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Analysis of Fisher Effects between Nominal Interests and Inflation

Ying Zhong[1,*]

[1] *School of Mathematics and Statistics, Wuhan University, Luo jia Hill, Wuchang District, Wuhan Hubei, China, 430072*
[*] *Corresponding author. Email: zhongying0227a@163.com*

ABSTRACT
The interest rate is the borrowing price in the capital market, while the real interest rate is the interest rate level after deducting the price factor from the nominal interest rate. The real interest rate not only affects the savings, consumption and investment decisions of micro subjects, but also has important reference value for asset pricing in the capital market and the formulation of fiscal and monetary policies in the macro economy. This study investigates correlation between nominal rate of interest and rate of inflation and tests the fisher effect in China based on data from 1978 to 2020 [9]. Because the equation of fisher effect is a simple linear equation, linear regression is used to fit data. After that, time series stationarity test is used to judge whether the regression is meaningful, followed by cointegration test and Granger causal relation test against each macroeconomic variable respectively. We consulted the research results of other people and found a large number of empirical studies failed to reach a consistent conclusion. In fact, the phenomenon is known as "Fisher Effect Paradox". Although it's hard to reach consistent conclusion, fisher effect does explain the relationship between interest rate and inflation to some degree. It's still a good theory to analyse macroeconomic. On the one hand, the rise of nominal interest rate is caused by the rise of inflation rate; on the other hand, it is the result of the central bank's loose monetary policy. Therefore, the rise and fall of nominal interest rate is not exactly the same as loose or tight monetary policy.

Keywords: *nominal rate; inflation; fisher effect; time series*

1. INTRODUCTION

Interest rates are divided into "nominal interest rate" and "real interest rate". Nominal interest rate tells us how fast the number of deposits in the bank account will increase in a certain period of time. The real interest rate is the nominal interest rate corrected for the impact of inflation, which reflects the purchasing power of our savings account. Fisher effect is that the nominal interest rate changes with the change of inflation rate. The relationship among nominal interest rate, real interest rate and inflation rate is: real interest rate = nominal interest rate - inflation rate (when calculating, the expected inflation rate is expected to be equal to the inflation rate). According to "fisher effect", in the long run, since the real interest rate is not affected, the nominal interest rate must be adjusted one-to-one basing on the change of inflation rate.

It seems that it's about time series econometrics, but the empirical analysis is more complex. Wallace and Warner (1993) [1] used Johansen's maximum likelihood estimation method to prove that there is a one-to-one adjustment relationship between nominal interest rate and inflation. Mishkin and Simon (1995) [2] conducted empirical analysis using the data of the United States and Australia respectively. The results show that there is a strong long-term Fisher Effect in some periods of these countries (although they reject the existence of short-term fisher effect). However, other literatures find that the regression coefficient of inflation on nominal interest rate is significantly different from 1 [3]. On the one hand, in the economic theoretical model, we always assume the Fisher Equation is established a priori and analyse the interest rate. On the other hand, in the empirical research, we find that there is no or only one-to-one adjustment relationship between nominal interest rate and inflation in some periods. This phenomenon is called "Fisher paradox" in the literature". But in our study, "Fisher paradox" will not be considered, because we just analyses the rough relationship between the two and the test methods also can't support us to finish the research off "Fisher paradox".

In this paper, the method of modern time series econometrics will be applied, combined with the relevant data from1978 to 2020, to make a simple analysis of the correlation between nominal interest rate and inflation rate, and compare it with fisher effect. Whether the change of interest rate can become an index to measure the tightness of the central bank's monetary policy depends on whether there is Fisher Effect between China's nominal interest rate and inflation rate.

2. THEORETICAL ANALYSIS OF THE RELATIONSHIP BETWEEN INTEREST RATE AND INFLATION RATE

According to the traditional economic theory, the changes of monetary interest rate and real interest rate are inversely proportional to the changes of general price level. Irving Fisher (1867-1947) [4], an American economist, first distinguished interest rate into real rate of interest and money rate of interest in 1930. Real rate of interest refers to the interest rate measured in kind, which is the interest rate obtained after excluding inflation factors; money rate of interest refers to the interest rate formed in the lending market measured by monetary standards.

In his analysis, monetary value and price level are two aspects of the same thing, and monetary value and general price level are reciprocal to each other. The change direction of interest rate is opposite to that of money value and the same as that of price change. When the general price level is high, the interest rate tends to increase, and when the general price level is low, the interest rate also tends to decrease, but the change of interest rate generally lags behind the change of price level. Obviously, the interest rate changes in the same direction as the general price level. The interest rate referred to here actually refers to the nominal interest rate.

Nominal rate of interest: i
Real rate of interest: R
Estimated annual inflation rate: p

$$1 + i = (1 + R)(1 + p)$$

$$i = R + p + Rp \quad (1)$$

When the inflation rate is only at the general level, the product term Rp will be very small and usually ignored in calculation. Because interest rates are two digits after the decimal point. $Rp \approx 10^{-4}$, which is much smaller than R and P ($R, p \approx 10^{-2}$). So, we just ignore it and get the formula below

$$i = R + p$$

3. EMPIRICAL ANALYSIS OF THE RELATIONSHIP BETWEEN INTEREST RATE AND INFLATION RATE

3.1. Method selection

Some scholars in China have conducted beneficial discussions on the "Fisher Effect" in the past. Different scholars took different methods or period of time and the results of their researches were not same. Liu Jinquan, Guo Zhengfeng and Xie Weidong (2003) [5] used Fractional integration theory to test Fisher Effect. In their study, I and P were not cointegration so they thought Fisher Effect didn't exist. Liu Kangbing, Shen Pu and Li Da (2003) [6] used E-G method to test and thought long term or short term Fisher Effect did exist. Wang Xinwen and Wu Xinfang (2005) [7] tried Modified ADF method (from Zivot and Adrews) to test and used Data from Taiwan. Their result showed Taiwan did not exist Fisher Effect. Wang Shangping and Chen Wenjing (2008) [8] used nonparametric unit roots and nonparametric cointegration test to test Fisher Effect and found there existed weak Fisher Effect. Above all, Whatever methods we choose, there are always shortcomings. Therefore, this paper mainly uses OLS and ARDL method to finish the test.

3.2. Variables and data

Nominal rate of interest: i

Estimated annual inflation rate: p

The inflation rate is replaced by the consumer price index CPI. The test sample is the data of 42 years, i.e. 1978-2019. The data type of the sample is time series data, which comes from the official websites of the people's Bank of China and the National Bureau of statistics [4]. In the empirical analysis, in order to reduce the error, we tend to choose the monthly data, whose sample size is relatively big. But we failed to find full monthly data, and instead we had to use annual data. So the number of samples may not be large enough, which may reduce the reliability of test results. Therefore, our test results are only respond for the samples we choose. For Fisher effect, it's just a reference.

3.3. Estimation and test of model parameters

3.3.1 Direct relationship between nominal interest and inflation.

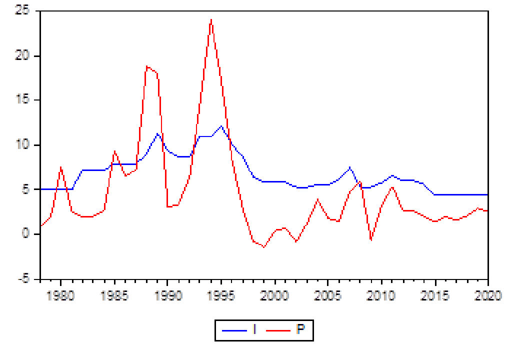

Figure 1. I-P time trend graph

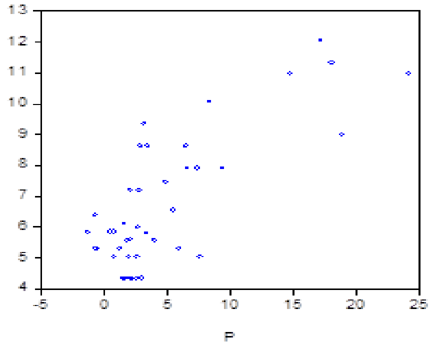

Figure 2. Yearly I-P scatter diagram (%)

From Figure 1 and Figure 2, around the end of the 20th century, it's obvious that there are connections between I and P. To some extent, it's reasonable to model the relationship between them with linear regression.

3.3.2 Unit root test

When one time series variable is used to regress another time series variable, even if there is no meaningful relationship between them, a high value is often obtained, that is, meaningless regression. Therefore, the stationarity test of the data should be carried out first to avoid the phenomenon of pseudo regression. Only when the two variable sequences are single integer sequences of the same order, whether there is cointegration relationship can be considered.

First, the unit root test is carried out for the time series I and P. The test is completed by ADF test (Augmented Dickey-Fuller test) in EViews 10. The result is as in Table 1.

Table 1. Unit root test

variable	Test type	ADF test	significance level	conclusion
	(C, T, L)	t-statistics	Test critical	
I(Original value)	(0, 0, 0)	-0.529	1%(-4.192)	Non-Stationary
ΔI(First order difference)	(0, 0,1)	-5.971	1%(-4.199)	Stationary
P(Original value)	(0, 0, 0)	-4.049	1%(-4.199)	Non-Stationary
ΔP(First order difference)	(0, 0,1)	-5.446	1%(-4.219)	Stationary

For I series, it is non-stationary at the level of 1%, and then we conduct the first-order difference post test. From table 1, it is stable at the level of 1%, so I first-order difference is stable, I (1) = 0. For P series, it is non-stationary at the level of 1% but it is stationary after the first-order P(1)=0. In this case, because ARDL(Autoregressive distributed lagged model) can judge lag orders automatically, we choose ARDL to do cointegration test.

3.3.3 Cointegration test and regression

The results show that I and P exist long term cointegration relationship, so it's reasonable to do regression between I and P.

OLS estimation: $I_t = 5.420 + 0.285P_t + \mu_t$ (2)

(7.762) (19.992)

$\overline{R^2}$=0.585172

Long term error correction:

$$EC = I_t - (0.4274P_t + 4{,}7139) \quad (3)$$

ARDL estimation:

$$\Delta I_t = -0.0063 - 0.0685\Delta I_{t-1} + 0.1127\Delta P_t + 0.0412\Delta P_{t-1} - 0.2693ECM_{t-1}$$

(-0.0477)（-0.4497）（6.0738）（0.7948）（-1.9522）

3.4. Granger causality test

From Fisher's theory, the nominal rate of interest is adjusted by the expectation of inflation rate. So, the

Granger test should be a one-way causal relationship. Based on result before, and are stationary series and here we make Granger causality test for them.

After LM(Lagrange multiplier test) test [10,11], appropriate lag orders can be got. Here is 1.

Table 2. Granger test table

Null Hypothesis:	Obs	F-Statistic	Prob.
DP does not Granger Cause DI	41	8.01700	0.0074
DI does not Granger Cause DP		0.10719	0.7452

$\Delta \boldsymbol{I}$ and $\Delta \boldsymbol{P}$ is a one-way causal relationship and we could use the change of inflation rate to predict the change of interest rate theoretically.

4. CONCLUSION

Using modern time series technology, combined with the relevant data of China from 1978 to 2020, this paper analyses the correlation between real rate of interest and rate of inflation. Although both of them are non-stationary time series, their cointegration has passed the test, indicating that they have a long-term equilibrium relationship, so OLS is effective, which further proves that there is a certain proportional relationship between I and P. This conclusion supports Fisher's (1930) original discussion on the relationship between inflation and interest rate. Although the final Granger causality test is a statistical analysis, it supports that the change of inflation rate has a one-way impact on the change of real rate of interest, which is consistent with our empirical judgment. That is, the expectation of inflation will affect the real rate of interest, which the relationship of expected impact. These findings are of great significance to decision makers.

It can be seen from the previous analysis that due to the existence of long-term and short-term fisher effect, the rise of rate of interest partly due to the tightening monetary policy implemented by the central bank, while the other part is caused by inflation. Therefore, the rise and fall of interest rates is not equivalent to loose or tight monetary policy. Therefore, we should carefully use interest rate as an indicator of monetary policy. The goal of monetary policy is to maintain price stability, but the adjustment of interest rate is not the same as the change of rate of inflation. Therefore, China's monetary policy objectives are more inclined to other objectives such as economic growth and full employment. And the response to the inflation rate is not obvious or slow, which can understand the behavioral logic of China's central bank's recent tendency of monetary policy to the legal goal of maintaining currency value stability better.

AUTHORS' CONTRIBUTIONS

This paper is independently completed by Ying Zhong.

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