Dynamic Fitting of China's Inflation Based on Polynomial Distributed Lag Model

Lei Shen[1, a], Yi Zhou[2, b], Zebin Liu[1, c], Yeguo Sun[4, d]
[a]shenlei0922@126.com, [b]zhouyi3280@163.com, *Corresponding author: [c]417181314@qq.com, [d]397797494@qq.com

[1234]School of Finance and Mathematics, Huainan Normal University Huainan, P. R. China

Abstract—China's economic growth has changed from high-speed to medium high-speed under the new economic normal. The declining growth rate could be accompanied by inflation and a decline in the unemployment rate. By combing the relevant theories of the Phillips curve, a polynomial distributed lag model is established to dynamically fit inflation by screening the consumer price index to represent inflation, and output gap data replace the unemployment rate. The results show that the output gap of the current period and the lagging period positively impact inflation. The smaller the value of the output gap is, the higher inflation and unemployment China will have. Additionally, the parameter value shows that the impact of the first-order output gap on inflation is higher than that of the current period, indicating a noticeable lag effect in the reflection of inflation on the unemployment rate.

Keywords-Inflation; Unemployment rate; Output gap; Phillips curve

1 INTRODUCTION

Under the influence of COVID-19 and population aging, China's consumption growth slowed down, and investment continued to fall. Additionally, foreign demand faces the risk of a trade war, resulting in an apparent downward trend in China's economic growth rate. The slowdown of economic growth will form greater employment pressure and a high unemployment rate. However, due to the continuous printing of money by the U.S. government and the continuous rise of domestic basic product prices, there are both imported inflation and endogenous inflation in China. Under the background of China's new normal economy, this paper estimates the output gap at first and then constructs a dynamic fitting model for inflation to study China's inflation. It helps to understand the dynamic change process of inflation in China. It helps explain the internal correlation mechanism between unemployment rate, output gap, and inflation in the complex economic environment to provide a reference basis for the scientific management of inflation.

Scheibe et al. [1] analyzed the quarterly data of output gap to explore the new Keynesian Phillips curve under the new characteristics. If people want to better control a country's inflation, you can start from the output gap, the expected factors, and the exchange rate.

Derek et al. [2-4] used vector auto-regression and other methods to explore the Phillips curve of the relationship between the unemployment rate and inflation rate, and they found a short-term correlation between inflation and unemployment, but not a long-term correlation.

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Zhang et al. [5-8] applied Phillips curve theory to China's economy, and they found that the output gap is one of the factors affecting China's inflation.

The main purpose of this paper is to study the dynamic impact of unemployment on inflation represented by the output gap. The rest of this paper is organized as follows. The second section introduces the distributed lag model and the principle of H-P filtering. The third section discusses the economic significance of the output gap and model parameters in detail. See section 4 for conclusions.

2 MATERIALS AND METHODS

2.1 Variable selection and sample determination

2.1.1 Measurement of inflation rate

This paper selects the year-on-year CPI to measure inflation rate. Recently, China's CPI has shown an apparent alternating fluctuation. The national economy is affected by the fluctuation of CPI inflation rate in production, consumption and investment.

$$CPI = \sum_{i=1}^{n} P_i^t q_i^t w_i / \sum_{i=1}^{n} P_i^{t-1} q_i^t \quad (1)$$

2.1.2 Measurement of unemployment

Theoretically, in the case of full employment, the unemployment rate is zero. At this time, all people willing to work in the market and all enterprises and factories willing to hire workers have reached a balance, At this time, the actual output is equal to the potential output, and there is no unemployed population. When the actual output is lower than the potential output, and there is an output gap, the existing social resources, especially human resources, are not fully utilized, and there is an unemployed population. Considering that the unemployment rate of the registered urban population can not fully reflect China's unemployment situation, this paper adopts the output gap as an alternative to the unemployment index and dynamic fitting of China's inflation according to the theoretical basis of Phillips curve.

2.1.3 Sample range

This paper selects 31 annual data from 1990 to 2020 as samples. The original data are from the National Bureau of the statistic of China.

2.2 Data preprocessing

2.2.1 Calculation of real GDP

Real GDP is to calculate the value of the final product in a certain period based on the price of the final product in a specific year. The real GDP is the primary indicator to measure a country's economic development. Real GDP measures the change of product output in two different periods of the economy and calculates the value of all products produced in two periods at the same price or constant amount. Excluding the influence of price, real GDP can better measure the output capacity of a country or region in a certain period. This paper takes the GDP in 1990 as the base period, according to the following formula is used for pretreatment.

$$G_{1989} = G_{1989}^{'} * G_{1990} / g_{1990} \quad (2)$$

$$G_t = G_t^{'} * G_{2000} / g_{2000} \quad (t = 2001\text{-}2005) \quad (3)$$

$$G_t = G_t^{'} * G_{2005} / g_{2005} \quad (t = 2006\text{-}2010) \quad (4)$$

$$G_t = G_t^{'} * G_{2010} / g_{2010} \quad (t = 2011\text{-}2015) \quad (5)$$

$$G_t = G_t^{'} * G_{2015} / g_{2015} \quad (t = 2016\text{-}2020) \quad (6)$$

G_i represents the actual GDP of a year, and $G_i^{'}$ represents the nominal GDP of a year.

2.2.2 Estimation of potential GDP growth rate by H-P filtering method

Before estimating the potential GDP growth rate, the actual GDP growth rate needs to be calculated. The real GDP growth rate is obtained by substituting the real GDP into formula 7, which is obtained from formula 2-6.

$$g_t = (G_t - G_{t-1}) / G_{t-1} \quad (7)$$

Based on the above calculation, the actual GDP growth rate is reprocessed by using the H-P filtering method, and finally, the potential GDP growth rate is estimated. Now, we introduce the principle of H-P filtering.

Set Y_t as an economic time series containing trend and fluctuation components, Y_t^T as the trend component contained in the sequence, Y_t^C as the fluctuation component contained in the sequence, *c(L)* as the delay operator polynomial.

$$Y_t = Y_t^T + Y_t^c \quad t = 1, 2, \cdots, T \quad (8)$$

The calculation of H-P filtering is to separate Y_t^T from Y_t. The following minimized solution is usually used to represent the unobservable part of Y_t^T.

$$min \sum_{t=1}^{T} \left\{ \left(Y_t - Y_t^T \right)^2 + \lambda \left[c(L) Y_t^T \right]^2 \right\} \quad (9)$$

$$c(L) = (L^{-1} - 1) - (1 - l) \quad (10)$$

Then, this loss function is the minimization problem of the H-P filtering method.

$$g_t^{'} = min \left\{ \sum_{t}^{T} \left(Y_t - Y_t^T \right)^2 + \lambda \sum_{t}^{T-1} \left[\left(Y_t^{T+1} - Y_t^T \right) - \left(Y_t^T - Y_{t-1}^T \right) \right]^2 \right\} \quad (11)$$

2.2.3 Calculation of output gap

The H-P filtering method estimates the potential GDP growth rate, and the output gap can be obtained by subtracting the potential GDP growth rate from the actual GDP growth rate.

$$GAP_t = g_t - g_t^{'} \quad (12)$$

2.3 Polynomial distributed lag model

In time series, time is an essential influence factor. The transmission of economic policies and the impact of other behaviours take a certain time to achieve. In this process, it is easy to lead to time lag. The CPI value used to represent inflation can be affected by its lag term, the lag

term of other variables, or both. Therefore, to better explore the relationship between inflation and unemployment, this paper uses the polynomial distributed lag model. We substitute the lag of explanatory variables into the equation one by one and select the model that can best reflect the relationship between variables. The basic model is set as follows:

$$CPI_t = C + \beta_0 GAP_t + \beta_1 GAP_{t-1} + \cdots + \beta_k GAP_{t-k} + u_t \qquad k = 0,1,\cdots T \qquad (13)$$

To alleviate the multi-collinearity of the fitted model and ensure the freedom of variables, the lag term of the output gap is respectively substituted.

3 RESULTS AND DISCUSSION

3.1 Estimation of potential GDP growth rate

According to the above theory, set Y_t as China's annual real GDP growth, and obtain the H-P filter diagram of the growth rate of real GDP and the growth rate of potential GDP. ZGDP in figure 1 represents the real GDP growth rate, Trend represents the potential GDP growth rate, Cycle represents the cycle between 1990 and 2020.

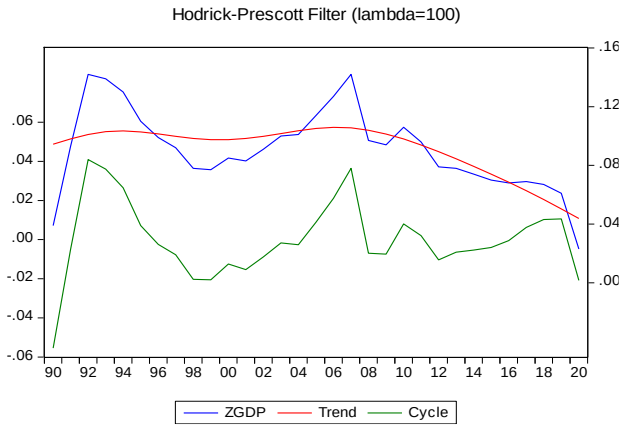

Figure 1 Estimated results of potential GDP growth rate

3.2 Results of a stationary test

In this paper, the unit root test is used to test the stationarity of CPI and gap. The results are as follows: the probability of rejecting the null hypothesis that there is a unit root is less than 5%. In other words, there is 95% confidence that CPI and GAP are stable time series.

Table 1 CPI and GAP stationarity test results

variable	ADF	P	conclusion
CPI	-2.98	0.0497	I(0)
GAP	-4.05	0.004	I(0)

3.3 Model regression results

When the order of distribution lag is determined to be one, the model result with PDLs term is

$$CPI_t = 103.90 + 99.97GAP_t + 153.13GAP_{t-1}$$
$$t = \ (136.81) \qquad (1.79) \qquad (3.28) \qquad\qquad (14)$$
$$R^2 = 0.52 \qquad F = 14.24 \qquad D.W. = 0.75$$

When the order of distribution lag is determined to be two, the model result with PDLs term is

$$CPI_t = 103.55 + 94.02GAP_t + 185.34GAP_{t\text{-}1} + 57.71GAP_{t\text{-}2}$$
$$t = (155.28) \qquad (1.57) \qquad (2.62) \qquad (1.20) \qquad (15)$$
$$R^2 = 0.67 \qquad F = 16.45 \qquad D.W. = 0.65$$

When the order of distribution lag is determined to be three, the model result with PDLs term is

$$CPI_t = 103.38 + 67.84GAP_t + 158.01GAP_{t\text{-}1}$$
$$t = (103.38) \ (0.76) \qquad (2.45)$$
$$+126.34GAP_{t\text{-}2} - 27.16GAP_{t\text{-}3} \qquad\qquad (16)$$
$$(1.36) \qquad (-0.29)$$
$$R^2 = 0.70 \qquad F = 12.54 \qquad D.W. = 0.73$$

The results show that the value of R^2 and F increases with the lag order of the output gap, but the estimated value of some coefficients decreases. In the third-order output lag model, the t-test shows that the model has multi-collinearity, the T value is tiny, and the coefficient is insignificant. Compared with the first-order lag model, the fitting degree of the second-order lag model is optimized, and the F value is increased, but the T value of some coefficients in the second-order lag model is minute and cannot pass the t-test. Although the fitting degree and F value of the first-order lag model are low, the coefficients of each explanatory variable pass the test. That is, there is no multi-collinearity between the variables. It shows that the model fitted by substituting the third-order and second-order output gap with lag is not significant than the first-order model. So the distributed lag model with $k = 1$ is the best.

3.4 Discussion on parameter significance

It can be seen from the first-order lag model that when the output gap is 0, the value of CPI is 103.9, indicating that the inflation index fluctuates up and down with 103.9 as the mean. The coefficient of output gap lagging behind the first order is 153.13, which means that when the output gap lagging behind the first order decreases by one unit, inflation decreases by 153.13 units. The impact of the output gap lagging behind the first period on inflation is greater than that of current the output gap. Therefore, the results show an obvious first-order lag effect in the impact of the output gap on inflation. When the increase in real GDP leads to the increase of the output gap, it will increase the inflation rate this year and form more serious inflation next year. Under the influence of the lag effect, government departments should consider the lag effect of policy effect when formulating price stability policies.

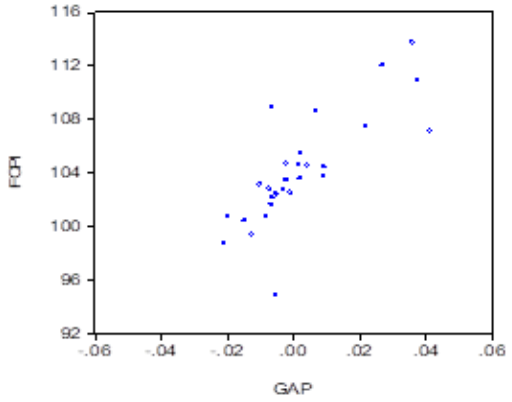

Figure 2 Scatter diagram of FCPI and GAP

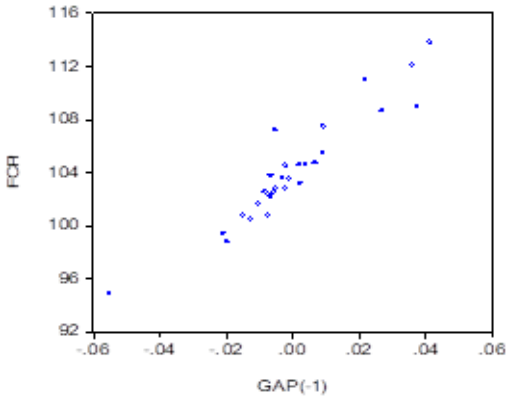

Figure 3 Scatter diagram of FCPI and first-order lag of GAP

According to the above regression results, the first-order lagged regression equation is selected to obtain the fitted value of inflation (FCPI) so that the constructed scatter diagram can better describe the relationship between inflation and output gap. From the fit value of inflation and output gap in Figure 2 and the scatter diagram of inflation and lagging first-order output gap in Figure 3, it can be seen that inflation changes with the change of output gap. The coefficients of all output gaps in the regression results are positive, indicating that inflation and the lag term of the output gap change in the same direction. When the output gap decreases, inflation also decreases. Therefore, government intervention departments can indirectly control the change of inflation by controlling the output gap.

4 CONCLUSIONS

The empirical results show that inflation and output gap change in the same direction and the calculation formula based on the output gap can change in the opposite direction between output gap and unemployment. Therefore, when the output gap increases, the unemployment rate decreases and inflation increases. That is, the relationship between inflation and unemployment

rate conforms to Phillips curve theory. Alternatively, the output gap with first-order lag has the most significant impact on inflation, indicating an apparent first-order lag effect in the impact of the output gap on inflation. Therefore, when implementing the output policy to adjust the inflation plan, the economic policy-making department should consider its impact lag, not implement the plan with a short-sighted vision.

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