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US Recession Analysis Based on Ordinary Least Squares Regression

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Abstract: The United States is the first developed economy that rebounded from the 2008 global financial. Theoretically, US economic cycle is influenced by several factors, this paper mainly focuses on the linkage of the US economic growth and The correlation between the unemployment rate and the U.S. federal funds rate. Between times with rising economic activity, known as expansions. Whereas, the periods of diminishing economic activity is known as recessions. The economic climate constantly shifts throughout time. Firstly, the rate of employment and the rate of federal funding are cointegrated. The findings of a regression analysis demonstrate that there is a negative concurrent correlation between the federal funds rate and unemployment rate. Secondly, in order to verify the linkage, through an in-depth review of the data, several interlinked and external factors behind the pattern of such correlation related to the variation on economic growth also need to be elaborated.

Keywords: economic growth, federal funds rate, unemployment rate

1. Introduction

The United States' economy witnessed one of the worst recessions due to the Great Depression in the aftermath of the 2008 financial crisis [1]. The crisis astounded many legislators, international organizations, experts, and investors [2]. The relationship between the United States Federal Reserve (Fed) interest rate and the unemployment rate is a topic of great interest to economists and policymakers. Federal funds rate refers to the target interest rate set by the Federal Open Market Committee (FOMC) [3]. PCE stands for Personal Consumption Expenditures, which used to measure the total amount of money spent by individuals and households on goods and services. Specially, it is a measure of the total economic output of a country, which can contribute to influence the GDP growth indirectly. As a matter of fact, the link between the two variables has received much attention in the popular press in the United States. The fed funds market is essentially a tool for reallocating bank reserves [4]. As such, it is an important market in terms of payment economics and the area of banking theory that investigates the function of interbank markets in assisting banks in managing reserves and offsetting liquidity or payment shocks [5]. Maximum employment and price stability are the FOMC's top priorities. Future FOMC decisions may be affected if the unemployment rate remains high for an extended period of time. Usually, as the unemployment rate rises during a recession, the

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FOMC lowers target rate in an effort to boost the GDP and lower the unemployment rate to the desired level [6].

Both the fed funds rate and inflation rates are FOMC's main instruments and crucial factors that impact FOMC decisions. The FOMC additionally stated that monetary policy measures may be adjusted if inflation remains consistantly above or below 2% [7]. Moreover, helping the economy achieve full employment is one of the FOMC's long-term goals. Future FOMC decisions could be affected if the unemployment rate remains high. Some experts believe that when the Fed rate is higher than the unemployment rate, it may be a sign that the economy is heading towards a recession. This hypothesis has been the subject of much debate and analysis, and historical data can help shed light on its accuracy [8]. According to the econometric analysis, conventional monetary policy tools may have had some impact on the unemployment rate since the 1990s, but not inflation [9]. As an outcome, it is possible that the impact of a change in the fed funds rate won't be as clear-cut as conventional economic theory would have us believe [10].

This paper's focus is the linkage of the economic growth and the relationship between the Fed rate and unemployment rate in the U.S. over time. Historical data will be examined to determine whether there is a correlation between these variables by using some given analysis. On top of that, whether the hypothesis of a higher Fed rate can bring an impending recession will be supported by the evidence [11]. Given that the federal funds rate is almost at zero, while the unemployment rate is still substantially greater than the natural rate of unemployment [12]. Furthermore, the two variables are causally related in both directions. Although the federal funds rate has been locked at or near zero, the unemployment rate hasn't fallen as much as would have been expected with a lower federal funds rate. Therefore, more factors of whether the variables that might be considered as economic growth indicators will be included in this paper according with discussions of the implications of these findings for policymakers and the broader economy.

2. Methods

2.1. Data Source

The most essential information for this paper is the statistics of three elements (historical data of US Fed rate, unemployment rate, US recession cycle). Primarily, as the basic information in United states, the historical statistics of US Fed rate and unemployment rate can be found in the official websites of the United States government-Federal Reserve Economic Data (FRED), US Bureau of Labor Statistics, respectively. Simultaneously, to get the US recession cycle, we considered the years of negative GDP growth as the standard for a recession, thereby the annual GDP data from 1960 to 2020 offered by US Bureau of Labor Economic Analysis are utilized.

2.2. Variable Description

The entire name, symbol, and explanation of the 3 variables utilized in the study are shown in Table 1 and Table 2.

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Table 1: Description of Variables (Historical data).

Full name	Symbol	Value Range
Federal Funds Effective Rate	FFR	[0.07, 18.90]
Unemployment Rate	UR	[3.4, 10.8]
Gross Domestic Product	GDP	[540.20, 26137.99]
Inflation rate	IR	[-0.36，11.05]
Personal Consumption Expenditures	PCE	[331.2,14392.7]

Among them, the variables listed in Table 1 are the basic data which can obtain from official websites directly, while the factors given in Table 2 are higher-order variables (based on original data, the growth rate, factors differences and other aspects are calculated). This study will discuss the influence of all the above variables to recession.

Table 2: Description of Variables (higher order data).

Full name	Symbol	Value Range
Gross Domestic Product Growth Rate	ΔGDP	[-0.73, 14.44]
Difference between Federal Funds Effective Rate and Unemployment Rate	ΔFRUR	[-9.78, 11.7]

2.3. Mathematical Statistics Method

2.3.1. Multiple linear regression model

The US GDP growth is selected as a dependent variable in the model, while the difference between the federal funds rate and unemployment rate, the inflation rate and personal consumption expenditure are regarded as independent variables as well as three factors that might affect GDP growth, while this paper stressed on the difference between federal rate and unemployment rate. The regression equation is specified as following:

$$\Delta GDP = \beta_0 + \beta_1 IR + \beta_2 \Delta FRUR + \beta_3 PCE + \varepsilon_i \quad (1)$$

Among them, ε is random error item, $\beta_0, \beta_1, \beta_2, \beta_3$ are regression coefficient, ΔFRUR represents the difference between the federal funds rate and unemployment rate while ΔGDP is the rate of GDP growth.

2.3.2. Ordinary least squares (OLS).

Using the residual sum of squares (RSS) to find the shortest straight-line distance between the predicted and actual values, so that to get the best fitting effect.

$$RSS = \sum_{i=1}^{n} (y_i - x_i^T b)^2 \quad (2)$$

$$\beta = (X'X)^{-1}X'Y \quad (3)$$

Based on the data obtained, finding the minimum RSS to build the OLS model and get the corresponding OLS coefficient estimate.

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3. Results and Discussion

3.1. Analysis of the Results

By means of the method of multiple linear regression model based on the annual data of three variables, the results are reported in table 3.

Table 3: Regression Output (Dependent variable: US GDP growth).

Variable	Coefficient	Std. Error	t-Statistic	P-value
C	7.407	0.720	10.280	0.000
ΔFRUR	0.257	0.094	2.723	0.009
IR	0.158	0.128	1.231	0.223
PCE	0.000	0.000	-3.692	0.001
R-squared 0.556			DW 1.500	
F-statistic 23.812			Prob(F-statistic) 0.000	

Notes: C = intercept; ΔFRUR = federal funds rate - unemployment rate; IR = Inflation Rate; PCE = Personal Consumption Expenditure; DW = Durbin Watson Statistic.

As Table 3 shows, the P-values indicate the probability of observing the coefficient value, or more extreme, it is used to identify whether the result is feasible and which data set from the result to work with. The significance level here is 0.05, since the P-value of inflation is 0.223, which is obviously larger than 0.05. Therefore, inflation rate should be rejected and not be considered as a reliable variable. The variables studied in this paper are eventually ΔFRUR, PCE and ΔGDP, which are all stationary in the time series data for the period 2000-2020 and can be directly regressed for analysis.

R-square here is 0.556, which means 55.6 percent of the observation of the dependent variables can be explained by the independent variables. Here, since it is larger than 50 percent, so it is valid.

The coefficient of ΔFRUR is positive but still less than 1, which implies that as the difference between fed rate and unemployment rate increase by one unit, the general GDP growth will slightly increase by 0.257 unit accordingly. Thus, the result indicated that ΔFRUR is directly proportional to GDP growth, which is obviously contrary to the hypothesis which stated that a larger disparity would bring a negative GDP growth. However, PCE is barely relative to GDP growth due to the coefficient approaching to zero.

Furthermore, The DW statistic, or Durbin-Watson statistic, is a measure used to examine the presence of autocorrelation in the residuals of a linear regression model. When there are linear correlations between the residuals, this is referred to as autocorrelation. This can result in inaccurate and inconsistent estimations of the regression coefficients, which subsequently compromise the validity of statistical inference. Here the DW value is 1.500 which is closed to 2 indicating the absence of first-order autocorrelation in the residuals. Since it is less than 2, it implies a positive autocorrelation, which again affirms the reversal of the assumption in the beginning.

3.2. Discussion

Changes in the federal funds rate can affect future employment in the same direction. This is based on the positive correlation between the Fed's interest rate and the unemployment rate (ΔFRUR = 0.391), a hypothesis confirmed by the results of the least squares regression analysis.

Monetary policy and the job market are two important aspects of the macro economy, and they have a complex interaction: First, the Fed's benchmark interest rate, which directly affects borrowing costs and investment costs. When the Fed raises interest rates, it raises borrowing costs, thereby reducing borrowing needs for businesses and individuals, curbing consumer spending and investment

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spending, and thus leading to higher unemployment. Instead, lower interest rates will stimulate consumption and investment spending, boosting economic growth and jobs, and thus leading to lower unemployment rates. There is a negative correlation between the federal funds rate and unemployment rates. Second, the job market is an important indicator of economic activity. When unemployment rises, it means that economic activity is weak and companies struggle to get enough investment funds, leading to slow growth. On the contrary, when the unemployment rate falls, it means that the economy is more active and companies have more investment funds, which leads to faster economic growth. Therefore, the situation of the job market has an important impact on GDP growth.

When the Fed raises interest rates to control inflation, it could slow and eventually lead to recession. Here are some of the expansion and recommendations that should first consider the implications of economic growth beyond the Fed's interest rates and unemployment rates, such as consumer confidence, government spending, and business investment. These factors can have an important impact on the direction of the economy and therefore need to be considered comprehensively. Secondly, formulate appropriate monetary policy. The Federal Reserve can influence the direction of the economy by adjusting interest rates, quantitative easing and other means. However, in taking these measures, the effects of various factors must be weighed to ensure the effectiveness and sustainability of the policies. Third, strengthen regulation and risk management. Risk management and regulation of financial markets are very important, because they can prevent the occurrence of financial crises. If poor regulation or poor risk management, it can lead to economic collapse or other serious consequences. Finally, promote structural reform, which can help boost economic growth and create jobs. This includes reforming the labor market, education systems, infrastructure and more to increase productivity and competitiveness. In short, when the Fed's interest rates are above unemployment, the economy is heading into recession can be a complex issue to consider the effects of multiple factors. The government and the central bank should take appropriate measures to promote economic growth and stability, while strengthening regulation and risk management to ensure the sustainable development of the economy.

There are still many defects to be corrected and perfected in the study of interest rate, unemployment rate and recession. For example, considering only two related variables in variable analysis may lack conclusion accuracy and scientific rigor, and the statistical sample range of only 60 years (1960-2020) may have some analytical accuracy errors. In studies, all predictor variables must be assumed to be exogenous variables from outside the model. Given the above deficiencies, the above will next be addressed by amplification factor variables and sample years and relaxing assumptions in this model in future studies.

4. Conclusion

Through studying the historical data from 1960 to 2020, this paper analyzed the impact of the difference between the two factors on the GDP growth with ordinary least squares regression. This study finds that the difference between the federal funds rate and the unemployment rate is positively correlated with GDP growth, which indicates that the higher the federal funds rate always brings a lower the unemployment rate, the less likely the economic recession will occur. On the contrary, during the last 20 years, all the recession happened in years with the difference below -6, so government and institutions should pay more attention on the circumstances when the difference between federal funds and unemployment rate has a large negative disparity to predict possible risks in the future. In addition, When the difference is positive, GDP growth is more stable and growth rate is more likely to be higher than 10 percent, which means the thriving market and can help investors judge the opportunity and timing of entering the market. However, because there are a variety of elements can affect GDP growth, thereby the difference between the Fed rate and the unemployment

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rate can only explain some of the trends in GDP growth, but there are still many exceptional years (like 1975, GDP growth reached 10.14 when the difference was -3) that cannot be explained by the relationship between these factors. Therefore, more variables need to be added to the model if researchers want to get the more accurate possibility of economy recession.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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