565 Project:

Forecasting the Federal Funds Effective Rate (1954-2023): A Time Series Analysis Incorporating the Taylor Rule

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Executive Summary:

This project endeavors to enhance the accuracy of forecasting the Federal Funds Effective Rate (FEDFUNDS) by integrating time series analysis, particularly ARIMA modeling, with the traditional Taylor Rule approach. The Federal Funds Rate is a pivotal tool influencing economic activity, making precise forecasting imperative for effective monetary policy decisions.

Through extensive time series decomposition, autocorrelation analysis, and ARIMA modeling, we examined the FEDFUNDS rate's historical data. Our findings indicate that non-seasonal ARIMA models, notably AR(1), offer superior forecasting accuracy compared to Taylor Rule-based econometric models. These ARIMA models strike a balance between simplicity and precision, showcasing lower Akaike Information Criterion (AIC) values.

Furthermore, we evaluated model performance using logistic regression, simulating the Federal Reserve's decision-making framework. Our analysis revealed that while both econometric and time series models struggled to predict policy responses during exceptional economic events like the Global Financial Crisis, the AR(1) model consistently outperformed all evaluated Taylor Rule variations.

Overall, this research underscores the efficacy of advanced statistical methods in economic forecasting, advocating for their incorporation into policy formulation processes. By providing more accurate predictions of the FEDFUNDS rate, these methodologies empower policymakers and market participants to make informed decisions, fostering economic stability and growth.

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565 Final Project Report

Abstract:

This paper addresses the question of how time series techniques, particularly ARIMA modeling, can improve the forecasting accuracy of the Federal Funds Effective Rate (FEDFUNDS) compared to traditional econometric models, such as those based on the Taylor Rule. Our objective is to develop a performance model that provides more precise guidance for monetary policy decisions and serves as a viable alternative to conventional econometric approaches. The importance of the FEDFUNDS rate in economic policy-making—due to its direct impact on borrowing costs and economic spending—necessitates the refinement of prediction models.

Our analysis employs extensive time series decomposition, autocorrelation (ACF), and partial autocorrelation analyses (PACF) to address initial nonstationarities confirmed by Augmented Dickey-Fuller (ADF) tests. By applying ARIMA and Seasonal ARIMA modeling, and comparing these with the Taylor Rule which adjusts rates based on inflation and output deviations, we highlight the models' ability to adapt to economic dynamics. A logistic regression approach adapts the Federal Reserve's methodology to quantify and compare the predictive accuracy of each model. Results indicate that non-seasonal ARIMA models, particularly an AR(1) model, provide a superior balance of model simplicity and forecasting precision, showing lower Akaike Information Criterion (AIC) values than those observed in Taylor Rule models.

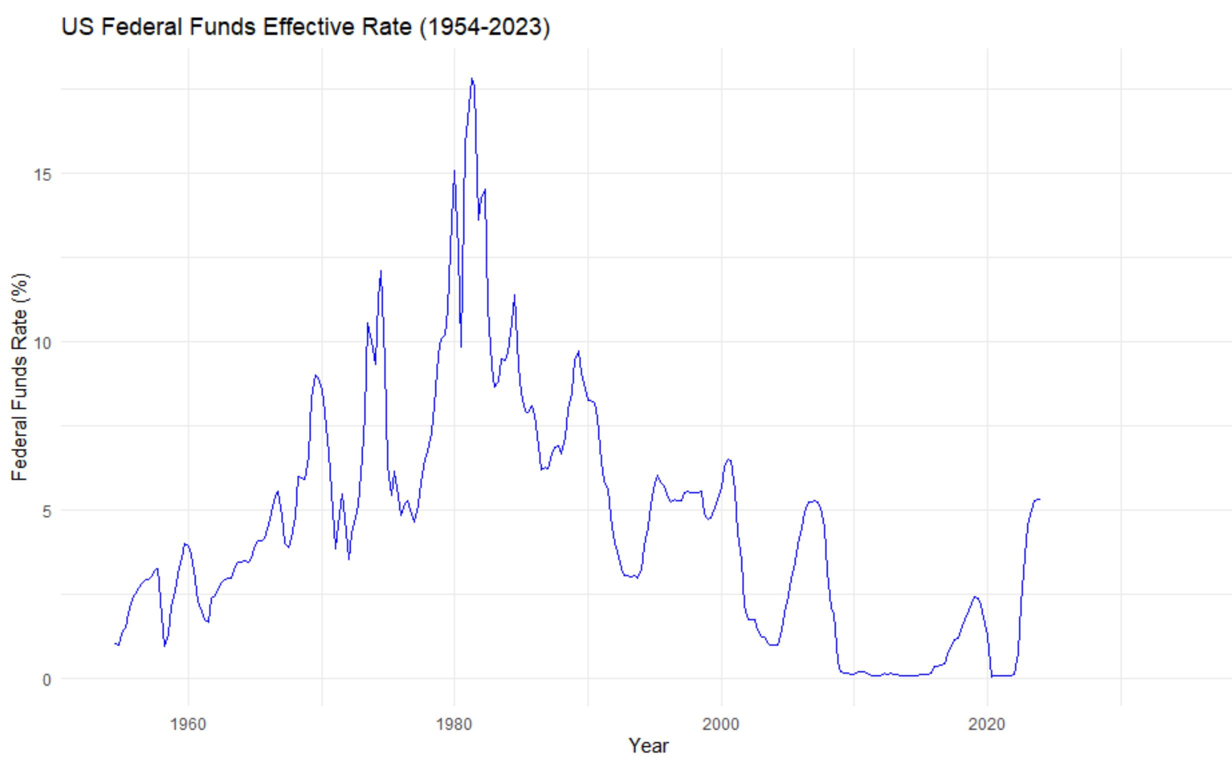
This research demonstrates that advanced statistical methods significantly enhance the predictability of crucial economic indicators, offering robust tools for policymakers and market participants. Our findings advocate for a shift towards more empirically driven approaches in economic forecasting and policy formulation.

Introduction:

1. Research Context and Objectives

This study is propelled by the following research question: How can time series techniques, including ARIMA modeling, enhance the forecasting accuracy of the Federal Funds Effective Rate (FEDFUNDS) when compared to traditional econometric models? Addressing this question is critical as the effectiveness of these forecasting models directly influences monetary policy decisions. Consequently, the primary objective of our research is to develop and offer a performance model that not only challenges but potentially surpasses the predictive prowess of existing econometric models, thereby providing more reliable guidance for monetary policy frameworks.

We create a time series plot of the FEDFUNDS rate below.[1]



2. Importance and Role of the FEDFUNDS Rate

The FEDFUNDS rate, a critical economic tool set by the Federal Reserve, plays an indispensable role in shaping the U.S. economy's landscape. By influencing the cost of borrowing and spending, it directly impacts economic activity and health. Historically, its fluctuations have mirrored or responded to economic conditions: rates escalated to nearly 20% during the inflation surge of the late 1970s and plummeted to almost zero during the Great Financial Crisis in the 2010s as part of a strategy to counteract economic downturns and stimulate growth. The responsibility of setting this rate lies with the Federal Open Market Committee (FOMC), which aims to target economic stability and growth through its policy decisions.[2]

3. Necessity of Advanced Analytical Techniques

The compelling need for precise forecasting of the FEDFUNDS rate is underscored by its significant implications for both economic policy and market dynamics. Enhanced predictive accuracy can facilitate more informed policy-making, potentially leading to more effective management of economic stability. Time series analysis, with its focus on understanding and leveraging patterns within data over time, offers promising avenues for predicting likely shifts in the FEDFUNDS rate, thus supporting the FOMC and other stakeholders in their strategic planning and decision-making processes.

Methodological Overview:

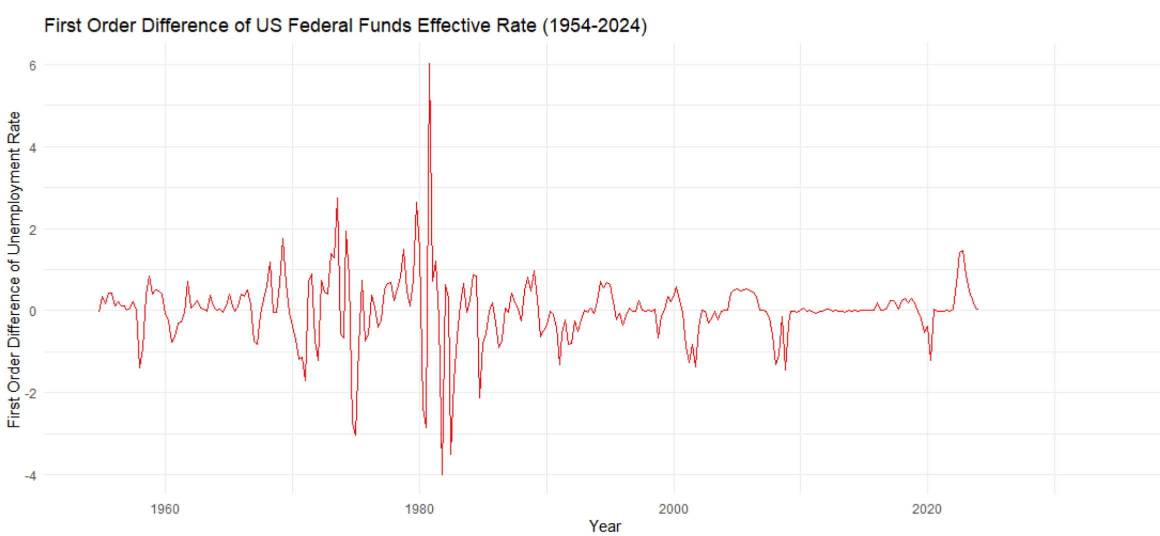
Our analytical approach incorporates several key techniques:

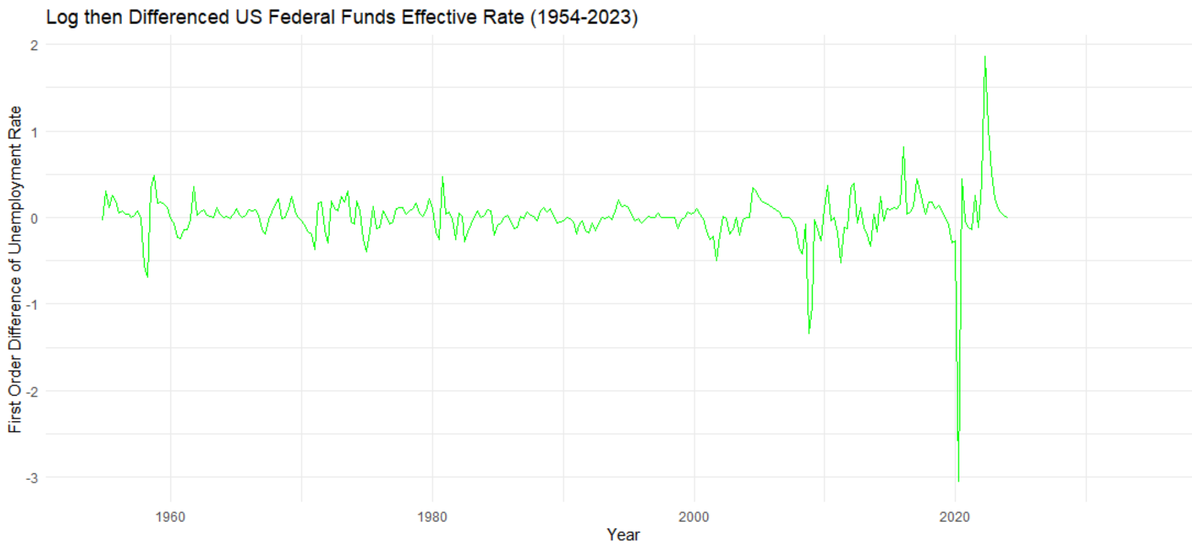
- Time Series Decomposition: We break down the historical data to understand underlying trends, cycles, and irregular components.
- Autocorrelation and Partial Autocorrelation Analysis: These tools help identify the nature of the statistical relationships within the time series data.
- ARIMA Modeling: We apply ARIMA and Seasonal ARIMA models to forecast future values based on both non-seasonal and seasonal factors.

- Comparative Analysis with Econometric Models: Specifically, we compare the forecasting results of our ARIMA models against those derived from econometric models based on the Taylor Rule.
- Model Evaluation: Through rigorous testing and validation, we assess the performance of each model to determine its effectiveness in accurately forecasting the FEDFUNDS rate.

Time Series Decomposition & ACF/PACF Analysis:

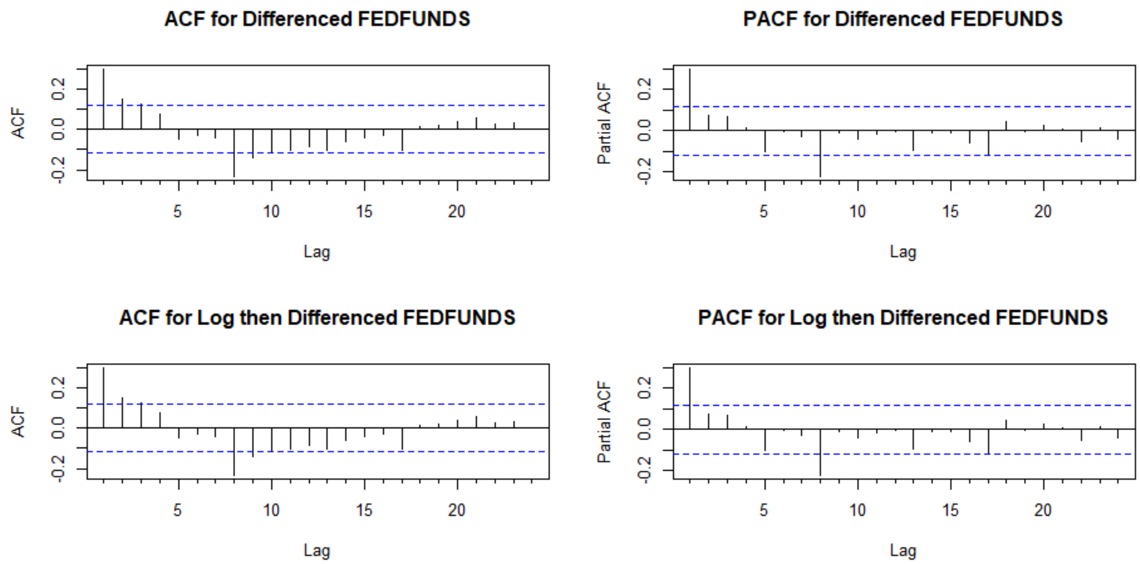
In our analysis, we initially assessed the stationarity of the Federal Funds Effective Rate using the Augmented Dickey-Fuller (ADF) test on the original data series, which showed non-stationarity with a p-value of 0.1816. This finding necessitated the application of a first-order difference, after which the ADF test confirmed stationarity with a p-value less than 0.01, making the series suitable for ARIMA modeling. Despite this transformation, the differenced series exhibited notable variances during key historical periods, especially around the 1980s, likely reflecting the Federal Reserve's monetary policy response to stagflation. These variations were visualized in the plot of the differenced rate, providing a clear graphical representation of the data's fluctuations over time. We note the first order difference of the rate below.





Similarly, the log transformation of the FEDFUNDS rate followed by a first-order difference also achieved stationarity, indicated by an ADF p-value significantly less than 0.01. The log differenced rate highlighted variances particularly around 2008 and the early 2020s, periods marked by the Global Financial Crisis and the COVID-19 pandemic, respectively. These economic disruptions visibly influenced the rate's behavior, as seen in the log differenced rate plot.

To further analyze the data, we also employed Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots for both the differenced and log differenced rates. We show the results below; most of the lag spikes are within the dashed line bounds, meaning that models can be employed for ARIMA modeling.



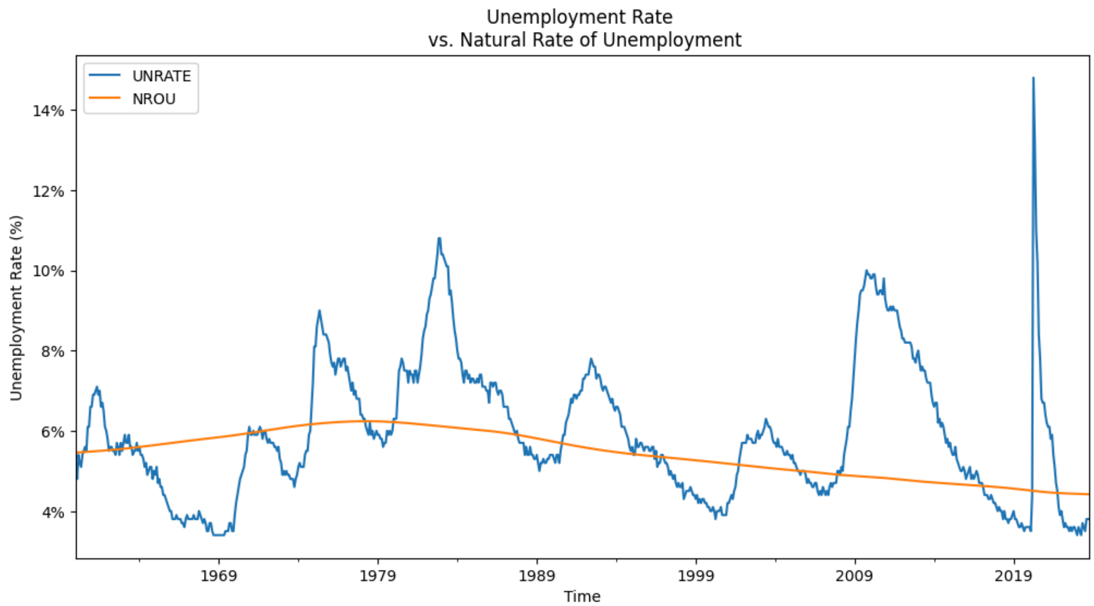
ARIMA Modeling:

In the selection of ARIMA models, simple models such as AR(1), MA(1), and ARMA(1,1) served as initial benchmarks due to their simplicity and effectiveness. However, ARIMA(3,0,7) emerged as the optimal model, balancing complexity and fit, as evidenced by its low Average Squared Errors (ASE) and diagnostic checks via EACF plots. Although ARIMA(14,0,4) presented the lowest Akaike Information Criterion (AIC), suggesting a good fit, its high parameter count raised concerns about overfitting, which could compromise its utility in broader applications. Examination of seasonal, multiplicative, and ARCH/GARCH models did not show significant improvements in AIC post-adjustment, leading to the conclusion that non-seasonal ARIMA models were more appropriate for this analysis.[3,4]

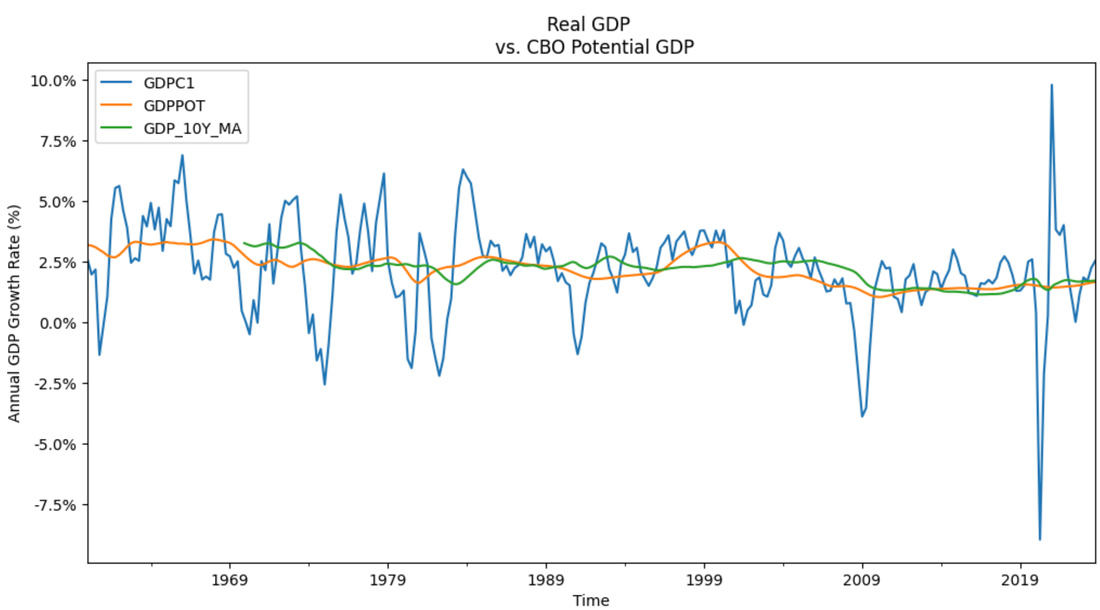
Consideration of Competing Econometric Models

The FOMC's decisions are made on a discretionary basis, however, these opinions are formed based on indicators of current economic conditions and their relationship to the Federal Reserve's mandates from Congress: to maintain price stability while maximizing employment to its full potential.[5,6]

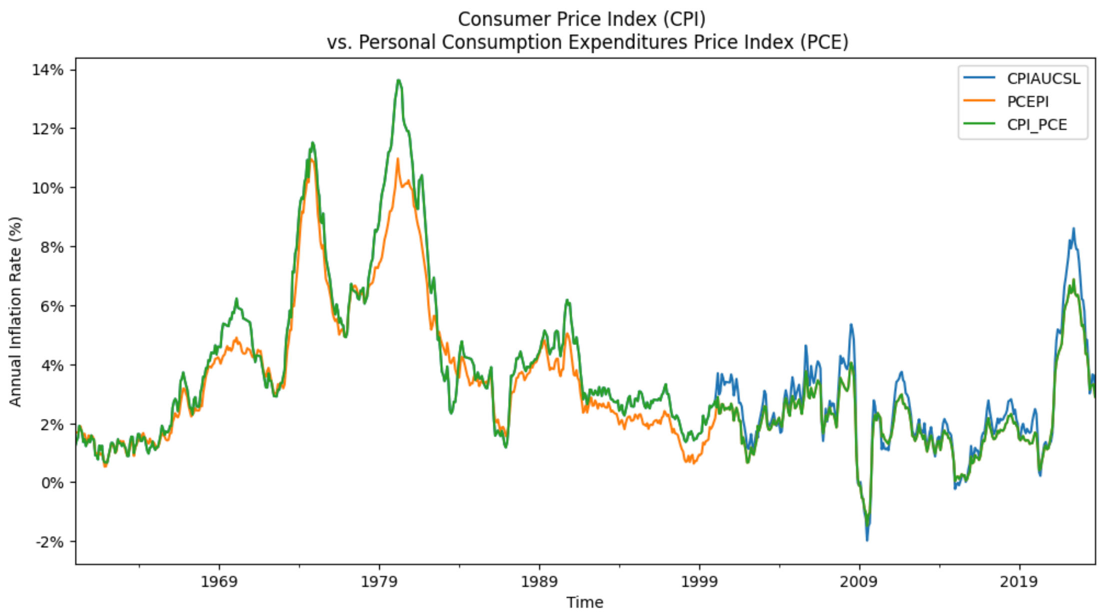
Among many indicators that the FOMC considers, some of the most important in its mandate of maximizing are comparing the current unemployment rate (U-1) to the “Natural Unemployment Rate” published by the Congressional Budget Office.



Additionally, Real Gross Domestic Product (GDP, adjusted for inflation) growth may be compared to the expected levels of growth either by comparison to some historical trend, or to a forward-looking expectation such as the Potential GDP published by the CBO.



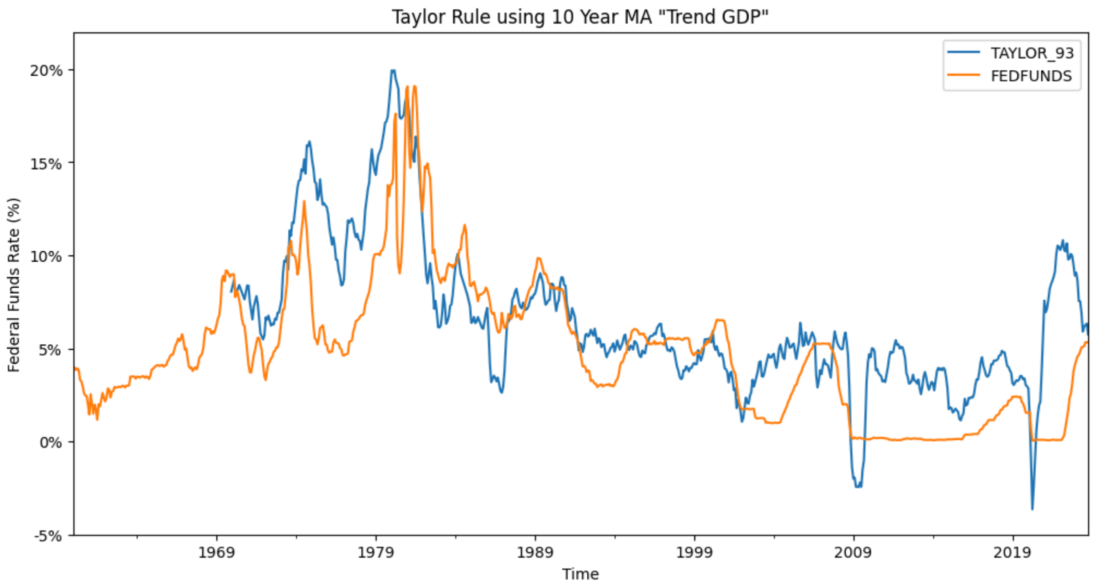
Historically, the Federal Reserve benchmarked its policy to its price stability mandate using the Consumer Price Index (CPI) as its measure of inflation. However in January 2000, under Chairman Greenspan, the Federal Reserve adopted the Personal Consumption Expenditures Price Index (PCE) as its replacement, citing that CPI had erroneously overestimated inflationary pressures in previous cycles and pragmatic benefits in the index's methodology/construction.[7]



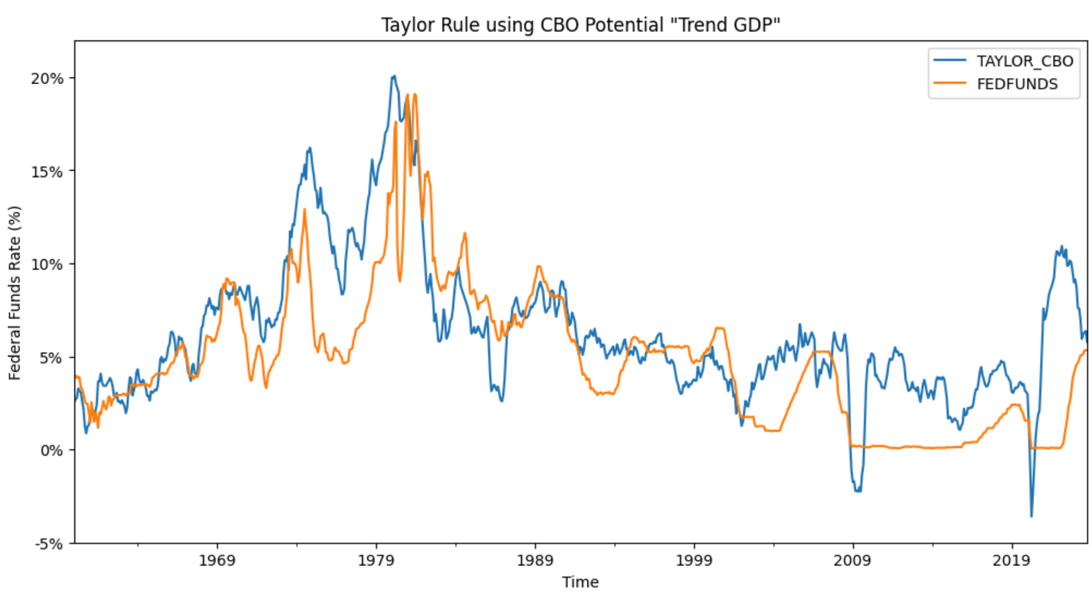
Economist John Taylor's 1993 paper would influence how the Fed benchmarks its policy to the environment. Taylor proposed a simple model, not aimed at mechanical policy, but as a benchmark for where the Fed may wish to target rates given the current economic conditions.

He discusses how there is no consensus on how rates should be benchmarked. He offers his variation based on "weighted deviations of the inflation rate (or the price level) and real output from some target."

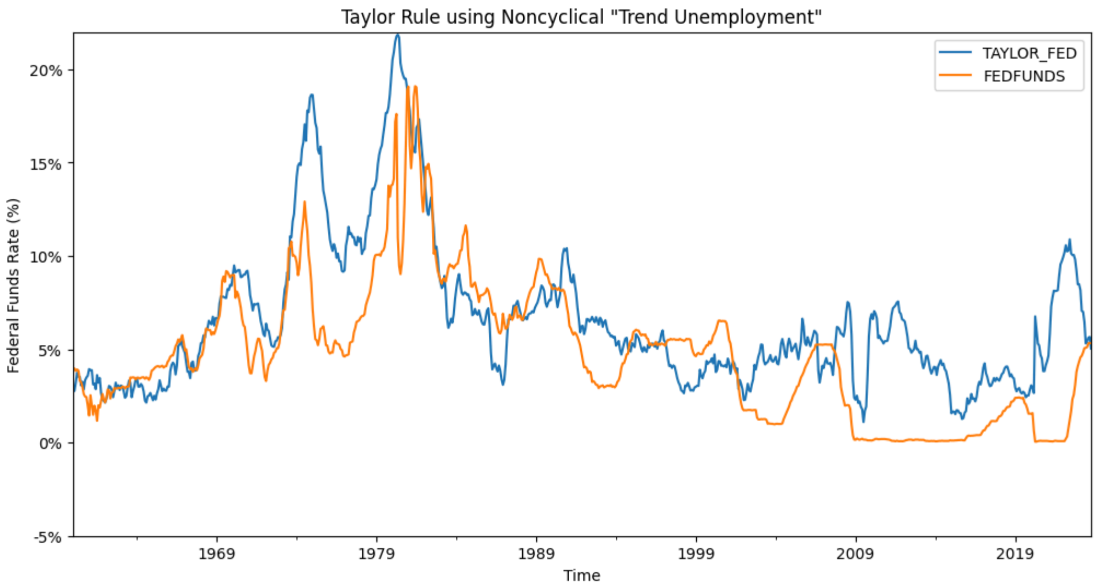
Taylor suggests the Fed place a long-term target inflation rate of 2%. To achieve this, rates should reflect the target inflation + current inflation + ½ weight to the difference in current inflation versus the target + ½ weight to the difference in current GDP growth versus the historical trend GDP. Specifically, Taylor uses 2.2% Real GDP growth as the trend GDP. This was the average annual growth rate from 1984 to 1992.



However, as previously mentioned, forward-looking expectations published by the Congressional Budget Office may provide a better understanding of the current landscape if future growth is not expected to follow the historical trend.[8]



Alternatively, the Fed may replace GDP expectations with its expectations for employment directly.[8]



Each of these model variations are, in general, referred to as “Taylor Rules”.[5-8]

<u>Model Evaluation</u>

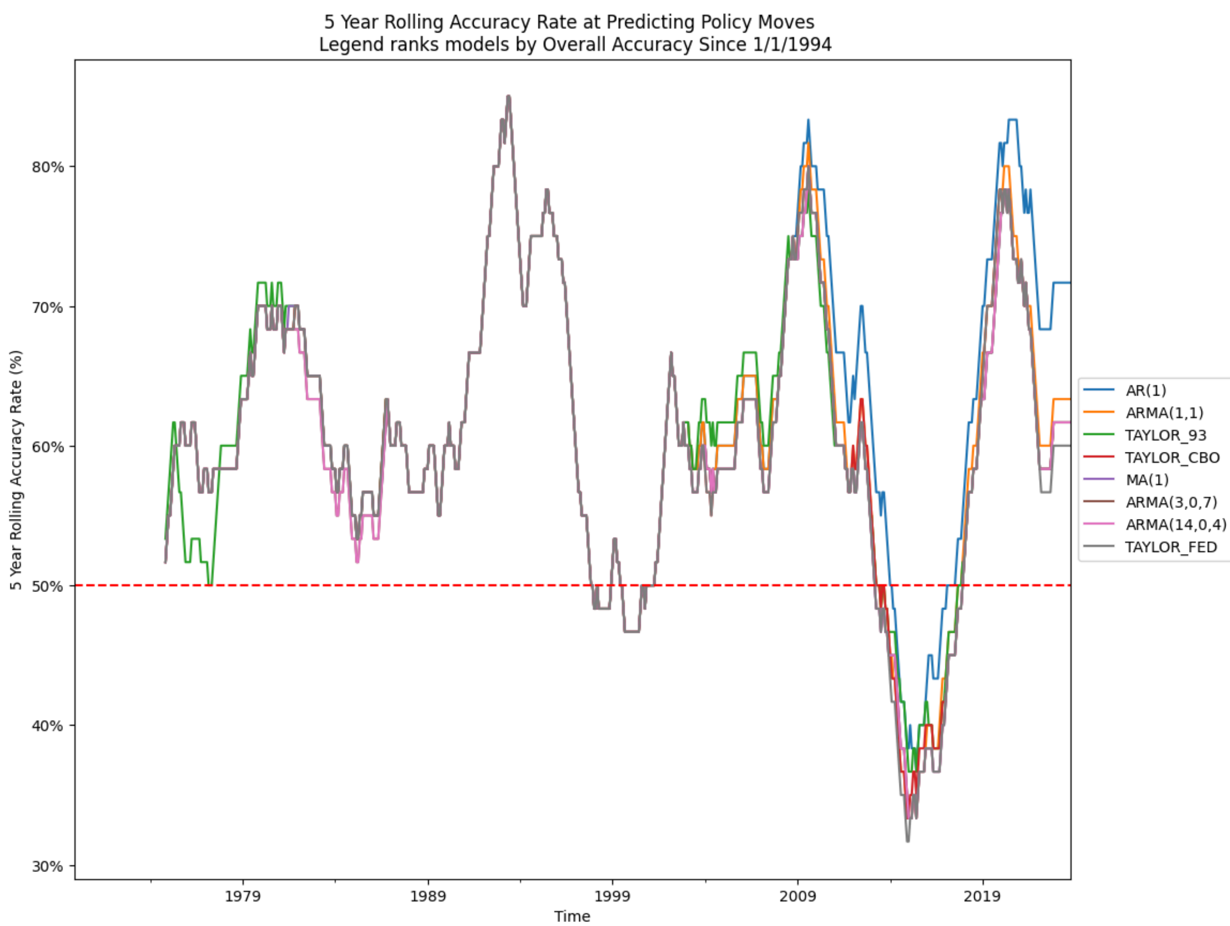
In evaluating model performance we adopt a similar approach to that used by the Federal Reserve in analyzing variations of the Taylor Rule, and their accuracy at predicting future policy moves.

A 2014 article by the Federal Reserve Bank of Cleveland suggests the following model: If the Taylor Rule exceeds the current FEDFUNDS rate by more than 150 basis points (bps), the Fed will likely increase the rate in the subsequent quarter. Conversely, if the Taylor Rule falls short of the current FEDFUNDS rate by less than 150 bps, but the Fed had raised the rate in the preceding quarter, it is expected to raise it again.

This 150 bps threshold is pragmatically determined by the Fed as a "significant deviation." Given the potential limitations of fitting the time series model within the confines of the 150 bps framework, we propose a generalized approach using Logistic Regression.

In this methodology, the response variable is categorized into three outcomes: -1 (indicating a decrease in the FEDFUNDS rate in the next quarter), 0 (suggesting no change), and 1 (signifying an increase in the FEDFUNDS rate in the next quarter). The predictors include the difference between the model (either a Taylor Rule or ARIMA) and the FEDFUNDS rate, as well as the response variable from the previous quarter. This methodology allows for a more adaptable framework in predicting the Fed's actions, accommodating variations in model fit regardless of whether they are an econometric or time series model, as well as explicitly capturing the influence of previous quarter decisions on future rate adjustments.

Using this framework, we produce a rolling one-step forecast with an expanding training window over the time series. Then to assess model performance, we measure the accuracy rate in predicting the previous 60 months' response variables. Additionally, we rank the models by their overall accuracy for the last 30 years - and the publication of the original 1993 Taylor Rule.[5-8]



Discussion: Findings and Limitations

We find that the performance of both econometric and time series models are correlated, perhaps indicating a series of decisions made by the Fed on information not present in any of the models. For example, we find that all models encountered challenges in accurately predicting the policy response to the Global Financial Crisis (GFC).

Between 2008 and 2015 the Federal Reserve implemented a Zero Interest Rate Policy (ZIRP) in an attempt to encourage lending/provide liquidity under tight conditions, aid in the re-stabilization of the financial markets, as well as provide pressure against deflation.[9] Severe model performance degradation coincides with this period. The severity and persistence of the response to GFC appear to fall outside the bounds of the Taylor Rule's assumptions, as well as the time series models'.

Taylor's original 1993 model demonstrated an accuracy of over 80% at the time of its publication. However, its predictive ability diminished substantially in the years following its adoption by the Federal Reserve, performing less effectively than a random coin flip. Nonetheless, among the econometric models examined, the 1993 model retained the highest level of predictiveness.

We note the dispersion in performance among all models was notably narrower prior to 2000, but has since widened significantly. During the last assessment period spanning from October 2018 to 2023, the AR(1) model consistently outperformed every evaluated Taylor Rule by a margin of at least 10%.

Conclusion:

In conclusion, our study shows how time series analysis techniques, particularly ARIMA modeling, can be an effective tool in forecasting the Federal Funds Effective Rate (FEDFUNDS). By comparing these methods with traditional econometric models such as the Taylor Rule, we demonstrate the superiority of ARIMA models in terms of forecasting accuracy.

The Federal Funds Rate plays a crucial role in shaping economic activity and stability, making precise forecasting essential for effective monetary policy decisions. Our research shows that ARIMA models, particularly the AR(1) model, offer a better balance of simplicity and precision compared to Taylor Rule-based models. This finding suggests that policymakers and market participants can benefit from incorporating advanced statistical methods into their decision-making processes.

Furthermore, our evaluation of model performance using logistic regression has provided insights into the predictive capabilities of both econometric and time series models. While challenges remain, particularly during periods of economic upheaval such as the Global Financial Crisis, our analysis indicates that ARIMA models consistently outperform Taylor Rule variations.

Overall, our study advocates for a shift towards incorporating time series modeling approaches in order to benchmark policy by the Federal Reserve. As we look to the future, continued research and refinement of these forecasting techniques will be essential in ensuring the resilience and effectiveness of monetary policy frameworks in an ever-changing economic landscape.

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Coding Files and Datasets (CSVs):

https://github.com/NizamIfar/565Project

Contributions:

Ryan McKinney contributed by conducting Taylor Rule expansion and modeling, evaluating models, and handling Python coding tasks. Mazin Rafi contributed to the project by conducting ARIMA analysis, performing R coding tasks, and preparing files and materials.