**FFR projection based on the factors of FFR and Treasury Yields with HMM**

**Abstract**

As we all know, in the last two years the Federal Reserve has raised interest rates multiple times (increasing the Federal Funds Rate), which has had a significant impact on financial markets around the world. The rate hikes have not only brought about the strength of the US dollar, which affects the Currency Markets, but also the pricing of global assets and the anchoring of sovereigns' credits, which makes the projection of the FFR very important. However, there are a number of obstacles to FFR forecasting: 1) lagging and insufficient publicly available data due to the low frequency of macro data releases; and 2) the susceptibility of market participants to historical data bias (e.g., being overly optimistic about FFR reductions). This study hopes to combine the Taylor Rule, commonly used by the FOMC, with the treasury yields to make a more forward-looking judgement on FFR.

**Introduction**

**Literature Review**

1. Federal Reserve Rate
   1. Monetary Policy

The Federal Reserve, through its monetary policy adjustments, creates a favorable economic environment characterized by appropriate employment rate and stable price. In a general sense, monetary policy functions to either encourage or curtail the growth of overall demand for goods and services in the economy. When the aggregate demand lags behind the economy's capacity to produce, it results in increased unemployment rate and reduced inflation. To counter this, the Federal Open Market Committee (FOMC) intervenes by reducing interest rates and implementing an expansionary monetary policy to stimulate aggregate demand, thereby helping stabilize the economy.

Conversely, if demand for goods and services becomes excessively strong, it can lead to unsustainably low unemployment rate and increased inflation. In such a scenario, the Federal Reserve employs a contractionary monetary policy by elevating interest rates to guide economic activity back to more sustainable levels. The procedure through which the Federal Open Market Committee (FOMC) enacts expansionary and contractionary monetary policies to achieve its goals can be summarized as shown in Fig.1.

The primary method employed by the Federal Open Market Committee (FOMC) to exert monetary policy is the adjustment of the target federal funds rate (FFR). Banks maintain reserve balances at the Federal Reserve to fulfill unforeseen liquidity requirements and adhere to various regulatory standards. As they are also able to transfer reserve balances among themselves to settle financial obligations, banks engage in borrowing and lending of reserves among one another based on their specific needs and prevailing market conditions. The federal funds rate represents the interest rate at which banks engage in overnight borrowing, and it plays a pivotal role in determining the expense of short-term credit.

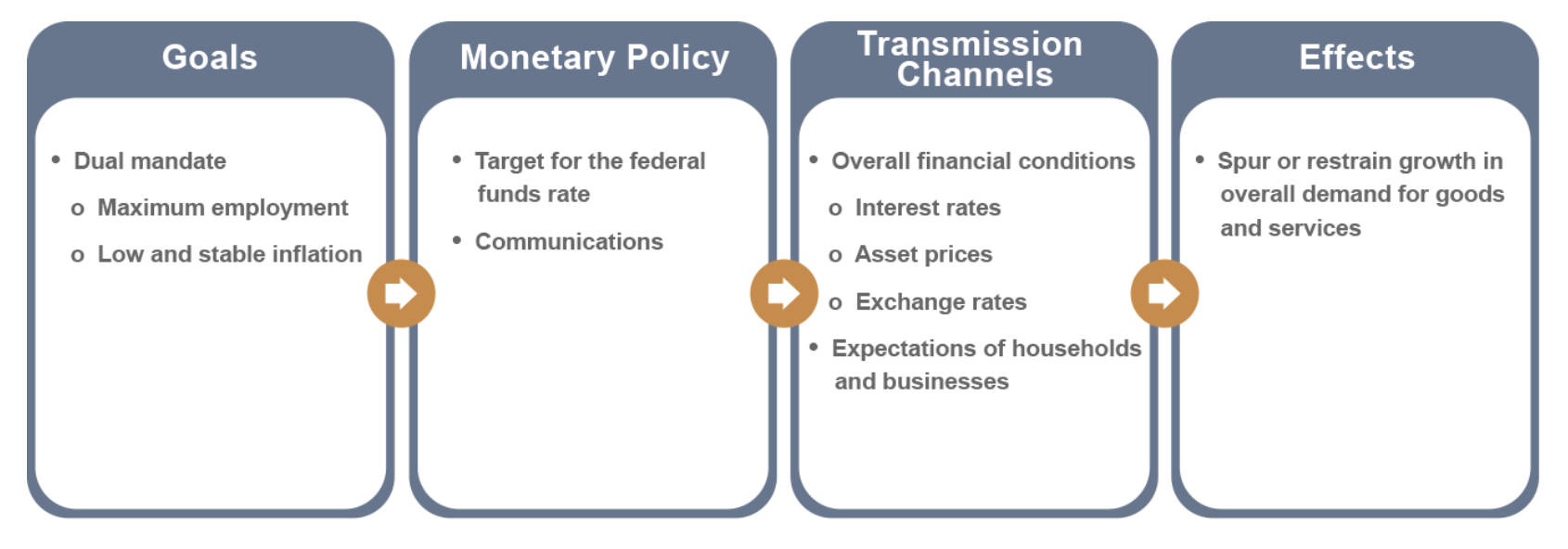


Figure 1. Federal Reserve Monetary Policy

* 1. FFR

To impact the federal funds rate, the FOMC can modify the interest rate applied to bank reserves. This adjustment leads to changes in the federal funds rate, aligning it with the FOMC's desired objectives and influencing the cost of short-term interbank credit.

In response to the 2008 economic crisis and subsequent economic recession, Federal Open Market Committee lower the target for the federal funds rate from 5.25% in mid-September 2007 to near zero by the end of December 2008 (See Fig. 2). This rate reduction was part of the Fed's strategy to stimulate economic activity and provide liquidity to the financial system. The goal was to make borrowing cheaper for banks, businesses, and consumers to encourage spending, investment, and lending. Together with various monetary policies such as buying back government securities, the market responded by purchasing large-scale asset, consequently fostering economic growth, job generation, and a gradual resurgence of inflation toward 2%. Notably, in December 2015, the Federal Open Market Committee initiated the process of increasing the target for the federal funds rate, transitioning from its near-zero level to a more conventional rate. Subsequently, in October 2017, the Federal Open Market Committee embarked on the gradual reduction of its securities holdings, marking another substantial step toward the normalization of monetary policy. As part of this shift, the Committee conveyed that future adjustments in the federal funds rate would serve as the primary mechanism for altering the overall stance of monetary policy.

In the recent context, the U.S. economy has been experiencing a robust recovery after a period of economic disruption, possibly due to the COVID-19 pandemic. Annual inflation rates have risen above the Federal Reserve's target of 2%. Inflation, as measured by the Consumer Price Index (CPI), is at 3.5%, and core inflation (excluding food and energy) is at 2.8%. To address these economic conditions, the Federal Reserve announces an increase in the target FFR from 0.25% to 0.50%. This is the first-rate hike in several years, signaling the central bank's confidence in the strength of the economic recovery.

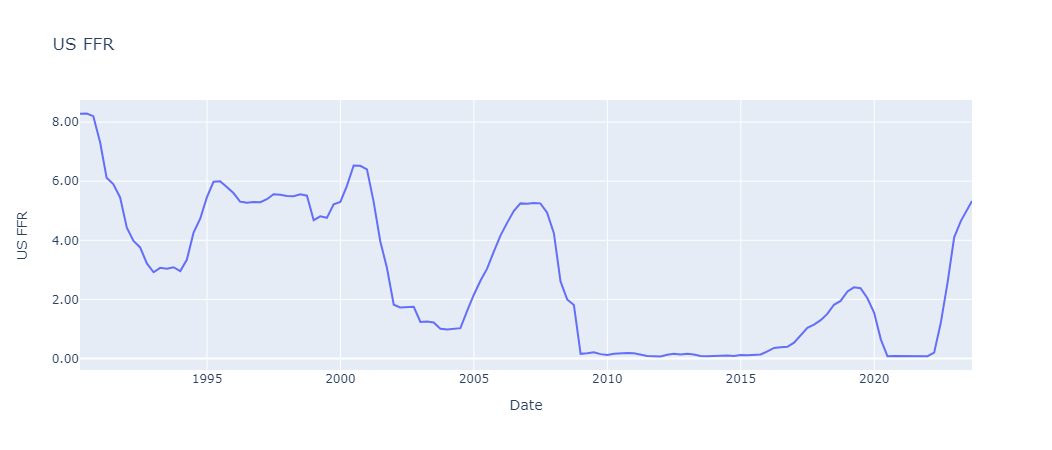
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Figure 2. US FFR Diagram

1. Taylor Rule

In a paper published in 1993, John Taylor showed how monetary policy in the United States from 1987 to 1992 was approximated by a formula that related the federal funds rate to three variables. The first variable is the inflation-adjusted long-run federal funds rate, the second is the deviation of current inflation from the 2% target set by the Federal Open Market Committee (FOMC), and the third is the percentage difference between actual GDP and its potential level.

Taylor Rule takes the following general form, with the specific meanings of the indicators shown in the table below.

|  |  |
| --- | --- |
| Variable | Implication |
|  | Federal fund Rate |
|  | Real Neutral Rate |
|  | Expected Inflation |
| 𝜋∗ | Target Inflation |
| − | Percent deviation between the current real GDP and the long-term linear trend in GDP |

Table 1. Variables Explanation in Taylor Rule

The Taylor formula illustrates that when inflation surpasses the 2% target, the federal funds rate increases at a rate 1.5 times that of the inflation increase. Furthermore, if the GDP exceeds its potential level, the federal funds rate increases by 0.5 times the difference between the GDP and its potential level.

The Taylor rule embodies the fundamental principles of monetary policy discussed earlier. Firstly, when the real long-term neutral federal funds rate, the actual and target inflation rates, and the real GDP level and its potential are all known, the adjustment based on the difference between the GDP and its potential level is zero, making policy rate prediction feasible. Secondly, it advocates for higher policy rates in response to rising inflation or increased resource utilization, and lower policy rates when inflation subsides or resource utilization declines. This alignment corresponds with the Federal Reserve's dual mandate. Lastly, the equation dictates that the federal funds rate should be adjusted by more than a one-to-one ratio when inflation experiences upward or downward movements, a characteristic often referred to as the Taylor principle.

1. Treasury Yield

U.S. Treasury yield is the yield on U.S. government bonds, whose metric measures the return an investor can earn by purchasing U.S. government bonds. U.S. government bonds are bonds issued by the government to raise funds and are usually classified as having different maturities, including short-term, intermediate-term, and long-term bonds.

Treasury yield is often used by investors and economic observers as an indicator of risk and market expectations. Based on the risk-neutral interpretation, treasury yields are equal to the average value of expected future short rates [5]. A low Treasury yield may indicate market concerns about future economic uncertainty, while a high Treasury yield may reflect investor optimism about economic growth and inflation. In addition, Treasury yield is used to determine the pricing of other financial instruments, such as mortgage rates and corporate bonds. Treasury yields can reflect economic conditions, monetary and fiscal policies, and expectations about future economic activity, real interest rates, and inflation [6]. What can be agreed upon is that whenever macroeconomic data is released differently than the consensus, treasury yields always have a noticeable jump, indicating the influence of macro economy situations to the treasury yields. In this research, we take 6 U.S. treasury yields from Bloomberg into consideration according to the dataset coverage [1], and the remained NAN values are forward filled based on the previous dates’ yield data. A visualization of the Treasury Yields is shown in Fig. 3:

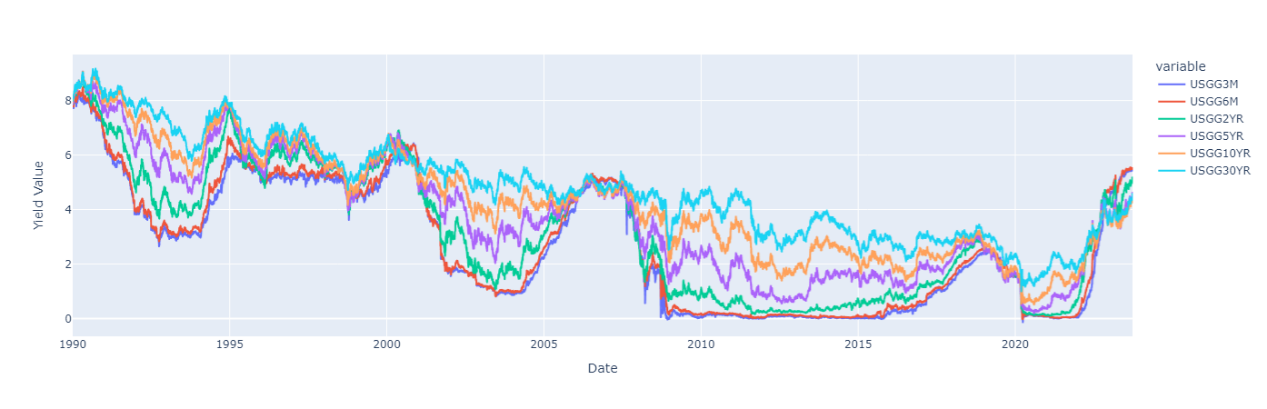


Figure 3. US Treasury Yields Diagram (Maturities including 3, 6 Months, 2, 5, 10, and 30 Year)

Additionally, the term structure of the treasury yields is also an important dimension to understand the economic situation at that point of time.

However, sometimes the yield curve was inverted, just like the current situation.

Indeed, treasury yields have strong correlation with FFR, especially in the short-term tenor parts. This is because…

**Research Objective**

1. Transform the treasury yields data into explanatory features, and then feed them to the GMM-HMM to obtain the leading macroeconomics factors.
2. Construct the model based on the traditional Taylor Rule and the generated new macro factors.
3. Adjust the incorporated information window to test the projection performance of the model.

**Methodologies**

1. Principle Component Analysis
2. GMM-HMM

Macro Factors from Taylor Rule

**??**

According to the basic assumptions of time series modelling, forecasts at moment t cannot use future information, but only current moment as well as ever information [3]. However, in the actual publication of economics data, although different economic indicators reflect economic conditions over the same period of time, they cannot be regarded as variables with the same time stamp due to the difference in publication time. This is also the case in our study, although based on the Taylor Rule, the FFR can be calculated using the relevant macroeconomic indicators for this period, the corresponding macroeconomic indicators are published 1-2 days after the publication time of the FFR (see Fig. ), and therefore in practice it is not possible to use such future information for FFR determination. In reality, researchers generally use the previous period's macroeconomic data as the input factor for the Taylor Rule, however, this can lead to a lagged effect as the calculation of the FFR ignores the most recent period's economic situation. There are also many relevant financial institutions that present alternative data for use, but this is not always publicly available and authoritative.

Perfect Situation:

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Real Implication

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is biased as it doesn’t consider the information from to .

We aim to provide an equation to build the with and the information from to , which is denoted by . As is the hidden information during the period of (,T), it is unobservable, but should still has the linear relationship with . Therefore, we have the new established formula:

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Based on our thinking, when the FFR is adjusted, Treasury Yield is affected first, while macroeconomic indicators are affected later on. This is because the adjustment of the FFR directly affects the cost of short-term borrowing, so that the short-term borrowing rates of banks and other financial institutions usually quickly follow the change in the FFR, which in turn affects Treasury Yield. However, macroeconomic indicators are affected by a variety of factors, and it usually takes time for changes in the economy to be transmitted, e.g. it takes some time for firms and individuals to make decisions about investing and consuming. time to adjust to the new interest rate environment. In addition, changes in Treasury yields have a direct impact on capital markets, which in turn affect economic activity and ultimately the macroeconomy. [4] stated that the short-term bond yields have relatively significant transmission effects on some output variables, such as consumption, investment, and the consumer price index, which are the macro indicators we concerned.

**Results Analysis**

**Conclusion**

**Reference**

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