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Application of Markov Chain to the Prediction of Consumer Price Index

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Abstract Review Article

This paper mainly uses the prediction method of Markov chain to predict the consumer price index. Taking the national consumer price index data from 1989 to 2005 as an example, this paper forecasts the consumer price index in three steps to illustrate the specific application of Markov chain method.

Keywords: Markov chain; Consumer price index; Transfer matrix.

INTRODUCTION

Consumer price index [1, 2] refers to the price of consumer goods and services purchased by residents. It is closely related to people's life and plays an important role in the price system of the whole national economy. It is an important index compiled by the Statistics Department of our government. In this paper, Markov chain is used to predict consumer price index.

The Establishment of Markov Chain Model

Markov process is a kind of random process without aftereffect. The object of markov chain prediction is the dynamic system with random change. It predicts the future development of the system according to the transition probability between states [3]. The specific steps of using Markov chain method to predict consumer price index are as follows:

- Step-1 State division: According to the relationship between CPI and inflation rate, CPI is divided into several states;
- Step-2 Establish the transition probability matrix: According to the statistics of the results obtained in Step1, the transition probability matrix of Markov chains with different delay times (step sizes) can be obtained. The formula of calculating the state transition probability matrix is $P_{ij} = N_{ij} / N_i$, $i, j = 1, 2, \cdots, s$, P_{ij} is the probability of going from state E_i to state E_j in one step, N_i is the number of occurrences of state E_i, N_{ij} is the number of times that state E_i transits to state E_j in one step. Thus, the one-step state transition probability matrix is obtained as P, then the n-step transition probability matrix is $P^{(n)} = P^n$;
- Step-3 Predict the state probability of the national consumer price index for the year:

$$P_i^{(k)},\ i \in E,\ k = 1,\ 2,\ \cdots,\ m$$

The Example Analysis

In this paper, taking the national consumer price index data of China from 1989 to 2005 as an example, Markov chain prediction is carried out to illustrate the specific application of Markov chain method and test it. Data of CPI are listed in Table-1.

Table-1: CPI and it's states

Years	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Price Index	118.0	103.1	103.4	106.4	114.7	124.1	117.1	108.3	102.8	99.2
Status	4	3	3	4	4	4	4	4	2	1

Years	1999	2000	2001	2002	20003	2004	2005
Price Index	98.6	100.4	100.7	99.2	101.2	103.9	101.8
Status	1	2	2	1	2	3	2

Step-1 State division

According to the relationship between consumer price index and inflation rate, the national consumer price index from 1989 to 2005 is divided into four state spaces, namely deflation, normal, inflation and serious inflation, as shown in Table 2.

Table-2: The state classification of CPI

State	Level	Interval
1	Deflation	$x < 100$
2	Normal	$100 \le x < 103$
3	Inflation	$103 \le x < 105$
4	Serious inflation	$x > 105$

According to the classification standard established in Table-2, the status of the data series of CPI in each year is determined as shown in Table-1.

Step-2 Establish the transition probability matrix

According to the corresponding states of each year in Table-1, according to the calculation of transfer probability matrix, the transfer probability matrix of each step can be obtained as follows:

$$P^{(1)} = \begin{bmatrix} 0.3333 & 0.6667 & 0 & 0 \\ 0.3333 & 0.3333 & 0.3333 & 0 \\ 0 & 0.3333 & 0.3333 & 0.3333 \\ 0 & 0.1667 & 0.1667 & 0.6667 \end{bmatrix}$$

$$P^{(2)} = \begin{bmatrix} 0.3333 & 0.4444 & 0.2222 & 0 \\ 0.2222 & 0.4444 & 0.2222 & 0.1111 \\ 0.1111 & 0.2778 & 0.2778 & 0.3333 \\ 0.0556 & 0.2222 & 0.2222 & 0.5000 \end{bmatrix}$$

$$P^{(3)} = \begin{bmatrix} 0.2593 & 0.4444 & 0.2222 & 0.0741 \\ 0.2222 & 0.3889 & 0.2407 & 0.1481 \\ 0.1296 & 0.3148 & 0.2407 & 0.3148 \\ 0.0926 & 0.2685 & 0.2315 & 0.4074 \end{bmatrix}$$

$$P^{(4)} = \begin{bmatrix} 0.2346 & 0.4074 & 0.2346 & 0.1235 \\ 0.2037 & 0.3827 & 0.2346 & 0.1790 \\ 0.1481 & 0.3241 & 0.2377 & 0.2901 \\ 0.1204 & 0.2963 & 0.2346 & 0.3488 \end{bmatrix}$$

Step-3 Forecast the state of 2006 National Consumer Price Index

According to the CPI in 2005, 2004, 2003 and 2002 and the corresponding state transition probability matrix, the CPI in 2006 was forecasted, as shown in Table-3.

Table-3: The CPI prediction of 2006

Initial year	status	Time lag/year	i =1	i =2	i =3	i =4	Probability source
2005	2	1	0.3333	0.3333	0.3333	0	$P^{(1)}$
2004	3	2	0.1111	0.2778	0.2778	0.3333	$P^{(2)}$
2003	2	3	0.2222	0.3889	0.2407	0.1481	$P^{(3)}$
2002	1	4	0.2346	0.4074	0.2346	0.1235	$P^{(4)}$
$P_i = \sum_{k=1}^{m} P_i^{(k)}, i \in E$			0.9012	1.4074	1.0864	0.6049	

According to Table-3, $\max\{P_i, i \in E\} = 1.4074$ and at this point $i = 2$. It can be seen that the corresponding state of the CPI in 2006 is 2 (normal), that is, the CPI in that year is between 100 and 103, which is a normal year, which is consistent with the actual value of 101.5.

CONCLUSION

At present, there are many forecasting methods in economic forecasting, such as markov chain method based on absolute distribution, superposition Markov chain forecasting method, etc. Compared with them, Markov chain has the characteristics of wide forecasting range, high reliability and reasonable and sufficient information utilization. Through the example analysis, it can be seen that the results predicted by the Markov chain model are scientific and reliable, and have strong application value [4, 5].

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