How Real Interest Rate Influences Real GDP, CPI and Unemployment Rate in EU countries

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Abstract. The article aims to use linear regression model to analyze quantitative correlation of real interest rate and three economic indices, namely real GDP, CPI and unemployment rate based on data of France, Germany and Italy. When the government tries to control the economic condition by adjusting interest rate, a clear quantitative correlation between interest rate and some important economic indices can make the consequence more controllable. A research based on real data can also help avoid mistake due to inconsistency between theoretical model and real life. As a result, the final model reveals that real GDP is negatively correlated with real interest rate, while CPI and unemployment rate are both positively correlated with real interest rate in short term, which is opposite to the initial expectation of CPI and unemployment rate. Such consequence may suggest the government to consider the possible opposite result in short term when they try to adjust the price level by altering real interest rate, as well as the unexpected change in unemployment rate.

Keywords: Interest rate, GDP, CPI, unemployment rate.

1. Introduction

Due to impact caused by novel coronavirus these years, the world economy is in sluggish, and that is why many countries are trying various ways to stimulate their economy, one of which is known as lowering interest rate. Though the present economic models generally tell that lowering interest rate makes contribution to the increase of GDP, the quantitative relation among real interest rate and other economic indexes keeps unknown, and this article aims to find out such relation.

There exist many researches about interest rate. The current research findings relevant to this field include innovations in interest rate policy, the sensitivity of interest rates to changes in money supply and total output, the political economy of interest-rate setting, inflation and income distribution, etc. [1-3]. Among those researches taking interest rate as independent variables, only one article focuses on influence of interest rate change exert on price, namely the economy index CPI this paper is going to do research [4]. The others are about the function between the aggregate consumption and interest rate, the prediction of interest rate next season based on the interest rate already known, and Federal policy about interest rate [5-7]. The current study suggests that the interest rate has a negative correlation with price, but in this study, there is no quantitative result revealed, and price is the only economic index included. According to the fact that there is no quantitative research about the correlation among real interest rate and some important economic indexes, this filed this article refers to is innovative and necessary.

This article analyzes the quantitative correlation of real interest rate and real Gross Domestic Price (GDP), Consumer Price Index (CPI), and unemployment rate respectively based on data collected from France, Germany and Italy. The article gets three linear regression model as a result, which reveals how real interest rate in two seasons exerts influence on the economic indexes stated above. According to the basic economic knowledge, real GDP and CPI all have positive correlation with real interest rate, and unemployment has no significant correlation with it, while the model suggests that only real GDP meets the expectation. Both CPI and employment rate are positively correlated with real interest rate in a short term. Based on such consequence, when the government is making policy to adjust CPI, they ought to take the result opposite to expectation in short term into consideration. What's more, the possible influence on unemployment should be considered.

2. Data and Methodology

2.1. Data

Data in this paper is collected from Federal Reserve Economic Data, including real GDP, consumer price index, unemployment rate and 10-year government bond yields, here represents real interest rate. France, Germany and Italy are chosen for the analysis as all of them are main parts of the European Union economy, so their economic data can better represent EU economy. Quarterly data is used in this paper as such time interval is more proper for the analysis. As this article focuses on the influence of lowering interest rate, data of year 2010 to 2014 are used for regression analysis, for three countries all lowered their interest rate during such time slot.

2.2. Methodology

This article uses linear regression model to do analysis. Regression is a mathematic method widely used to solve quantitative questions in various fields, like using regression for interest group ratings [8, 9]. Though in this article the simplest linear regression model is used for analysis, regression has many kinds of improvements, for example taking various mixing proportions into model [10]. In the model, the potential hysteresis is considered by including real interest rate data in two sequent seasons as independent variables, while difference among countries is presented by dummy variables. As elasticity, namely the percent change of dependent variable corresponding to a unit percent change in independent variable, is a consequence better represents quantitative relationship between real interest rate and three dependent variables that will be considered, all data are in nature logs during analysis. The linear regression models are stated below.

$$\ln rGDP_{i,t}= \beta_0+\beta_1 \ln r_{i,t}+\beta_2 \ln r_{i,\,t-1}+\theta_1 IT+ \theta_2 GR+\epsilon_{i,t} \tag{1}$$

$$\ln CPI_{i,t}= \alpha_0+\alpha_1 \ln r_{i,t}+\alpha_2 \ln r_{i,\,t-1}+\vartheta_1 IT+ \vartheta_2 GR+\omega_{i,t} \tag{2}$$

$$\ln UE_{i,t}= \gamma_0+\gamma_1 \ln r_{i,t}+\gamma_2 \ln r_{i,\,t-1}+\mu_1 IT+ \mu_2 GR+\delta_{i,t} \tag{3}$$

In these equations, rGDP represents real Gross Domestic Production (Millions of Chained 2010 Euros), CPI represents Consumer Price Index, UE represents unemployment rate and r represents real interest rate, which is displayed by 10-year government bond yields in this article. As for real interest rate, $r_{i,t}$ represents real interest rate in the same season as dependent variable ($rGDP_{i,t}$, $CPI_{i,t}$ or $UE_{i,t}$), and $r_{i,\,t-1}$ represents real interest rate in the last season. Based on the basic economic knowledge, here gives expectation of coefficients in the model. Real interest rate is expected to have negative correlation with real GDP, positive correlation with CPI and be irrelevant with unemployment rate. As for coefficient of $\ln r_{i,t}$ and $\ln r_{i,\,t-1}$ particularly, at least one of them should be consistent with the expectation. IT and GR are dummy variables, determining whether the country is Italy or Germany or not, so there is no expectation of their coefficients.

3. Results

3.1. Descriptive Analysis

Firstly, basic property of those economic index data will be showed, including mean, standard deviation, maximum and minimum. Table 1 shows the descriptive statistics for data of France, Germany and Italy. France has the highest real interest rate on average among three countries, it also experiences the most severe change in real GDP. Germany has the highest real GDP and the lowest unemployment rate and CPI on average. As for Italy, change in each economic index of it during several decades keeps at a low extent.

Table 1. Descriptive Statistics for France, Germany and Italy

		Obs	Mean	Std. Dev.	Min	Max
France	r	254	6.526	3.973	-0.319	17.073
	rGDP	194	414,534	101,783	237,076	572,688
	CPI	54	1.579	2.544	-0.243	6.070
	UE	162	9.715	1.393	7.100	12.50
Germany	r	254	5.401	2.861	-0.614	10.80
	rGDP	130	631,034	76,163	509,825	754,883
	CPI	54	1.996	2.048	-0.951	8.591
	UE	130	6.718	2.464	2.900	11.200
Italy	r	129	5.196	3.373	0.637	13.848
	rGDP	114	393,947	18,418	335,261	426,611
	CPI	54	1.907	2.549	-0.486	11.736
	UE	129	9.637	1.732	6.033	12.933

3.2. Regression Analysis

Before the final model, two simpler model will be considered at the beginning. For these two models do not lead to the final consequence, only real GDP are treated as dependent variable in them. The first one is the model only treats real interest rate in the same season as real GDP as explanation variable, while the second one adds real interest rate in the last season as an extra explanation variable. Using Stata for regression analysis, the consequence of three groups is displayed in Table 2.

Table 2. Regression results with interest rate and its first lag

	France		**Germany**		**Italy**	
$\ln r_t$	-0.036***	-0.014	-0.050***	-0.032	0.037***	0.131***
	(0.008)	(0.017)	(0.008)	(0.020)	(0.017)	(0.036)
$\ln r_{t-1}$		-0.024		-0.012		-0.124**
		(0.021)		(0.023)		(0.027)
Adj-R^2	0.512	0.500	0.5983	0.5563	0.174	0.414
Prob>F	0.000	0.002	0.000	0.000	0.038	0.006
Obs	20	20	20	20	20	20

Notes: *p<0.1 **p<0.05 ***p<0.01. Standard errors in parentheses.

Table 2 is a summary of the two models. Focusing on the simplest model that only has one explanation variable, namely data in the first, third and fifth column, data suggests that coefficient of $\ln r_t$ in Group France and Germany are negative, which just meets expectation of it. What's more, the significance level of coefficient and the whole equation are in a low enough level so that initial hypothesis are rejected. However, coefficient of $\ln r_t$ in Group Italy is positive, which is opposite to the initial expectation of its coefficient. This could be caused by problem of omit variable, which is improved in the next model.

Data in column 2, 4 and 6 corresponds to the second model, which takes first lag into consideration. $r_{i,t}$ and $r_{1,t-1}$ in the table corresponds to the real interest rate of two sequent years. In this model, all coefficients of $\ln r_{t-1}$ are expected to be negative, namely change in real interest rate in last season has negative correlation with real GDP in this season, which is consistent with basic economic knowledge. While for $\ln r_{i,t}$ here, it would be better that their coefficient keep negative, but a positive result is also acceptable as $\ln r_{i,\,t-1}$explains for change in $\ln rGDP_{i,t}$.

As is expected, all coefficients of $\ln r_{t-1}$ are negative, and coefficients of $\ln r_t$ in group France and Germany keep negative too. Result of F-test suggests that the fitting is good, as the initial hypothesis will be rejected under standard significance level of 0.05. However, t-test of coefficients are not good. Only coefficients in Group Italy pass t-test, while the others surpass 0.05 at a large

extent. Such problem may be caused by autocorrelation, as there tends to be correlation between two seasons' real interest rate.

After solving problem of first lag, a more general consequence is the next target, and that's exactly the model stated in the Methodology section. When doing regression analysis, all data of those three countries are included in the regression analysis, and dummy variable IT (whether this country is Italy) and GR (whether this country is Germany) are added to the model to distinct three different countries. Table 3 displays the result of regression under these models.

Table 3. Regression results (Dep. Var: log of real GDP)

	ln rGDP	ln CPI	ln UE
$\ln r_t$	0.009	1.508***	-0.225*
	(0.019)	(0.513)	(0.128)
$\ln r_{t-1}$	-0.046**	-0.283	0.311**
	(0.022)	(0.596)	(0.149)
IT	-0.238***	-0.541**	0.032
	(0.008)	(0.209)	(0.051)
GR	0.256***	0.571***	-0.583***
	(0.007)	(0.177)	(0.044)
Adj-R^2	0.993	0.382	0.852
Prob>F	0.000	0.000	0.000
Obs	60	59	60

Notes: *p<0.1 **p<0.05 ***p<0.01. Standard errors in parentheses.

All of them pass the F-test, then each coefficient will undergo t-test with standard significance level of 0.05. For $\ln rGDP$, coefficient of $\ln r_t$ fail to pass t-test, which means there is no significance influence $\ln r_t$ make on $\ln rGDP$, so data in Table 3 tells that real interest of last season is positively correlated with real GDP this season. Similarly, result of t-test tells that real interest is positively correlated with CPI, altering simultaneously, while real interest rate correlates with unemployment rate positively with a lag.

4. Conclusion

This article uses method of linear regression to figure out how change in real interest rate will influence real Gross Domestic Production, Consumer Price Index and unemployment rate by analyzing economic data of three main member of European Union, France, Germany and Italy. Change in real interest rate is expected to have negative correlation with real GDP and CPI, but be irrelevant with unemployment rate. Under standard significance level of 0.05, the result is that lowering real interest rate has hysteretic positive influence on real GDP, immediate negative influence on CPI, and hysteretic negative influence on unemployment rate, which means only GDP meets the initial expectation about correlation with real interest rate.

There exist a few limitations in this article. First, as is suggested in the model only treats two seasons' real interest rate as independent variables, such selection of independent variables may bring autocorrelation, for it makes sense that real interest rate in a particular season is correlated to one in the last or next season. Second, number of observations are insufficient. Due to limitations in data collection, only economic data from year 2010 to 2014 are included in the regression. Small sample size could explain why correlation between real GDP and real interest rate, unemployment rate and real interest rate do not meet the expectation. Third, this article focuses on data of France, Germany and Italy only, which means these three models cannot be extended to a more general condition, and that's where a further study can be done. Based on potential limitations stated above, future studies in this field should search for new explanation variables with better statistics property and applicability for more general conditions.

References

[1] Modigliani F and Sutch R. Innovations in Interest Rate Policy. The American Economic Review, 2014, 56 (1/2): 178 - 197.

[2] Gibson W E, and Kaufman G. The Sensitivity of Interest Rates to Changes in Money and Income. Journal of Political Economy, 2016, 76 (3): 472 - 478.

[3] Rochon L P and Setterfield M. The Political Economy of Interest-Rate Setting, Inflation, and Income Distribution. International Journal of Political Economy, 2008, 37 (2): 5 - 25.

[4] Wicksell K. The Influence of the Rate of Interest on Prices. The Economic Journal, 2015, 17 (66): 213 - 220.

[5] Gylfason T. Interest Rates, Inflation, and the Aggregate Consumption Function. The Review of Economics and Statistics, 2012, 63 (2): 233 - 245.

[6] Bicksler J and Chen a H. An Economic Analysis of Interest Rate Swaps. The Journal of Finance, 1985, 41 (3): 645 - 655.

[7] Ireland P N. Interest Rates, Inflation, and Federal Reserve Policy Since 1980. Journal of Money, Credit and Banking, 2015, 32 (3): 417 - 434.

[8] Manski C F. Regression. Journal of Economic Literature, 2015, 29 (1): 34 - 50.

[9] Herron M C. Interest Group Ratings and Regression Inconsistency. Political Analysis, 2016, 9 (3): 260 - 274.

[10] Huang M and Yao W. Mixture of Regression Models with Varying Mixing Proportions: A Semiparametric Approach. Journal of the American Statistical Association, 2012, 107 (498): 711 - 724.