation, such as unemployment rate, per capita disposable income and per capita GDP. In data processing, in order to avoid the difference of different data measurement units, data are standardized, and

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the influence of different measurement units on the analysis results is eliminated by data centralization.

Table 1. Fixed Asset Investment and Related Variables of Economic Growth

Fixed asset investment variable	
Agriculture, Forestry, Animal Husbandry and Fishery(100 million yuan)	x_1
Mining industry (100 million yuan)	x_2
Manufacturing (100 million yuan)	x_3
Electricity, gas and water production and supply industry (100 million yuan)	x_4
Construction industry (100 million yuan)	x_5
Transportation, warehousing and postal services (100 million yuan)	x_6
Information transmission, computer services and software industry (100 million yuan)	x_7
Wholesale and retail trade (100 million yuan)	x_8
Accommodation and catering industry (100 million yuan)	x_9
Financial industry (100 million yuan)	x_{10}
Real estate industry (100 million yuan)	x_{11}
Leasing and business services (100 million yuan)	x_{12}
Scientific research, technical services and geological exploration (100 million yuan)	x_{13}
Water conservancy, environment and public facilities management industry (100 million yuan)	x_{14}
Resident services and other services (100 million yuan)	x_{15}
Education (100 million yuan)	x_{16}
Health, social security and social welfare (100 million yuan)	x_{17}
Culture, sports and entertainment industry (100 million yuan)	x_{18}
Public Administration and Social Organization (100 million yuan)	x_{19}
Economic growth variable	
Gross production value of agriculture, forestry, animal husbandry and fishery (100 million yuan)	y_1
Industrial production value (100 million yuan)	y_2
Construction industry production value (100 million yuan)	y_3
Transportation, warehousing, postal industry production value (100 million yuan)	y_4
Wholesale and retail production (100 million yuan)	y_5
Total production value of accommodation and catering industry (100 million yuan)	y_6
Gross financial industry production (100 million yuan)	y_7
Real estate industry production value (100 million yuan)	y_8
Per capita GDP (yuan)	y_9
unemployment rate(%)	y_{10}
Per capita disposable income (yuan)	y_{11}

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4.2. Selection of Indicators

In order to analyze the typical correlation between fixed assets investment and economic growth, 19 fixed assets investment variables, 11 related industries and other major economic growth variables, which are divided by industry in 31 provinces, municipalities directly under the Central Government and autonomous regions of China in 2016, are adopted. The first group of variables reflects the changes of fixed assets, and the second group reflects the economic situation, as shown in the table below.

4.3. Results and Explanations of Typical Correlation Analysis

4.3.1 Typical correlation analysis

Through the canonical correlation test in R language, at the level of α=0.05, three canonical correlations are significant, that is to say, three canonical variables are needed to construct the linear combination of the first three pairs of canonical variables as follows:

U1=−0.022305x1+0.061848x2−0.189454x3+0.080392x4+0.0273954x5−0.016433x6−0.194483x7+0.156840x8+0.172555x9+0.168274x10+0.104282x11+0.208469x12−0.255488x13−0.187070x14−0.315461x15−0.136462x16+0.249311x17+0.194150x18+ 0.000732x19

V1=−0.00174y1+0.25830y2−0.21881y3+0.23074y4−0.22256y5+0.20541y6+0.18914y7 −0.33824y8 −0.24204y9−0.00462y10+0.16298y11

U2=−0.00819x1−0.05851x2+0.10582x3+0.00342x4+0.01240x5+0.06378x6+0.19709x7+0.23270x8−0.18296x9−0.08553x10−0.00320x11−0.05730x12+0.00998x13+0.17798x14−0.02812x15−0.04058x16−0.12770x17−0.01673x18

−0.11910x19

V2=0.0111y1+0.1712y2+0.0473y3+0.0224y4−0.2522y5−0.0632y6−0.0846y7+0.22y8+0.2051y9+0.0288y10−0.07y11

U3=0.09496x1−0.11643x2−0.04451x3+0.03634x4+0.01854x5−0.13033x6+0.10277x7+0.10111x8+0.09085x9−0.00953x10−0.03313x11−0.02019x12

−0.09156x13+0.13095x14−0.12984x15+0.05365x16−0.00885x17−0.17987x18+0.00778x19

V3=0.12301y1−0.23421y2+0.13271y3−0.19852y4−0.444y5+0.06338y6−0.35754y7+0.79596y8+0.04985y9+0.06655y10+0.15753y11

4.3.2 Explain the economic meaning of the results

a. Because r1=1, r2=1, r3=0.998, it shows that there is a very high correlation between U1, V1 and U2, V2 and U3, V3, especially r1 and r2. In their respective linear portfolios, the coefficients of variables are positive and negative, indicating that although there is a significant correlation between fixed asset investment and economic growth, the direction of the correlation is not clear.

b. In the first pair of typical variables U1 and V1, U1 is a linear combination of fixed assets investment indicators, including x15 (fixed assets investment in residential services and other services), x13 (fixed assets investment in scientific research, technical services and geological exploration), x17 (fixed assets investment in health, social security and social welfare industries). has a larger load than other variables, indicating that residential services and other services, scientific research, technical services and geological exploration are the main indicators of fixed assets investment, and they play an important role in fixed assets investment. Among them, x15 (fixed assets investment in residential services and other services) is the largest load, which shows that the economic benefits of fixed assets investment in residential

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services and other services are greater than that of fixed assets investment in other industries. V1 is a linear combination of various indicators to measure economic growth, among which the variables with larger loads are y8 (gross value generated by the real estate industry), y2 (gross industrial product), y9 (gross domestic product per capita). This shows that x15 (investment in fixed assets in residential services and other services), x13 (investment in fixed assets in scientific research, technical services and geological prospecting), x17 (investment in fixed assets in health, social security and social welfare) and y8 (total value generated by the real estate industry), y2 (gross industrial product), y9 (per capita). Gross domestic product (GDP) is closely related. The effects of residential services and other services, scientific research, technical services, geological exploration and fixed assets investment in health, social security and social welfare on economic growth are mainly manifested in the real estate industry, industry and per capita GDP. That is to say, in order to maintain the driving role of fixed asset investment in economic growth (especially in industry and real estate), it is not only necessary to ensure the amount of fixed asset investment in the industry, but also to strengthen the development and improvement of the service industry.

c. In the second pair of typical variables, the linear combination of fixed asset investment indicators, x8 (wholesale and retail), x7 (information transmission, computer services and software), x9 (accommodation and catering) and x14 (water conservancy, The environmental and public facilities management industry) has a larger load than other variables, with the largest load in the wholesale and retail sectors, indicating that wholesale and retail are key indicators of fixed asset investment. Among the indicators of economic growth, the load of y5 (wholesale and retail production), y8 (real estate GDP), and y9 (per capita GDP) is larger, indicating wholesale and retail trade and industry. Development has a greater dependence on fixed asset investment. Moreover, wholesale and retail trades are highly correlated with fixed asset investments.

d. In the third pair of typical variables, the correlation coefficient between U3 and V3 is still as high as 0.998. Although there is no complete correlation between the first two groups of correlation coefficient 1, it can fully explain the correlation between fixed asset investment and economic growth. Among the linear portfolios of fixed assets investment, x18 (culture, sports and entertainment industry), x14 (water conservancy, environment and public facilities management industry), x6 (transportation, warehousing and postal industry) and x15 (residential services and other services) have the greatest loads, among which culture, sports and entertainment also have the greatest loads. At this stage, China attaches great importance to the development of culture, sports and entertainment, and increases investment in fixed assets of the industry. Among the indicators of economic growth, y8 (real estate gross product), y5 (wholesale and retail gross product) and y7 (financial gross product) are loaded heavily, which shows that real estate industry is a key indicator of economic growth, and the real estate industry has a strong dependence on fixed assets investment. At the same time, wholesale and retail industries and the total production value of the financial industry and fixed assets investment also have a certain correlation.

e. From the above three pairs of typical variables analysis, we can see that in the aspect of fixed assets investment, the economic benefits of fixed assets investment in agriculture, forestry, animal husbandry and fishery are not so obvious. In fact, from the original data, the proportion of fixed assets investment in agriculture, forestry, animal husbandry and fishery is not high relative to manufacturing, transportation, storage, postal and real estate industries, which shows that the mechanization of agriculture, forestry, animal husbandry and fishery in China is difficult to improve, the mechanization of production is immature, and the mechanization productivity of agriculture, forestry, animal husbandry and fishery is low. It also shows that the investment status of agriculture in the national economy has declined. In the aspect of economic growth, the loads of agricultural, forestry, animal husbandry, fishery, construction,

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transportation, storage and postal industry, per capita GDP and unemployment rate are not very large, which shows that the relationship between economic growth and fixed assets investment in these industries is not very big. This can also be understood as follows: in agricultural production activities, according to the actual situation of our country, the highly mechanized agriculture is not mature at this stage, and the main problem of agricultural production in our country can't be solved by fixed assets investment; the construction industry has tended to be saturated, which is also in line with the current economic situation of our country. The economic effect of transportation, warehousing and postal industry has lagging effect, so it can't fully reflect its relevance in the same year when the total fixed assets investment is completed; the load of unemployment rate is small, indicating that the correlation between fixed assets investment and unemployment rate is low, and the effect of fixed assets investment on the improvement of employment situation is limited.

f. When the original data is brought into the first pair of typical variables, the scores of the typical variables U1 and V1 can be obtained. According to the scores of each region, the scoring plane equivalence map can be drawn, as shown in the following figure.

It is easy to see from the scoring equivalence plan that scatters representing provinces, cities and autonomous regions are almost distributed in a straight line, and the relationship between them is almost linear. This shows that the method of canonical correlation analysis can better explain the correlation between fixed asset investment and economic growth. The scatter plot shows almost no difference from the group, which shows that the relationship between fixed asset investment and economic growth is relatively stable and the fluctuation is relatively stable.

From the following table, we can see the correlation coefficient between the two groups of typical variables. The correlation coefficient of the first pair of typical variables is 1, which is larger than the correlation coefficient of any other indicators given in the following table. From the correlation coefficient test results given by p value, we can see that when we test the null hypothesis that all the typical correlations in the population are zero, the first pair, the second pair of typical variables is less than 0.00001, and the third pair of typical variables is 0.00186. That is to say, the first pair and the second pair of typical variables have significant correlation, and the third pair of typical variables also had significant correlation at the level of 2%.

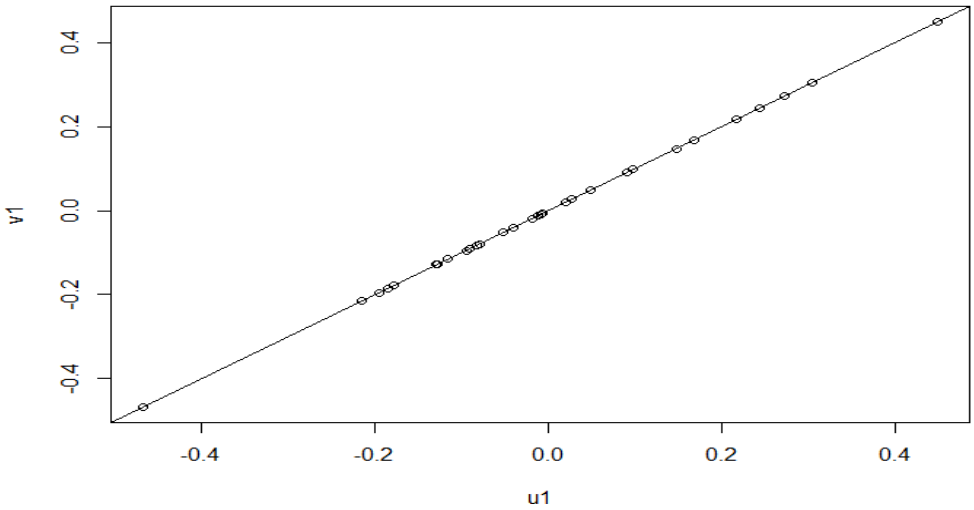

Figure 2. Score Equivalent Plane

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Table 2. typical correlation test

	r	Q	P
[1,]	1.000	810.861	0.00e+00
[2,]	1.000	313.985	2.46e-09
[3,]	0.998	208.712	1.86e-03
[4,]	0.987	130.238	4.28e-01
[5,]	0.976	83.455	9.40e-01
[6,]	0.950	48.714	9.99e-01
[7,]	0.842	25.476	1.00e+00
[8,]	0.795	14.068	1.00e+00
[9,]	0.669	6.407	1.00e+00
[10,]	0.607	2.575	1.00e+00
[11,]	0.326	0.394	1.00e+00

5. CONCLUSION

According to the above empirical analysis, we can see that fixed asset investment and economic growth have a strong correlation, and this empirical result is consistent with our general understanding of reality. Moreover, canonical correlation analysis can explain the degree of the change between the variables of fixed assets investment and economic growth. Canonical correlation analysis can provide some basis for the resource allocation of fixed assets investment in promoting economic growth in China to a certain extent.

The canonical correlation analysis in this paper is reasonable to some extent. The results show that there is a clear correlation between fixed asset investment and economic growth, which basically achieves the purpose of this study. Among the loads of each index, the performance of the index is not stable, which is somewhat different from the research expectation. This may be the cross-sectional data selected in this paper. However, the investment of fixed assets has the characteristics of lagging behind and the investment cycle is long, so the cross-sectional data can't fully reflect the planning of investment in fixed assets and the actual economic effect.

The investment in social fixed assets is the necessary basis for the development of social economy. No matter in any period, we should not skip the link of investment in fixed assets in order to carry out economic construction. At the same time, as one of the economic policies, fixed assets investment also has the function of stimulating or inhibiting economic growth in different economic development cycles. Fixed assets investment is not only an activity for enterprises and society to produce and live, but also a means to regulate economic development. In view of the key role of fixed assets investment in economic growth, China should take into account the upgrading of industries, the rotating benefits of industries, and the rational allocation of investment. At the same time, it should also pay attention to the investment in science and technology and pay more attention to people's lives, so as to realize the quality of people's lives while promoting economic growth. Continuously improve to ensure the healthy, stable and rapid development of China's economy and society.

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