

Time Lag of Monetary Policy at Different Interest Rate Stages

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Abstract—This paper selects the data of 12 major member states of the Eurozone, and uses the PVAR model to compare and analyze the output lag of four kinds of monetary policy instruments: money supply M1, overnight lending rate r, loan balance LOAN and exchange rate e in positive, zero and negative stages. It has reached the following conclusions: First, there are heterogeneity in the output time lag of monetary policy instruments in different interest rate stages, and the longest output lag in the negative interest rate period. Second, the policy effect during the period of negative interest rate is the weakest. Third, the heterogeneity of the output lag of monetary policy instruments at different interest rate stages is due to changes in the transmission channels of monetary policy. Fourth, zero interest rates and negative interest rates threaten financial stability. According to the conclusions, policy suggestions are given for the economic development of our country: firstly, we should adhere to the supply-side reform, focus on returning to the real economy, and improve the return on investment of enterprise through innovation; secondly, we should pay attention to the coordination of fiscal policy and monetary policy when dealing with structural economic problems.

Keywords: PVAR, impulse response, monetary policy tool output time lag

I. INTRODUCTION

After the 2008 financial crisis, the global economy suffered a heavy blow, and the euro zone was not spared, where inflation fell below zero and deflationary pressures increased. The European Central Bank (ECB) adopted unconventional monetary policy to deal with the economic recession, including a series of long-term refinancing schemes (LTRO), securities market plan (SMP), interest rate and deposit reserve ratio cuts. On July 11, 2012, the deposit reserve ratio was reduced to zero.

However, a series of unconventional monetary policies only led to a gradual rise in inflation levels. In order to control deflation and rebound the economy, the European Central Bank began to implement the negative interest rate policy on June 5, 2014. In addition to the euro zone, Denmark, Japan, Switzerland and Sweden also have implemented negative interest rate policies. The former chairman of the Federal Reserve Greenspan also said: "The negative interest rate spread to the United States is only a matter of time". The implementation of the negative interest rate policy seems to be the general trend.

Interest rate policy is an important monetary policy tool, which is used by countries all over the world to regulate and control the economy. Early economists affirmed the effectiveness of interest rate policy in the period of positive interest rate, but negated the ultra-low interest rate or negative interest rate. In 1896, Fisher put forward the Zero Lower Bound. He believed that if the interest rate was negative, residents would choose to hold cash instead of lending it. Gesell (1958), who first proposed the policy of negative interest rate, defined the policy of "negative interest rate" as the central bank taxing the excess reserve of commercial banks. He emphasized that it had no effect on the public deposit interest rate, only meant that the central bank's benchmark interest rate was negative, but he still insisted that the interest rate should be positive. After the implementation of the negative interest rate policy, scholars began to study the negative interest rate policy from different perspectives. Scholars concerned about the impact of negative interest rate policies on financial markets, focusing on the impact of negative interest rate policies on financial institutions' profitability and financial stability. For example, Thomas Scheiber & Maria Silgoner & Caroline Stern (2016) compared the bank profitability of Swiss, Swedish and Danish countries before and after negative interest rates, and found that negative interest rates have not caused a significant drop in bank profitability, especially net interest income. Thomas I. Palley (2016) proposed that a negative interest rate policy is very dangerous. Negative interest rates will cause a decline in aggregate demand and financial fragility. More serious, it will trigger an international currency war and hinder the development of the world economy. Lopez & Jose A. & Rose Andrew K. & Spiegel Mark M. (2018) compared the bank profitability of negative interest rates with low positive interest rates and found that negative interest rates have had a surprisingly positive impact on commercial banks. Urbschat & Florian (2018) believes that negative interest rates may lead to a decline in bank profitability and tightening monetary policy. If negative interest rates persist for too long, banks may have excessive risk credit.

Some literature focuses on evaluating the effects of negative interest rate policies. For example, Pan Chengfu (2012) qualitatively analyzed the reasons why the actual

effect of unconventional monetary policy was not as expected, and pointed out that "time" was the main factor, even if monetary policy could be effective, it would take a long time to transmit to the real economy. Sun Guofeng (2017) based on the theory that credit supply is determined by credit demand and monetary policy, established a DSGE model with micro basis to study the transmission mechanism of negative interest rate between banks and entities, they found that the lower limit of zero interest rate greatly hindered the transmission of policy and inhibited the effect of monetary policy. Spiegel Mark M. & Tai Andrew (2018) used the FAVAR model to analyze Japanese economic data. The results show that short-term low interest rates and even negative interest rates have a substantial impact on inflation. Allaudeen & Andrew K. (2018) studied in Switzerland and found that negative interest rates have little effect on observable exchange rate behavior.

In the past, scholars have important significance in the study of negative interest rate policy. However, it seems that the previous literature is still in a blank stage for the study of the time lag of monetary policy under different interest rate stages.

Since the financial crisis, the euro zone has experienced the path of central bank policy interest rate from positive to zero, and then from zero to negative. In the period of positive interest rate, the time lag of monetary policy has always existed. Hume (1752) first proposed the time lag of monetary policy. He pointed out that the increase of gold and silver will inevitably lead to the rise of commodity prices, but it does not happen immediately, it takes a certain period of time, which is called "intermediate state" or "intermission period". Wicksell, Fisher, and Keynes also demonstrated the existence of monetary policy lags from different perspectives. The biggest contribution to the monetary policy lag is Friedman (1972), who used comparative methods and correlation and regression analysis methods to measure the length of the US monetary policy time lag, laying the foundation for theoretical and empirical research on time lag of monetary policy. In recent years, some literatures have evaluated the time lag of monetary policy, in order to provide reference for monetary authorities to evaluate and use monetary policy. For example, Masahiko Shibamoto (2007) used vector autoregressive method to analyze Japan's monetary policy shocks and found that the time lag of monetary policy shock transmission varies with various macroeconomics. Nina&Yen-Jong&Yuan-Ho (2010) used structural vector autoregressive models to study the lag of the impact of Taipei's monetary policy on housing prices, and concluded that tight monetary policy could not stabilize the overheated current real estate market. Xiao Weiguo (2013) divides monetary policy instruments into two parts: predictable and unpredictable. SVAR model is used to analyze the time lag of monetary policy, and it is found that the former is longer than the latter. Zhang Zehua (2019) used the PVAR model to compare the effects of traditional monetary policy tools and the central bank in communicating monetary policy, and found that the effect of central bank communication is more timely than that of traditional monetary policy.

In the past, scholars' research has high theoretical and practical value. In today's negative interest rate trend, the shortcoming is that the research on the time lag of monetary policy still stays at the positive interest rate stage, but there is no systematic comparative study on the time lag of monetary policy at different interest rate stages. This paper expands on the basis of previous scholars' research. The innovations are as follows: Firstly, using the economic data of the major member states of the Eurozone, establish the PVAR model, and compare the monetary policies of the three interest rate stages of positive interest rate, zero interest rate and negative interest rate. This has reference significance for China's monetary authorities to evaluate and apply monetary instruments at different interest rate stages. Secondly, explore the reasons. Whether the monetary policy transmission path is smooth and whether the conduction process is tortuous will have an impact on the time lag of monetary policy. Through comparative research, it is of great significance to systematically study the currency transmission mechanism of zero interest rate and negative interest rate.

II. SELECTION OF VARIABLES AND MODEL DETERMINATION

A. Variables and Data Selection

The transmission channels of monetary policy are divided into currency transmission and credit transmission. Therefore, the selected intermediate variables include: money supply M1, overnight lending rate r , euro-dollar exchange rate e and domestic credit balance LOAN; the final variable selected is domestic production GDP.

For the completeness and continuity of the data, this paper refers to the sample selection method of Marley (2018) and selects the panel data of 12 EU member states, including Germany, France, Belgium, Ireland, Spain, Portugal, Greece, Greece and Greece. The monthly data of each variable from January 2002 to May 2019 (sourced from CECI database), where GDP is quarterly data, this paper uses three-spline interpolation method to convert quarterly data of GDP into monthly data. The sample time covers the three stages of positive interest rate, zero interest rate and negative interest rate in the euro zone. It has the advantages of large sample capacity and long time span, which can obtain more convincing empirical results.

B. Model Determination

In this paper, using panel vector autoregressive (Panel VAR, PVAR) model, refer to Inessa Love & Lea Ziccino (2006) on GMM estimation method, the model is set as equation (1):

$$Y_{it} = \alpha_0 + \sum_{j=1}^n \alpha_j Z_{i,i-j} + \eta_i + \varphi_t + u_{i,t} \quad (1)$$

Where i represents country, t represents time, and the variable set $Y_{it} = (M_1, r, e, LOAN, GDP)^{-1}$.

III. DATA STATIONARITY TEST

A. Data Stationarity Test

The variables selected in the article, the overnight lending rate *r*, the exchange rate *e* of the euro against the US dollar are time series data, using the ADF test method; the money supply *M1*, the credit balance *LOAN* and *GDP* are the panel data, using the LLC and IPS test methods, The results are as follows: in the period of positive interest rate, *e* is stationary, *LOAN*, *M1*, *r* and *GDP* are first-order monolithic; in the period of zero interest rate, *LOAN*, *GDP*, *r* and *e* are stationary, *M1* is first-order monolithic; in the period of negative interest rate, *M1* and *GDP* are first-order monolithic, and the rest are stationary. In order to ensure the validity of the model estimation, this paper performs first-order differential processing on all variables in each period.

B. Cointegration Test

Johansen cointegration test is a classical method for checking whether there is a cointegration relationship between variables. The results are shown in Table I, it shows that at the 1% significant level, at the positive, negative and zero periods, the variables selected in this paper all have a cointegration relationship, indicating that there is a long-term relationship between them and there is no pseudo-regression. We can carry out the next test.

TABLE I. JOHANSEN COINTEGRATION TEST RESULTS

Interest rate background	Statistic			
	Variable name	Statistic	Probability value	conclusion
Positive interest rate	0 cointegration vectors	123.9	0	Reject
	Up to 1 cointegration vector	16.72	0.7788	Accept
Zero interest rate	0 cointegration vectors	383.9	0	Accept
	Up to 1 cointegration vector	161.2	0	Accept
	Up to 2 cointegration vector	75.23	0	Accept
	Up to 3 cointegration vector	35.22	0.0368	Reject
Negative interest rate	0 cointegration vectors	447.4	0	Accept
	Up to 1 cointegration vector	151.4	0	Accept
	Up to 2 cointegration vector	57.75	0	Accept
	Up to 3 cointegration vector	23.29	0.3853	Reject

C. Determination of Optimal Lag Order

Before establishing the PVAR model, the optimal lag order needs to be determined. Based on AIC, BIC and HQIC criteria, this paper determines that the optimal lag order of positive interest rate and negative interest rate is 5. Because AIC criterion is too conservative, according to BIC criterion, the optimal lag order of zero interest rate period is 3. The results are shown in Table II.

TABLE II. OPTIMAL LAG ORDER DETERMINATION

Interest rate background	Statistic			
	Lag	AIC	BIC	HQIC
Positive interest rate	1	59.5302	59.8383	59.6456
	2	57.5115	57.9185	57.6640
	3	57.1471	57.6544	57.3372
	4	56.8001	57.4090	57.0284
	5	55.7805*	56.4924*	56.0476*
Zero interest rate	1	53.4179	54.6519	53.9162
	2	51.3823	53.0614	52.0612
	3	50.1767	52.3357*	51.0506
	4	50.1882	52.8664	51.2734
	5	49.2972*	52.5398	50.6124*
Negative interest rate	1	53.1925	53.7750	53.4192
	2	51.4998	52.2753	51.8018
	3	50.4597	51.4338	50.8394
	4	49.7402	50.9188	50.2000
	5	48.7925*	50.1817*	49.3349*

Note: ***, ** and * are significant at 1%, 5% and 10% levels respectively.

IV. EMPIRICAL RESULTS

In this paper, the GMM estimation under the PVAR model is first carried out, and the results are shown to be significant, indicating that the variables and data selected in this paper satisfy the basic assumptions of the model. Now we have a standard deviation of the positive, zero and negative interest rate stages for each currency instrument variable, and obtain the impulse response graph of *GDP*. The output time lag results obtained by combining the pulse corresponding graph are shown in Table III.

TABLE III. OUTPUT TIME LAG OF MONETARY POLICY INSTRUMENTS WITH DIFFERENT INTEREST RATE BACKGROUNDS

Monetary instrument	Interest rate background		
	Positive interest rate	Zero interest rate	Negative interest rate
<i>M1</i>	2	2	9
<i>r</i>	3	5	5
<i>LOAN</i>	No time delay	6	4
<i>e</i>	1	2	9

Table III is a summary table of the delays in output of *M1*, *r*, *LOAN* and *e* monetary policy instruments under different interest rates. In the positive interest rate period, *M1*, *r*, *LOAN*

and e, the Monetary policy output time lag in the euro zone is two months, three months, no time lag and one month; in the zero interest rate period, M1, r, LOAN and e, the Monetary policy output time lag is two months, five months, six months and two months; in the negative interest rate stage, M1, r, LOAN and e, the Monetary policy output time lag is nine months, five months, four months and nine months. Comparative analysis of the reasons and conclusions are as follows :

Firstly, the output lag of M1, r, and e is gradually increasing after the period of positive interest rate, zero interest rate, and negative interest rate. In the negative interest rate stage, the policy effect of M1 and e is very weak, because the channels of monetary policy transmission in the three interest rate stages have long been completely different. The traditional monetary policy transmission channels are divided into currency transmission and credit transmission. In the low interest rate stage such as zero interest rate and negative interest rate, they will fall into the "liquidity trap" of Keynesian theory. Traditional monetary policy transmission channels will be invalid.

Secondly, the loan balance LOAN is special. There is no output lag in the period of positive interest rate, and the output lag in the period of zero interest rate is higher than that in the period of negative interest rate. But overall, the output lag in the period of zero interest rate and negative interest rate is higher than that in the period of positive interest rate. It can be inferred that the loan balance in the period of positive interest rate can be smoothly converted into investment, while in the period of zero interest rate and negative interest rate, with the weakness and the decline of real economic returns, investors are more inclined to invest capital in the capital market in pursuit of higher returns, thus failing to achieve the policy goal of promoting investment by increasing loans.

The zero interest rate and negative interest rate policies are monetary policies that some countries have innovated in order to combat deflation and stabilize the exchange rate after the financial crisis. This paper uses data from 12 major countries in the Eurozone from January 2002 to May 2019, covering three interest rate stages of the positive interest rate, zero interest rate and negative interest rate. Through comparative analysis of the output time lag of monetary policy instruments under different interest rate stages, lead to the following conclusions:

Firstly, there are heterogeneity in the output time lag of monetary policy instruments in different interest rate stages, and the output lag in the negative interest rate period is the longest.

Secondly, the policy effect during the negative interest rate period is the weakest. In the negative interest rate period, except for the longest output lag of monetary policy instruments, the effect is very weak, especially M1 and e. After giving them a positive impact, the performance of GDP is very dull, it is inferred that during the period of negative interest rates, it is not ideal to stimulate GDP growth through monetary policy instruments.

Thirdly, the heterogeneity of the output lag of monetary policy instruments at different interest rate stages is due to

changes in the transmission channels of monetary policy. During the period of positive interest rate, the transmission channel of monetary policy is the money channel and credit channel. During the period of zero interest rate and negative interest rate, the economy has fallen into a "liquidity trap" and the traditional monetary policy transmission channel has failed. Attention should be paid to the study of the transmission channels of monetary policy during the period of zero interest rate and negative interest rate, which is of great significance for enriching the transmission channels of monetary policy.

Finally, the author believes that zero interest rates and negative interest rates threaten financial stability. During the positive interest rate period, the credit balance has no output lag, which is enough to reflect that the increase in credit can directly stimulate the growth of investment and GDP. During the period of zero interest rate and negative interest rate, the output lag of credit balance is greatly increased due to the weakness of the real economy and the return on entity investment is low. Investors are unwilling to invest in the real economy and turn their money to capital markets with higher risk and return, which is undoubtedly a time bomb for financial stability.

The negative interest rate policy has now become a "magic weapon" for the developed countries to save the deflationary economy. Although China has not yet seen zero interest rates and negative interest rates, China's benchmark interest rate has also continued to decline, and corporate investment returns have also gradually declined. From zero interest rates and negative interest rates policies in developed countries, it can be seen from the conclusions of the study that it is ineffective to promote economic growth only by lowering interest rates. In the process of stimulating economic recovery, monetary policy is not a panacea. Therefore, we give the following policy recommendations: first of all, we should return to the real economy and adhere to the supply-side reform. In the face of saturated markets, we should attach importance to and encourage investment in R&D. Innovation is the basis of enterprises' survival, it not only creates demand, but also improve the return on investment of enterprises. Secondly, in the face of adjusting the economic structure, monetary policy seems to be more than enough. We should pay attention to the combination of fiscal policy and monetary policy, give full play to the advantages of policy combination, and create a favorable environment for realizing China's economic growth and financial stability.

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