

**A study of economic sophistication of China
by using principle component analysis**

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Abstract

Following the Global Recession in 2008, European countries and U.S. recognized irreversible changes resulting from financial shock that lead their own countries into a new stage of economy, called “New Normal” . Since the Chinese economy is not independent of the global economy, China also recognized that its own economy was entering the “New normal,” or “Xin Changtai” in Chinese. Furthermore, to suit their economy to “Xin Changtai” , new economic growth policy was necessary. During the 2014 APEC meeting, President Xi Jinping declared that China aimed to change their engine of economic growth from foreign trade and investment to innovation and consumption, in addition to the harmonious upgrade of the region and society between each province to achieve sustainable economic growth. Although existing literatures suggest the use of Genuine Progress Indicator (GPI) to evaluate the sophistication of society, there is no consensus on the construction of the components or the evaluation of each component of GPI, therefore, a more objective evaluation index is needed. This study employs the principle component analysis method to calculate an indicator to evaluate the sophistication of society. This indicator reflects the degree of the characteristics readily used in developed countries, and in the present study it is applied in the evaluation of China’s 31 provinces. Empirical results show that a few provinces in coastal areas developed their society, while most inland provinces were left behind. Moreover, as a result from the examination of the correspondence between the geographic distribution of the index and China’s seven geographic divisions, it is shown that a disparity in social sophistication occurred in each division.

Key Words: Chinese Economy, New Normal, Principle Component Analysis (PCA), Economic Disparity

JEL Classification: D63 E38 N95

Introduction

Since China joined the World Trade Organization in 2001, its economic growth rate has risen, however the growth rate was slowed due to the global recession in 2008. The average growth rate between 2001 and 2007 was 10.8%, while the average rate between 2008 and 2018 was 8.1%. Europe and U.S. recognized that the financial shock brought irreversible changes into their economies, resulting in a new stage of economy called “New Normal.” Similarly, China conceded that its economy had entered “Xin Changtai” , Chinese for “New Normal.” During the APEC summit in 2014, China’s President Xi Jinping declared that China should change its engine of economic growth to suit their economy to “Xin Changtai.” At APEC, President Xi presented a plan titled “Seek Sustained Development and Fulfill the Asia-Pacific Dream*¹,” suggesting that China changes its engine of economic growth from investment and foreign trade to innovation and consumption, and the upgrade of region and society should be harmoniously executed between each province. Following that background, this study aims to evaluate the sophistication of society of each province in China with a comprehensive indicator calculated by using the Principle Component Analysis (PCA) method.

In this field, numerous studies on the Genuine Progress Indicator (GPI) have been reported. GPI is a welfare indicator, which evaluates not only economic wealth, but also the social and environmental costs of sustainable growth. The unit of GPI is local currency, and many studies on the evaluation of various countries and economies are reported*². Social costs include the rate of crime, family breakdown and unemployment. Furthermore, environmental costs include air pollution, noise pollution, and in some studies, carbon dioxide emissions are also included. The GPI studies that evaluate the Chinese economy include Wen et al. (2007), Hou (2017) and

*¹ https://www.fmprc.gov.cn/mfa_eng/zxxx_662805/t1210456.shtml

*² Refer to Ogawa (2013).

Long and Ji (2019). Wen et al. (2007) evaluate 4 cities in China with GPI per capita, which shows Suzhou and Guangzhou are wealthier than U.S. Hou (2017) examines the evaluation of Liaoning province by GPI, in which the environment account includes Carbon Dioxide emissions. The cost value of one ton of Carbon Dioxide emission is assumed as 89.57USD of the year 2000 base, which refers to existing literature. The welfare of Liaoning evaluated by GPI is diverged from the evaluation by GDP, and it is suggested that the welfare evaluation by GDP can be overestimated. Long and Ji (2019) calculate all values of GPI for the 31 provinces and evaluate the welfare in each. The results indicate that the inequality of the welfare counted by GPI has narrowed between 1997 and 2016, and that economically developed coastal areas have suffered more damage in environmental accounts.

Xiao et al. (2018) evaluate the Chinese economy from another viewpoint. In a context that China requires the progress of industry to adopt “Xin Changtai,” they derive an indicator which is calculated from the information of GDP’s tertiary industry components ratio using the Arc Cosine method. Moreover, to identify the factor which affects the degree of the industrial upgrade in each province, they estimate the fixed-effect model, and the objective variable of the model is upgrade index, and covariates are thought to be the fluctuation factors of the industrial upgrade. They also examine the effect of “Xin Changtai” using the dummy variable, but the dummy effect is insignificant.

As shown above, although there are numerous studies that attempt to evaluate China’s provinces with GPI or an industrial upgrade indicator, both methods have issues which need to be solved. In GPI studies, there is little consensus on what kind of variables must be included as the components of social costs or environmental costs, furthermore, what worth the components of the costs have in monetary values. Therefore, because the values and selection

of social and environment accounts in Chinese studies listed above are not uniform, it is difficult to guarantee the objectivity of GPI. On the other hand, the industrial upgrade index has a simple structure, so it is thought to guarantee the objectivity of the indicator. Although the industrial indicator does not include the arbitrariness, the indicator covers only the industrial side which the indicator evaluates. The present study considers the above points and calculates the sophistication indicator from social and economic viewpoints, a method constructed of four economic variables using the PCA method. The aim of calculating the indicator is to evaluate the upgrade of each region and society, and to examine the ratio of components in the indicator. Here, results show that the indicator weighs the degree of income level and foreign investment ratio, and that the sophistication of society and regions are highest in coastal provinces in China. These outcomes are consistent with initial perceptions.

Data and method

This study evaluates the sophistication of social and economic viewpoints in each province using the PCA method. The characteristics of the calculated indicator reflects the features often shown in developed countries. The components of indicator include GDP per capita, foreign (include Hong Kong, Macao and Taiwan) investment ratios of total investment, tertiary production ratios of total production and elder people population ratios of total population, which are converted from Per Capita Gross Regional Production, Gross Regional Production, Total Investment in Fixed Assets from Hong Kong, Macao and Taiwan, Total Investment in Fixed Assets Foreign Funded, Total Investment in Fixed Assets in the Whole Country, Value-added of the Tertiary Industry, Population Aged 65 and Over and Total Population data. One of the scores which is derived from the PCA method indicates high GDP per capita, foreign capital

investment rate is high, tertiary production ratios are high and aging rate is high, which are the features noted in developed countries. This article recognizes the sophistication index, which displays the degree of features that can be seen in developed countries. The sample period is from 2006 to 2017, and the average values of the sample period are used for carrying out PCA.

Since the GDP per capita variable is thought to be related to labor productivity, this variable is selected as the factor of sophistication. GDP per capita reflects the degree of added values by the economic agent in the targeted economy, then when the amount of labor is constant, GDP per capita shows labor productivity. Higher labor productivity means higher sophistication of the society. The foreign investment ratios reflect the ease of firm activity by foreign enterprise. When the ratios of foreign enterprise investment on total investment in a province is high, the province is preferred by foreign firms than other provinces, which is linked to advantages in the environment in the province, such as profitability or fewer government restrictions. The higher ratios of tertiary production on total production reflect a higher opportunity cost of production activity which is not included in GDP, such as one's own housework or own transportation. According to the Rule of thumb known as Petty-Clark's law, following the economic growth, both of a decrease in the primary industry share and increase in secondary industry occurs, after which, tertiary industry will start to increase. Due to economic growth, since the labor productivity and real wage rate rise, then the opportunity costs of one's own housework or transportation instead of spending the time traveling to work will be higher. The opportunity cost causes the higher added values produced by housework or transportation services, resulting in the introduction of a new service industry into the grown economy. Furthermore, because the activity range or demand on the entertainment industry will be expanded along the economic growth, the transportation and entertainment industries will appear. The aging rate is necessary

to increase along economic growth. Since medical technology and the development of medicine grow on account of economic growth, the lifespan will be prolonged and prolific habitation will decline. Moreover, the sophistication of the society and the cost of nurturing and education increase, therefore, the decline in the birth rate accelerates.

From the viewpoint above, this study evaluates the degree of sophistication in China's 31 provinces using the scores of the PCA method, which is derived from four variables.

Empirical results

The standardized variables are used as components of the sophistication indicator, the coefficients of each variable are calculated as shown in Table. 1. The coefficient vector of first component shows that all the signs of coefficients are negative, therefore, the score calculated with this coefficient vector displays the degree of a province being left behind. The bottom values of the table show the cumulative explanation powers, then the first component has 57% explanation power of whole fluctuation of the variables. This study interprets the first component score multiplied by minus one as the degree of sophistication of society and figures out the features of each province. The construction of the first components are shown as below (the values are standardized, which the coefficient of GDP per capita converted as one).

$$ypc : ter : fdi : epr = 1 : 0.824 : 0.951 : 0.361$$

ypc denotes GDP per capita, *ter* denotes tertiary production ratios, *fdi* denotes foreign investment ratios and *epr* denotes elder people ratios. GDP per capita and foreign investment ratios are higher and tertiary production ratios and elder population ratios follow. The first component shows 57% of explanation power on whole fluctuation of the variables, which means this

component cannot explain all the features of a province, instead, only the features of social sophistication.

Figure.1 and Figure.2 show the degree of sophistication of society in each region. Deep green denotes upper 25% quartile provinces, and deep blue denotes lower 25% quartile provinces. Light green and blue show middle term degree of sophistication of society in regions, when the province is middle term and above average, it is painted light green, otherwise the middle term provinces are colored light blue. Figure.2 displays that the deep green provinces are concentrate in coastal areas, and deep blue provinces are prominent in western and central areas of China, which is consistent with initial forecasts. Furthermore, the estimated probability density by using kernel estimation (Figure. 3) shows that the distribution is not symmetrical, the highest density is concentrated in the lower range, and that other than a few sophisticated provinces, most are being left behind. It is consistent with the result that the upper 25% provinces are more fluctuated than any other class of provinces.

Figure.4 displays the construction of the indicator in each province. Between the upper 25% provinces and lower 25% provinces, the features in which the indicators are larger than average values or not are consistent with the features where the GDP per capita is larger than average values or not. The features in which the foreign investment ratios are higher than average values or not are consistent with the feature of the same viewpoint in all provinces except for Shandong. Furthermore, Beijing and Shanghai are extremely high in the GDP per capita and tertiary ratios. Although highly sophisticated provinces show their elder population ratios tend to be higher than average value, the value of Beijing is lower than average value and some provinces in Middle high term class are higher than the value of upper 25% provinces. The features of middle term provinces show no trend in the contribution of the indicator from their component.

Chongqing has special features; its GDP per capita and tertiary production ratio are lower than average, but its elder population ratio is higher than average. Middle lower indicator provinces display lower GDP per capita and higher contribution of elder population ratios except for Inner Mongolia. Inner Mongolia is higher GDP per capita while other components are lower than average, then the whole indicator is also lower than average. A special feature in Xizang is that the tertiary production ratio is extremely high, yet other components are lower than average.

As shown above, the sophistication indicators are high in fewer coastal provinces, while many provinces in other areas trail in social sophistication. The ranks of the social sophistication indicator are reflected in 5, and the seven geographical divides are shown in Figure.6. The labels show that HD denotes Huadong, HB denotes Huabei, HZ denotes Huazhong, HN denotes Hunan, XN denotes Xinan and DB denotes Dongbei. In comparing the two figures, there are characteristics to each province, however, there is a disparity of the indicator in each geographical divide. The most sophisticated class of province or provinces are respectively, Liaoning in DB, Beijing and Tianjin in HB, Shanghai, Zhejiang, Jiangsu and Fujian in HD, Hubei and Hunan in HZ, Inner Mongolia in XB and Sichuan and Chongqing in XN. All geographical divides have a province or provinces which is two classes lower than the most sophisticated class. Since the seven geographical divides are decided geographically and not from an economic viewpoint, then it is possible that an accumulation point exists in each geographical divide. When there is an accumulation point in arbitrary space, the point can have absorb power or epicenter power. To identify the features of each accumulation point, execution of the spatial statistic method is necessary.

Conclusions

In response to China's declaration that its economy required sophistication in line with "Xin Changtai," this study suggests an indicator to evaluate the degree of social sophistication in each of China's 31 provinces. Existing literatures propose the GPI or industrial upgrade index, however, both methods have issues yet to be solved. Since a consensus cannot be reached on GPI and the component of social or environment account or the money base values of their accounts, this indicator can include the variables unlimitedly, which does not guarantee the objectivity of the evaluation. As for the Industrial upgrade index, while it is objective, it evaluates only a part of sophistication of the society. Upon review, the present study instead utilizes the PCA method, combining four variables that reflect the features observed in developed countries, not only for the level of added value. Empirical results show that a few coastal provinces have progressed in terms of the sophistication of society, however, many provinces have been left behind in terms of social sophistication, a fact consistent with our initial thoughts. The examination of the seven-divides of China show that each divide has an accumulation point, whose characteristics may display absorb feature or epicenter feature. To identify these features, spatial statistics method is required, and this will be carried out in future works.

Finally, the method suggested in this study can be executed using basic economic data. The aim of this study concentrates on the examination of the effectiveness of the indicator and evaluation of each province in China. To follow up on the current status and changes along China's "Xin Changtai," the indicator suggested in this study is worth considering.

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Table. 1 Coefficient vector

	PC1	PC2	PC3	PC4
GDP PC	-0.61	0.05	-0.11	-0.79
Tertiary ratio	-0.50	0.46	0.66	0.33
FDI	-0.58	-0.11	-0.62	0.52
Elder ratio	-0.22	-0.88	0.42	0.06
Cum explanation	0.57	0.83	0.94	1.00

Author calculated

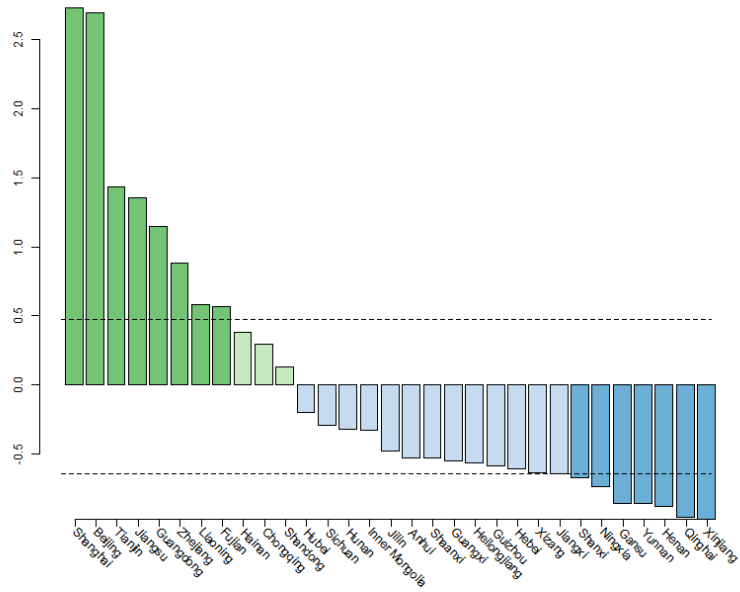


Figure. 1 Sophistication score bar-plot(value)

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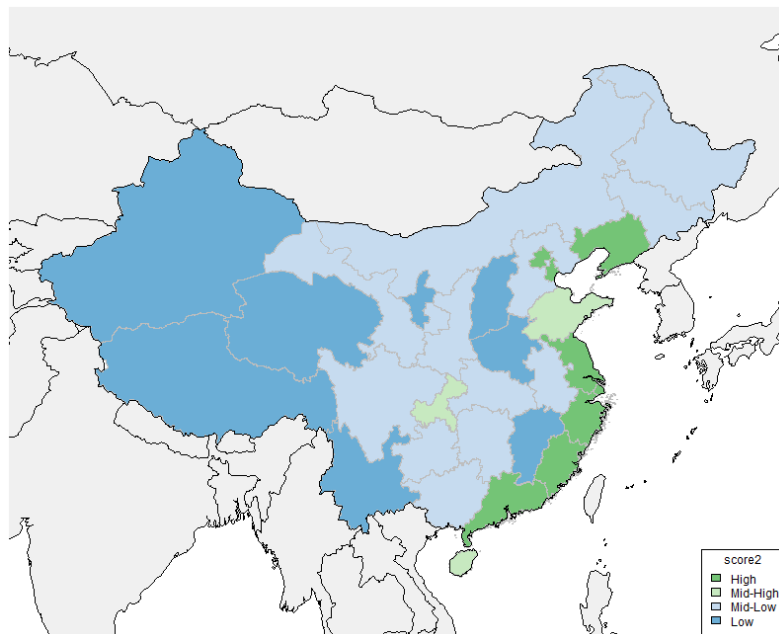


Figure. 2 Sophistication score map (mean)

Author created

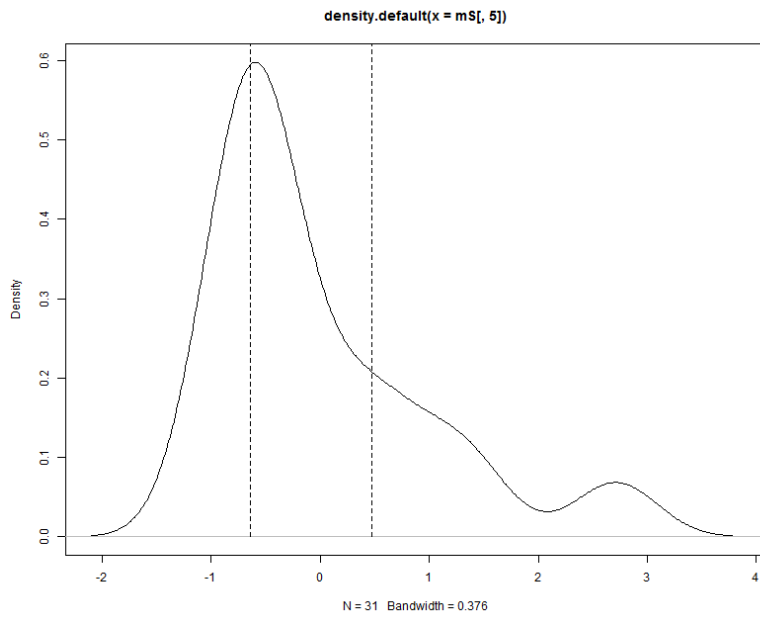


Figure. 3 Kernel estimation of probability distribution

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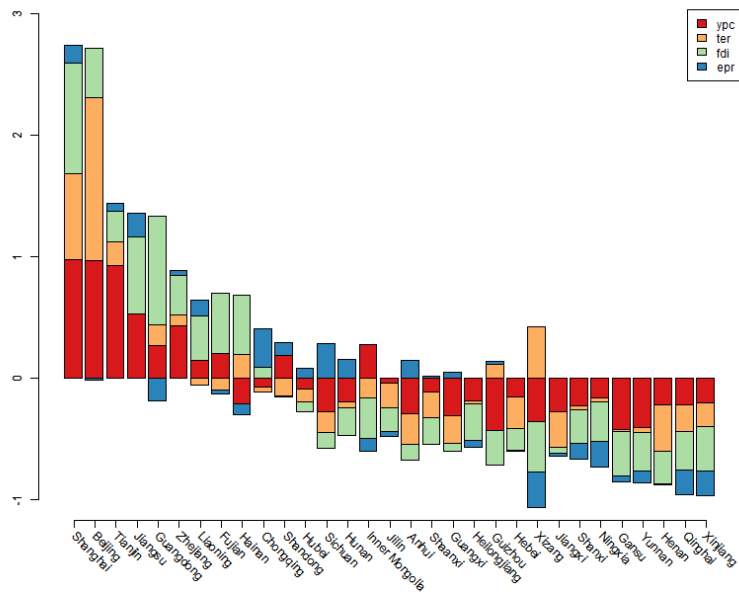


Figure. 4 Sophistication score bar-plot(value)

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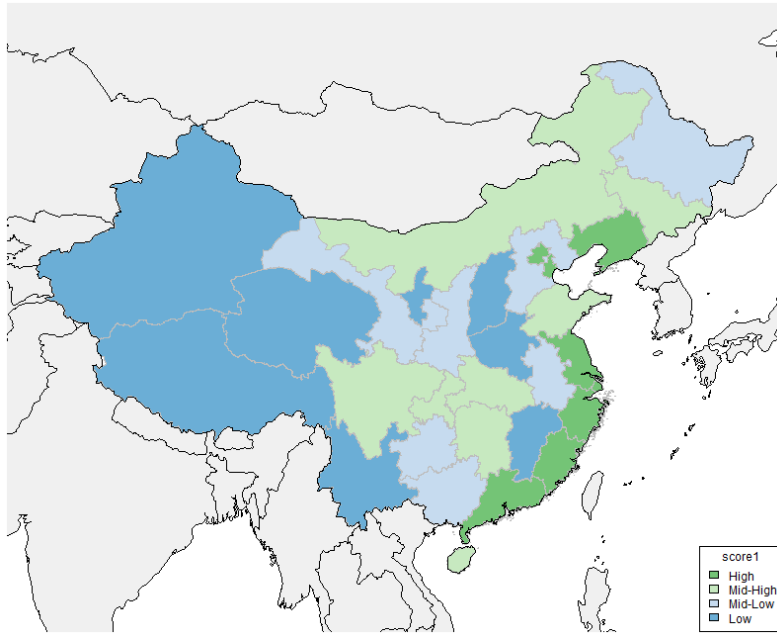


Figure. 5 Sophistication score map (median)

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Figure. 6 Seven divides of Chinese land (median)

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