A Comprehensive Evaluation of Economic Vitality and Markov's Prediction: An Empirical Study of a Major City in China

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Abstract: The region's economic vitality is an important part of its competitiveness. Based on previous studies, we use the grounded theory to perform indexing and then uses the Entropy method and Topsis evaluation methods to conduct a comprehensive evaluation of economic vitality for a major city in China. Finally, Markov forecasting is deployed. The forecasting method studied the trend of the vitality. Economic vitality is of great significance to regional economic division and regional policy formulation. Our thesis uses Chinese data to construct a model of economic vitality, filling an empirical gap in economic vitality research.

1 INTRODUCTION

Since China joined the world trade organization, the economy has grown exponentially. Although economic development can be perceived by the enhancing of life quality, the evaluation of regional economic development is still necessary. For a long time, GDP as the index dominate the economics evaluation in China. However, the gross domestic product index cannot fully represent the situation of the economy especially the vitality of the economy. So the Economic vitality(EV) index is constructed in this paper, which is a comprehensive index includes the dimensions of multiple industries and can provide support for economic policy decisions.

2 LITERATURE REVIEW

Many scholars have made contributions to the regional economic vitality, some of which define the economic vitality index. For foreign scholars, Human Capital Index(HCI) indicators (Kraay A, 2018) are often used to represent the vitality of a region (Yang et al, 2020; Barro & Lee, 2013), or to link economic vitality with community development (Martyniuk et al, 2016).For Chinese scholars, after many efforts of defining the economic vitality, there is currently no dominant indicator for EV and there is also a lack of functional test of indicators. Here we summarize the definition as follows:

Table 1: Summary of literature.

Metrics	Authors
Production output; Fiscal surplus; Number of enterprises; Disposable income; Science and technology spending; Health and pensions etc.	Lou et al, 2005
Fiscal revenue; Education and manpower; Income; Employment; Innovation ability etc.	Lu et al, 2007
Urbanization; Industrialization; GDP etc.	Sun et al, 2007
Economic growth; Enterprise benefit; Social security etc.	Jin et al, 2007
The degree of opening; Quality of life; The innovation ability etc.	Hou et al, 2015
Human resources; Private economy; Industrial structure etc.	He et al, 2019
Government intervention; Consumption; Infrastructure construction; The investment structure etc.	Lu et al, 2019

It can be seen that the current research on economic vitality has some problems, such as the inconsistency between the definition and the selection criteria of indicators. As for the HCI index, it is too difficult to obtain relevant data. Therefore the education index is often used to replace all HCI indicators, which can only reflect only one aspect of the region vitality and the prediction based in that

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indicator for the overall situation is not convincing. Moreover, the economic vitality is limited to the economic vitality of the community, which leads to its narrow definition and is not an macroeconomic indicator. The selection criteria of indicators are not open and clear enough, which brings doubts on the credibility and usefulness of indicators.

Based on the above problems, our research refers to the development of a comprehensive evaluation system of economic vitality from a macro perspective, in which the data of evaluation indicators are easy to obtain, and the effect of this index is performed.

3 DEFINITION OF ECONOMIC VITALITY

We will define metrics through the following criteria: Data accessibility, Comprehensiveness, and Data continuity. Economic activity will be measured by following metrics:

- Consumer price index(CPI)
- International tourism arrivals(ITA)
- Real estate investment (RI)
- Industrial production(IP)
- Imports and Exports(IE)
- Transport(T)

The data come from the Shanghai bureau of statistics.

4 COMPREHENSIVE EVALUATION

4.1 Entropy Method

a. First, we establish the decision-making matrix of the indicators. In the matrix, each row is matched with a time node and the column refers to the indicators. Then we using the concept of entropy information to determine the weight of the indicators:

$$X=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1s} \\ x_{21} & x_{22} & \cdots & x_{2s} \\ \vdots & \vdots & \cdots & \vdots \\ x_{t1} & x_{t2} & \cdots & x_{ts} \end{bmatrix} \quad (1)$$

where x_{ij} represents the value of the j indicator of the time node i.

After normalized:

$$r_{ij}=\frac{x_{ij}}{\sum_{i=1}^{t} x_{ij}} \quad (2)$$

b. So we can find the information entropy of the indicators:

$$e_j^*=-\frac{\sum_{i=1}^{t} r_{ij}\ln r_{ij}}{\ln t} \quad (3)$$

c. Calculating weight vectors:

$$w_j=\frac{1-e_j}{\sum_{j=1}^{s}(1-e_j)} \quad (4)$$

4.2 Topsis Evaluation

After the entropy method is deployed, Topsis evaluation method is used to calculate the overall performance score of the various indicators of each time node, and it finally returns a column with Topsis value between 0 to 1.

Here we note that the information utility value of an indicator depends on the difference coefficient of the indicator, its value directly affects the size of the weight, the greater the information utility, the greater the importance to the evaluation,and the greater the weight.

a. Calculate the normal matrix:

$$\overline{a_{ij}}=\frac{a_{ij}}{\sqrt{\sum_{j=1}^{n} a_{ij}^{\ 2}}} \quad (5)$$

b. Recalculate the normalized matrix after weighting:

$$V_{ij}=\overline{a_{ij}}\times\omega_j \quad (6)$$

c. Then find the ideal optimal solution and the ideal worst solution to the index. Here we define that if the indicator is considered beneficial to economic vitality then the optimal solution will be the maximum value of all the observation concerning the weight for this indicator. And vice the unhelpful indicator takes the minimum value. The worst solution and the optimal solution value is opposite to each other, and obviously, here only the CPI is a non-

beneficial indicator which we always expect to be at a appropriate interval.

i. Calculates the ideal optimal solution of the Euclid distance.

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(V_{ij} - V_j^+)^2} \tag{7}$$

j. Calculating the ideal worst solution of the Euclid distance of the standardized matrix.

$$S_i^- = \sqrt{\sum_{j=1}^{n}(V_{ij} - V_j^-)^2} \tag{8}$$

k. Finally get performance ratings for each time nodes.

$$E_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{9}$$

4.3 Inspection of the Result Data

After we get the economic vitality, we need to further analyze the general trend of Shanghai's economic vitality.

We will use the ' Moving horizon estimation' to fit the general trend of economic vitality in Shanghai. The process is as follows. We assume that the prediction of a value in the future depends on the average of the 'n' number in front of it. The predicted value of target, the mathematical expression is:

$$\hat{y}_t = \frac{1}{k}\sum_{n=0}^{k-1} y_{t-n} \tag{10}$$

In fact, this also has the effect of smoothing the original time series data to find the changing trend of the data.

We made a smooth data graph with sliding window values of 4(month), 12(month) and 24(month). The results are shown in the following figure.

From the graph, we can see that all of the data in these three images are within the confidence interval. Moreover, these smoothing results indicate that the economic vitality of Shanghai is rising steadily, which is the most obvious among the smoothing results with a sliding window value of 24 months. This is consistent with the actual situation and reflects the rationality and accuracy of the index.

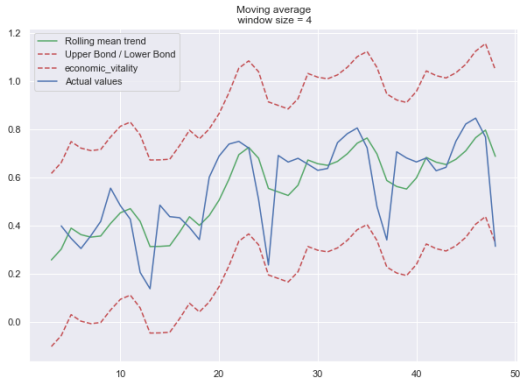

Figure 1: Moving average size=4.

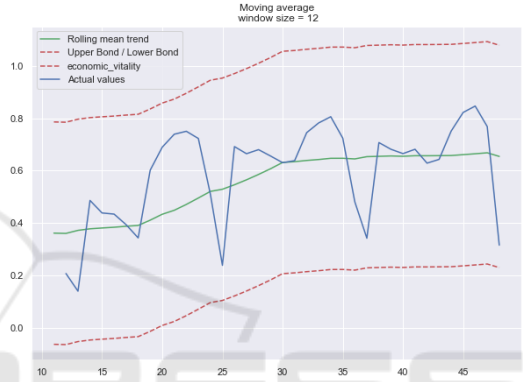

Figure 2: Moving average size=12.

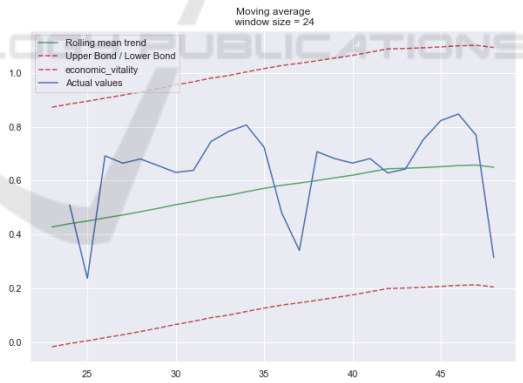

Figure 3: Moving average size=24.

5 MARKOV PREDICTION

5.1 Markov Prediction Model

By defining economic vitality index, we use Topsis and entropy method to get the weight of each economic vitality index. After determining the index weight, the specific value of the economic vitality of each month in Shanghai is obtained. By observing the

time series diagram, it is concluded that the economic vitality growth rate of Shanghai defined by various indicators has periodic fluctuation in time. Based on this property, 'Markov' model can be used to analyze and predict the growth rate of Shanghai's economic vitality in the coming months. And compared with the actual results, the difference between the actual results and the predicted results was analyzed. Summarize the reasons and make further assumptions.

5.2 Model Calculation

a. Establishment of decision matrix:

$$H=\begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1f} \\ h_{21} & h_{22} & \cdots & h_{2f} \\ \vdots & \vdots & \cdots & \vdots \\ h_{e1} & h_{e2} & \cdots & h_{ef} \end{bmatrix} \quad (11)$$

b. The value NEY_i is the monthly economic vitality

c. Calculate the monthly growth rate of economic activity:

$$gr_i=\frac{NEY_i-NEY_{i+1}}{NEY_{i+1}} \quad (12)$$

d. In our study, we found that the quarter digit, median digit and three-quarters digit of the economic vitality growth rate of Shanghai were about -0.15, 0,0.15 respectively.

We define the probability matrix of state transition. Firstly, C_1 can be defined as grade a, C_2 as grade b , C_3 as grade c and C_4 as grade d. As shown in the following table.

Table 2: Transition Table.

Rank	A	B	C	D
Economic vitality growth rate rating	(-∞,-0.15)	[-0.15,0)	[0,0.15)	[0.15,+ ∞)

Then, according to the definition of conditional probability, The state transition probability $P(C_i \rightarrow C_j)$ from state C_i to C_j is the conditional probability $P(C_j \mid C_i)$, as:

$$STP_{ij}=P(C_i \rightarrow C_j)=P(C_j \mid C_i) \quad (13)$$

So we get the transition probability matrix：

$$STP=\begin{bmatrix} STP_{11} & STP_{12} & \cdots & STP_{1f} \\ STP_{21} & STP_{22} & \cdots & STP_{2f} \\ \vdots & \vdots & \cdots & \vdots \\ STP_{f1} & STP_{f2} & \cdots & STP_{ff} \end{bmatrix} \quad (14)$$

It is obvious that:

$$\begin{cases} 0 \le STP_{ij} \le 1 \\ \sum_{j=1}^{f} STP_{ij}=1 \end{cases} \quad (15)$$

e. Markov prediction method is used to predict the probability of state occurrence in the process of time development. The state probability is represented by the symbol $\pi_j(k)$, and k is the transfer times：

$$\sum_{j=1}^{f}\pi_j(k)=1 \quad (16)$$

Then according to markov process's no aftereffect and Bayes conditional probability formula, we can get:

$$\pi_j(k)=\sum_{i=1}^{f} STP_{ij}\pi_i(k-1) \quad (17)$$

We have the row vector

$$\pi(k)=[\pi_1(k) \quad \pi_2(k) \quad \cdots \quad \pi_f(k)] \quad (18)$$

and we use that to get the vector iteration formula：

$$\pi(k)=\pi(k-1)STP=\cdots=\pi(0)(STP)^k \quad (19)$$

5.3 Prediction Result

The predicted results are shown in the following

Table 3: The results of the Markov.

Year.Month	Rank	Probability
2020.2	A	0.428571
	B	0
	C	0
	D	0.571429
2020.3	A	0.183673
	B	0.28514
	C	0.171429
	D	0.359184

Table 3: The results of the Markov. (cont.)

Year.Month	Rank	Probability
2020.4	A	0.153153
	B	0.386359
	C	0.225048
	D	0.23544
2020.5	A	0.16573
	B	0.394502
	C	0.226987
	D	0.212781
N month (steady state)	A	0.172996
	B	0.387838
	C	0.22255
	D	0.216617

5.4 Prediction Result Analysis

Through the analysis of the above table, it can be seen that February 2020 presents A polarized form, and the probability of economic vitality growth rate grade A is' 0.428571 ', while the probability of economic vitality growth rate grade D is' 0.571429 '.This shows that according to the historical data of the last four years, January 2020 is in the trough of cyclical fluctuations in the growth rate of economic vitality.

Therefore, based on the historical data, it is predicted that the possibility of a continuous decline in the economic vitality growth rate in '2020.2' is' 0.408571 '. This is because of the particularity of the Chinese year cycle, and there is such a long holiday as the Spring Festival in China. In Holiday people will reduce a variety of normal economic activities; The date of the Spring Festival is determined by the lunar calendar, which usually falls in January or February. So this form of polarization makes sense, and it fits the reality.

6 INSIGHTS ADVICE TO THE GOVERNMENT

Markov forecast allows us to have a comprehensive grasp of the future economic situation, so that the government can adjust economic policies in time. For the current Markov results, Shanghai, as China's economic center city, has maintained a stable growth of economic vitality. In some months, such as the months of Chinese Spring Festival, we can clearly see that the economic vitality reaches a local maximum.

But in the long run, it is more and more difficult to maintain high economic vitality with the increase of economic volume. At present, China's economic growth is slowing down. As a prior indicator of economic development, economic vitality can effectively show the current and future economic level of a region.

This paper suggests that the government can use the following methods to maintain economic vitality: Carrying out industrial reform, using welfare fiscal policies, improving the level of international opening-up, speeding up the regional integration development strategy and forming regional growth poles.

7 FUTURE WORK

Due to the current situation of COVID-19 pneumonia, China's economy and even the world economy have been disrupted by the sudden epidemic. In the context of blocking cities, reducing international exchanges and suppressing agglomeration, the economy has suffered huge losses. The next work can assess the economic loss of the epidemic through the economic vitality determined in this paper, and provide theoretical support for the economic recovery.

REFERENCES

Kraay, A. (2018). Methodology for a World Bank human capital index. The World Bank.

Yang, Z., & Pan, Y. (2020). Are cities losing their vitality? Exploring human capital in Chinese cities. Habitat International, 96, 102104.

Barro, R. J., & Lee, J. W. (2013). A new data set of educational attainment in the world, 1950–2010. Journal of development economics, 104, 184-198.

Martyniuk-Peczek, J., Parteka, T., & Peczek, G. (2016). Territorial Aspects of Entrepreneurial Activity in Polish Suburban Zones. *Procedia engineering*, *161*, 1639-1646.

Lou haimiao, & sun qiubi. (2005). Evaluation of economic vitality of Chinese provinces based on factor analysis. Journal of fuzhou university (philosophy and social sciences) (03), 33-36.

Lu xiaoli, & guo wanshan. (2007). Comprehensive evaluation index system of urban economic vitality. Statistics and decision-making, 2007 (11), 77-78.

Sun faping, ma hongbo, & wang lanying. Research on strengthening economic vitality of qinghai. Qinghai ethnic studies (3), 92-98.

Jin yan-jie. Evaluation of urban economic vitality in China. Geography science (1), 11-18.

Hou rongtao. Construction of economic vitality evaluation system and empirical analysis of futian district [J]. Economist (6) : 148-150.

He Ruqun. (2019). The pearl river, west river economic belt urban economic dynamism evaluation research. (Doctoral dissertation, guangxi normal university).

Lu jin, & wang xiaofei. (2019). Fixed asset investment, aging and economic vitality - a study based on the provincial perspective. Journal of population (5).