Chapter 40
The Macroeconomic Leading Indicators Analysis Based on the Method of K-L Information Content and Time Difference Correlation Coefficient

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Abstract It is common to have fluctuations of development and growth level in the process of economic development. Thusit is quite important to found a reasonable macro economic leading indicators to analyze the macro economy. First, we analyzed the composition of the proportion of GDP and chose the composite index of over scaled industry increasing value and total retail sales of social consumer goods which make up great amount of GDP as reference index. Then, we use K-L information content and time difference correlation coefficient to analyze the macro economic indicators, Through the method we chose the indicators which have the leading feature. Finally, by the help of composite index in the method of economic sentiment index, we had the leading indicators. The empirical analysis shows that the leading indicators for Chengdu can predict the trend of the macro economy in Chengdu in a way, so it can help the government to make decisions in advance.

Keywords Leading indicator · K-L information content · Time difference correlation coefficient · Composite index · Macro economy

40.1 Introduction

The macro economic fluctuation is a cyclical period during which the economy fluctuates from depression to recovery then to high. This fluctuation is presented by continuous evolution of various economic indicators in different economic process. If the fluctuation of a indicator do not agree with overall economic fluctuation in the peak and valley at the same time (the benchmark cycle represented by benchmark index), and is in a forward position in time axis, this index is called leading indicator. Xie et al [1] pointed out:this kind of economic indicators change before

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the whole national economic fluctuation and for the cyclical fluctuation of national economy, the indicators are ahead in time, and come up before overall economic growth and decline. In the book ≪ *Economic Cycle Research* ≫, Wang [2] analyzed external impact and internal conduction mechanism for China's economic cycle and provided theoretical basis for us to do qualitative analysis on economic leading indicators.

Currently, there are no fixed standards for analyzing macro economic leading indicators overseas. He et al [3] said every method should be suitable for its national condition. For example, American leading indicator system includes Labor, Finance, Equipment supplies, Consumption and Comprehensive class. Besides, The National Bureau of Economic Research, The Conference Board, The United States Institute of Business Cycles, The US Bureau of Economic Analysis use different leading indicators. For the leading indicators in the eurozone, finance class uses money supply index, Eonia, exchange rate index and EMU-11 stock index; Equipment supplies uses order position; Consumption class uses the number of new car registration; Comprehensiveness class uses OECD leading indicators. About its theoretical basis, Lahiri et al [4] came up with the new theory and concept about leading indicators in the book ≪ *Leading Economic Indicators: New Approaches and Forecasting Records*≫ and also mentioned a time series framework about leading indicators.

Our country have been studying establishing leading indicator system since 1980s. We can see from the former consequence, there are some achievements on the national level. But on the province or lower level, few work has been done. For example, Sachs [5] synthesized Goldman Sachs economic activity index and Goldman Sachs leading indicators to monitor China's macro economy. These two indicators were founded on national level. The first areal economic indicator in our country is Beijing's economic leading indicator which was imported from BEA by Ding [6] and it acted quite well in test run. For method, it was Zhang et al [7] who introduced gray correlation method, fuzzy nearness method and discriminant analysis method to select leading indicators; However the most popular method in our country includes peak and valley corresponding method, time difference correlation coefficient method, Stage Average of Reference Cycle and K-L Information Criteria. Li [8] introduced these methods about picking out leading indicators in 2002; Otrok et al [9] used Bayes theorem in establishing leading indicators. Anyway, breakthrough in method is still a big bottleneck of research. As for final research production, publications with depth and authority was little and most of them were about introducing indicators for western countries. For example, Stock et al [10] used leading indicators to predict the time that economy began to decline in last century; Banerjee et al [11] used mathematic methods to study the stability of leading indicators' predicting effect. This is a great help for us to pick out more accurate leading indicators of different data set. The existing researches are basically about the economic leading indicators on national level and few researches are on areal level. Besides, the existing researches usually use industrial increasing value as benchmark index and do not consider the characteristic of areal economy.

As for the above problems, this essay took Chengdu's characteristic into consideration and used K-L information content and time difference correlation coefficient to establish Chengdu's macro economic leading indicators. Besides, we chose the composite index of over scaled industry increasing value and total retail sales of social consumer goods as the benchmark index.

40.2 Methods of Constructing the Macro Economic Leading Indicators System

By the look of experience in development in different countries, the construction of economic indicator system include conforming benchmark index, selecting economic leading indicator system and establishing leading indicators in economic process.

40.2.1 Conforming Benchmark Index

The substance of selecting benchmark index (or indicator) is to determine reference system for the time difference, this is the foundation for constructing the overall economic leading indicator system. Countries with sophisticated statistical indicator system (such as America, some OECD members and Eurozone members) mostly use GDP as benchmark index. In our country, most institutions choose "industrial increasing value" as benchmark index, this include two reasons: (1) There are more time series data for industrial increasing value than GDP. GDP is recorded quarterly, industrial increasing value is recorded monthly; (2) industrial increasing value can reflect the actual changes in GDP better than total industrial output value. Yan et al [12] suggested as industry is the main part of secondary industry, industrial increasing value making up large proportion in GDP determines that it can replace GDP as benchmark index. Chengdu's GDP was recorded quarterly from the end of 2004 till now, So we consider using other monthly indicators as benchmark index. From the perspective of Chengdu's economic development, industry's average share in GDP is 34.4% from 1999 to 2006, it is quite a large proportion; However, tertiary industry's average share in GDP is 47.6%. As a result, we consider choosing the composite index of over scaled industrial increasing value and the important representative index for tertiary industry — total retail sales of social consumer goods as benchmark index.

Using the the composite index of over scaled industry increasing value and total retail sales of social consumer goods and GDP's quarterly Year-on-year data to do X-11 seasonal adjustment, then we have our graph. We can see that the composite index's trend is basically the same as the GDP's. So we choose the composite index of over scaled industry increasing value and total retail sales of social consumer goods as benchmark index, as shown in Fig. 40.1.
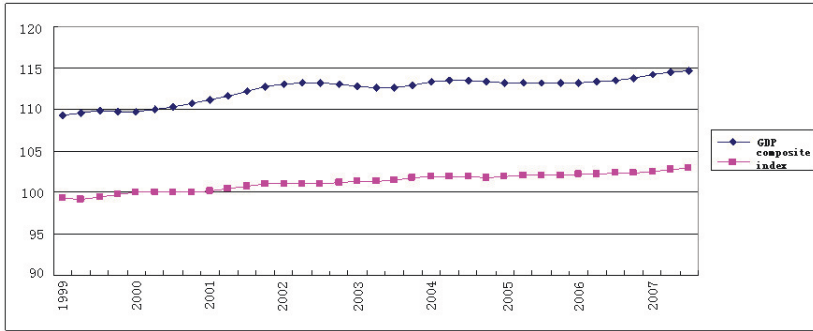
Fig. 40.1 The comparison between the trends of composite index and GDP

40.2.2 Selecting Leading Indicators

After confirming benchmark index, we can use suitable mathematical method to se-
riously calculate every index in basic index library (shown in Table 40.1) and pick
out leading indicators with real ahead meanings. Here we use K-L information con-
tent method and time difference correlation coefficient to measure the correlativity
between every indicator and benchmark index.

Table 40.1 Basic index library (1991.1 ∼ 2007.10)

Category	Indicators
Industry	Over scaled industry increasing value, the over scaled total industrial output value, cigarette production, cement output, the over scaled marketing rate on industrial output, steel production, Chinese patent medicine production
Fixed-asset investment	Total fixed asset investment value, Commodity House sales, renovation and reformation investment
Price	Consumer price index (CPI)
Finance	Local financial revenue, local financial expenditure
Banking	Deposit balances at a financial institution, deposits of enterprises, loans at a financial institution, industrial loan, financial institution's cash income, Financial institution's cash outlayresidents' deposit balance
Domestic trade	Total retail sales of consumer goods
Foreign trade	Total export-import volumetotal export, actual utilized foreign investment value
Transportation	Cargo volume, passenger traffic volume
People's liveli-hood	Per capita disposable income of urban residents, per capita living expenditures for consumption of urban residents

(1) K-L information content

For the occasional random phenomenon, it can usually be considered as realizations for random variables which obey certain probability distribution. If the probability distribution is already known, we need a measurement to estimate the chosen model's similar degree with real probability distribution, so we can tell the model is suitable or not, this is called Kullback-Leibler information content (K-L information content) which was came up with by Zhu et al [13].

Suppose that the probability distribution list for random (benchmark) variable is $\mathbf{p} = \{p_1, p_2, \cdots, p_m\}$, p_i is the event probability of w_i, restricted that $p_i > 0$, $\sum_{i=1}^{m} p_i = 1$.

Suppose that the probability distribution list for random (estimated) variable is $\mathbf{q} = \{q_1, q_2, \cdots, q_m\}$, $q_i > 0$ is the event probability of w_i, so define expectation $I(\mathbf{p}, \mathbf{q}) = \sum_{i=1}^{m} p_i \ln \frac{p_i}{q_i}$ as probability distribution list $\mathbf{q}$'s K-L information content related to probability distribution list $\mathbf{p}$. Assume that benchmark index is $\mathbf{y} = \{y_1, y_2, \cdots, y_n\}$. As sequence $\mathbf{p}$ which meet the needs of $p_i > 0, \sum p_i = 1$ can be considered as probability distribution list of certain random variable. So after standardized treatment for benchmark index, the sum of indicators is 1, $\mathbf{p}$ is the sequence that have been treated, then:

$$p_t = y_t \bigg/ \left(\sum_{j=1}^{n} y_j \right), \ t = 1, \cdots, n \ (y_t > 0).$$

Suppose that the chosen indicator $\mathbf{x} = \{x_1, x_2, \cdots, x_n\}$ is also standardized and $\mathbf{q}$ is the final sequence, then:

$$q_t = x_t \bigg/ \left(\sum_{j=1}^{n} x_j \right), \ t = 1, \cdots, n \ (x_t > 0).$$

By the equation $I(\mathbf{p}, \mathbf{q}) = \sum_{i=1}^{m} p_i \ln \frac{p_i}{q_i}$, K-L information content can be calculated as:

$$k_l = \sum_{t=1}^{n_l} p_t \ln \left(p_t / q_{t+l} \right), \ t = 0, \pm 1, \cdots, \pm L.$$

In the equation, l represent the time ahead or behind. If l is negative it means ahead, positive means behind. l is called time difference or delayed number, L is the largest delayed number, n_i is number of data after been completed. When the $2L+1$ K-L information content have been calculated, the smallest value k_{ln} will be pick out as the K-L information content for the chosen indicator $\mathbf{x}$ related to benchmark index $\mathbf{y}$:

$$k_{l'} = \min_{-L \leq l \leq L} k_l,$$

where l' is the most appropriate months (quarter) that is ahead or behind. The smaller (more close to 0) K-L information content is, the closer indicator $\mathbf{x}$ is with benchmark indicator $\mathbf{y}$.

(2) Time difference correlation coefficient

Time difference correlation coefficient is a method use correlation index to confirm the relationship weather Economic time series is ahead, agreed or behind. Assume $\mathbf{y} = \{y_1, y_2, \cdots, y_n\}$ is benchmark index, $\mathbf{x} = \{x_1, x_2, \cdots, x_n\}$ is selected indicator, r is time difference correlation, then:

$$r_l = \frac{\sum\limits_{t=1}^{n_l} (x_{t-l} - \bar{x})(y_t - \bar{y})}{\sqrt{\sum\limits_{t=1}^{n_l} (x_{t-l} - \bar{x})^2 \sum\limits_{t=1}^{n_l} (y_t - \bar{y})^2}}, \; t = 0, \pm 1, \pm 2, \cdots, \pm L.$$

In the equation, represent the time ahead or behind. If l is negative it means ahead, positive means behind. l is called time difference or delayed number, is the largest delayed number, n_l is number of data after been completed. When choosing the sentiment indicators, usually several time difference correlation for different delayed number are first calculated, then compare the results. The largest time difference correlation $r_{l'} = \max_{-L \le l \le L} r_l$ is considered to reflect the time difference correlation between selected indicator and benchmark index, delayed number l' represent the time ahead or behind. Dong et al [14] pointed out that we should pay attention to the following when estimating, choosing and classifying indicators:

- Indicators' time difference correlation usually do not larger than 0.5.
- Indicators' correlation coefficient sequences fluctuate a lot, they have obvious cyclical fluctuation feature.
- The size of time difference correlation do not restricted by sign.
- Time difference between ahead and behind indicators is usually more than three months.

40.2.3 Establishing Leading Indicators in Economic Process

Although economic booming trend can be observed and analyzed by fluctuations of various economic variables, comprehensive consideration on all variables's fluctuation should be take to observe overall process of macro economy's fluctuation. So, a comprehensive analysis method is needed to reflect macro economy's fluctuation in economic process, that is the method of economic sentiment index. It includes DI (Diffusion Index) and CI (Composite Index). DI regard indicators which are continuous increasing or decreasing as a process economic sentiment affect and permeate. It will be used to predict turning point of economic sentiment and grasp the process of effect; CI can be used to observe the degree that economic sentiment changes and provide quantitative descriptors. Meanwhile, it can also reflect the turning point of economic sentiment. The two indexes are both more reliable and authoritative than single index. The difference is that DI can not reflect the degree of increasing and decreasing but only can reflect the direction of change and the turning point; while

CI can not only predict the turning point of economic fluctuation but also can reflect the degree of economic cyclical variation in a way. Therefore, we adopt CI to deal with the selected leading indicator and finally get the leading indicators. Here, we use the mathematic method of synthetic index from OECD (Organization for Economic Cooperation and Development).

OECD uses the method of sentiment index to analyze and predict its members according to the concept of "cyclical increasing" from 1978. The method that OECD [15] uses to make synthetic index is quite easy and it is designed for leading synthetic index.

First, OECD decomposed the trend of indicators in leading indicator group (the sequence has been adjusted seasonally) by the stage average method and removed tendency in indicators. Then OCED got the cyclical elements sequence and assume it is $C_j(t)$ $(j = 1, 2, \cdots, m)$, m is the number of indicators. Meanwhile, benchmark index should be $X(t)$, it is also a cyclical element sequence obviously.

(1) Calculating the standard deviation SD_j of every indicators first:

$$SD_j = \left(\sum_{t=1}^{n} |C_j(t) - \bar{C}_j| \right) \Big/ n, \ j = 1, 2, \cdots, m,$$

$\bar{C}_j$ is the mean of jth indicator.

(2) Calculating the average standardized sequence of leading indicators $S(t)$:

$$S(t) = \left(\sum_{j=1}^{m} (C_j(t) - \bar{C}_j)/SD_j \right) \Big/ m, \ t = 1, 2, \cdots, n.$$

(3) Calculating two adjustment factors k, d to make leading indicators go with benchmark index consistently and easy to compare by adjusting the range of the two factors.

$$k = \left(\sum_{t=1}^{n} |X(t) - \bar{X}| \right) \Big/ \left(\sum_{t=1}^{n} |S(t) - \bar{S}| \right),$$

$$d = \bar{X} - \bar{S},$$

where $X(t)$ is benchmark index, $\bar{X}$ is the mean of $X(t)$, $\bar{S}$ is the mean of $S(t)$.

(4) Calculating the leading synthetic index of cyclical increasing finally:

$$\mathrm{CI}(t) = k \times (S(t) + d), \ t = 1, 2, \cdots, n.$$

We can see that OECD uses cyclical increasing method to analyze cyclical element C's fluctuation. However, most developing countries use cyclical increasing rate method to analyze the fluctuation of cyclical element TC and secular trend in time series. Therefore, we choose TC's time series to calculate the leading composite index.

40.3 Empirical Analysis

Based on the methods above we can pick out leading indicators first. After using X-11 method to adjust 28 indicators, the two methods in Sect. 40.2.2 can be used to calculate K-L information content and time difference correlation of selected indicators and benchmark index. Through repeated comparison, 6 leading indicators were finally picked out, these indicators cover industry, investment, finance, banking and so on. As shown in Table 40.2.

Table 40.2 The leading indicator system established by the methods of K-L information content and Time difference correlation coefficient

Indictors	Time difference	K-L information content	Time difference correlation coefficient
The over scaled marketing rate on industrial output	−12	0.47	0.42
The over scaled total industrial output value	−12	11.04	0.94
fixed-asset investment	−9		0.71
Local fiscal revenues	−12	20.16	
Financial institution's cash income	−10	24.25	
Financial institution's cash outlay	−10	27.21	−0.46

Then, we can get the leading composite indicators for Chengdu by using the methods in Sect. 40.2.3. After comparing it with benchmark index we can see the tendency of leading composite indicators is similar with that of benchmark. As shown in Fig. 40.2.

Fig. 40.2 The comparison between trends of the leading composite indicator and benchmark index

The leading indicator is a synthetic index, the every number that consists it will affect the indicator. So it is very changeable and almost changes every month. According to a general rule, we should observe its trend. If the indicator has been in-

creasing or decreasing for several months, it means new changes will be in the economic circulation. If the leading indicator keeps increasing for more than 8 months, benchmark index may have a return and GDP which have the similar fluctuation with benchmark index will climb up too. The duration of the recovery will be $3 \sim 7$ months behind in comparison with the leading indicator; Meanwhile, if the leading indicator has been decreasing for $5 \sim 12$ months, benchmark index will have a decline and GDP may also has the same fluctuation. The duration of the decline will be $3 \sim 9$ months behind the leading indicator. As shown in Tables 40.3 and 40.4. Besides, we can see from the analysis: Time difference between duration of the leading indicator keeps rising and duration of benchmark index's recovery is not obvious. The former is about $8 \sim 13$ months and the latter is about $11 \sim 14$ months; Time of the leading indicator's decreasing is about $7 \sim 12$ months which is longer than that of benchmark index's (about $5 \sim 7$ months).

Table 40.3 The comparison between the leading indicator and benchmark index in rising months

Duration of the leading indicator kept rising	The time the leading indicator began to rise	The time benchmark index began to rise	Duration of benchmark index kept rising	Rising period behind the leading indicator
13 months	2000.05	2000.12	14 months	7 months
12 months	2001.11	2002.05	11 months	6 months
9 months	2004.08	2005.01	11 months	4 months
8 months	2006.03	2006.06	17 months	3 months

Table 40.4 The comparison between the leading indicator and benchmark index in decreasing months

Duration of the leading indicator kept decreasing	The time the leading indicator began to decrease	The time benchmark index began to decrease	Duration of benchmark index kept decreasing	Decreasing period behind the leading indicator
7 months	1999.11	2000.08	5 months	9 months
9 months	2002.10	2003.04	5 months	6 months
5 months	2004.04	2004.07	7 months	3 months
12 months	2005.04	2005.11	5 months	7 months

40.4 Conclusions

In the essay, we chose the composite index of over scaled industry increasing value and total retail sales of social consumer goods as benchmark index to help us to pick out leading indicators for Chengdu with the quantitative method of K-L information content and time difference correlation coefficient. Then we analyzed the synthetic leading indicators and found the leading indicators can predict the trend

of Chengdu's macro economy to help the government department make decisions in advance.

But due to the limitation of data sources, the essay is short of some indicators with important meanings. For example, the candidate indictor group lacks of indictors to reflect upstream economic movement (such as order for goods, survey index) and employment index etc. Therefore, the accuracy and comprehensiveness if affected in a way when choosing the indicators. After all, we should take steps to better the economic leading indicator system for Chengdu.

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