Predicting Both the FedFunds Rate & the Talyor Rule Seeing Comparisons

Introduction to Problem & Data

Problem Statement

Recently over the summer, I worked at an internship where I had to be very aware of the fed funds rate and any changes that may have happened. This semester, I also took Economics of Global Business, and recently, we went over the Fed's tools to control inflation. One is the effective funds rate or the rate at which banks borrow from one another. This is very important and influential as it is one of the main tools used by the Fed to control inflation, and it has a massive impact on the financial system. Altering the fed funds rate has the ability to increase or decrease the money supply in the economy as depending on the rate banks will be either incentivized to loan out money (low rate environment) or rather hold onto reserves (high rate environment). In that course, we also learned about the Taylor Rule, which is a strategy that helps determine at what level should the funds rate be set depending on factors such as inflation and GDP growth. This model will try to predict future rates based on historical data in the past and use it to model what has happened previously given the situation we are in economically. I believe comparing both the fed funds rate and the Taylor rule, will be interesting to see if the models predict similar trends or if differing trends are reflected. This model will be useful and helpful to understand what rate environment the US may be entering based on historical precedent. This model will be useful for those involved in the financial industry along with those looking for a mortgage, as these fluctuations in rates have an immense impact on the 10-year treasury, mortgage rates, and other debt instruments.

Dataset Description

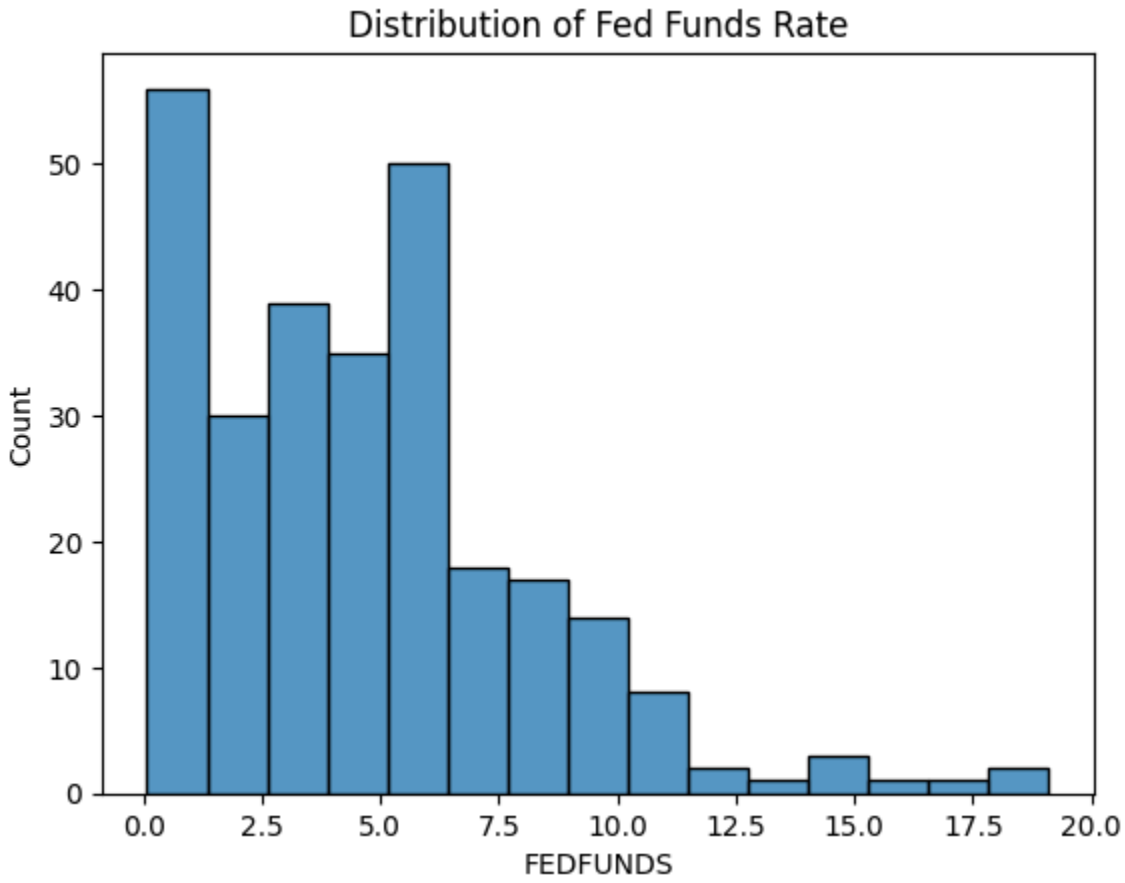
Data for this project is sourced from FRED in CSV format, providing necessary information regarding the changes in rates and other economic indicators in the United States. The data was uploaded to a GitHub and I attached the link so anyone could call the same information I pulled. The economic indicators pulled were CPI, GDP Price Deflator, Taylor Rule, GDP Growth Rate, and Potential GDP. The data will need to be attended to as it requires cleaning and formatting to be able to properly run the models in the following steps. As some of the columns have more data points than others, I want to ensure they all have an equal amount. Not only that each column have an equal number of values, but also that the years and quarters involved are the same throughout. Also note that it may be difficult to model the data as there is no real trend or seasonality, as the fed funds rate and Talyor rule are dependent on other economic factors. Therefore, due to the volatility, the models may struggle to accurately predict the coming years. I hope that at least some general trend of which direction the rates are going and for how long can be agreed upon by the end.

This dataset will go from 1955 Q1 until 2024 Q1.

Data Pre-Processing & Preliminary Examination:

The updated dataset that I will be working on contains all the information for the next models.

Interest Rate Markov regression



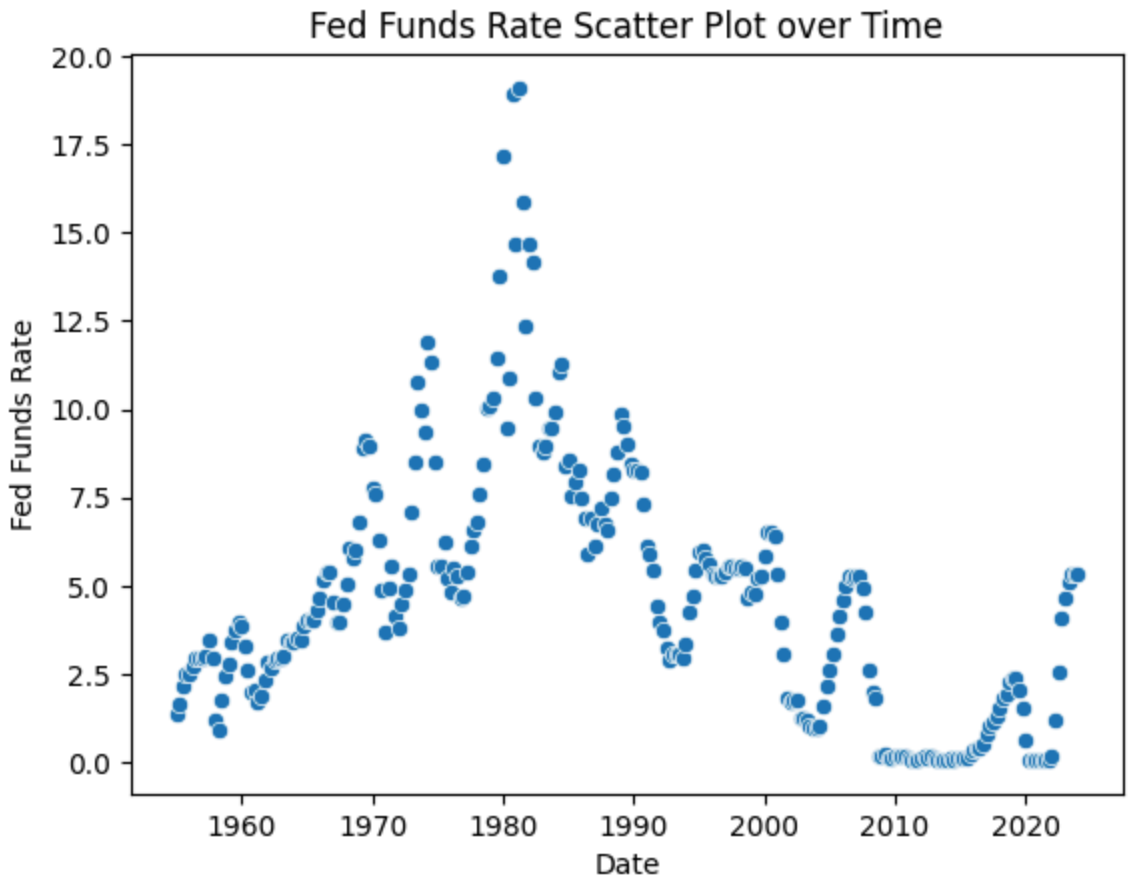
Here, we see that the data is right-skewed, meaning that the lower interest rates make up more of the Fed's policy than higher rates. This will be interesting compared to Markov's regression later in this report, particularly the differing interest rate regimes and how they compare to the given histogram.

4.641046931407942
Here, we see the mean effective funds rate in the US since 1955.

4.32
Here, we see the median effective funds rate in the US since 1955.

19.1
Here, we see the max fed funds rate.

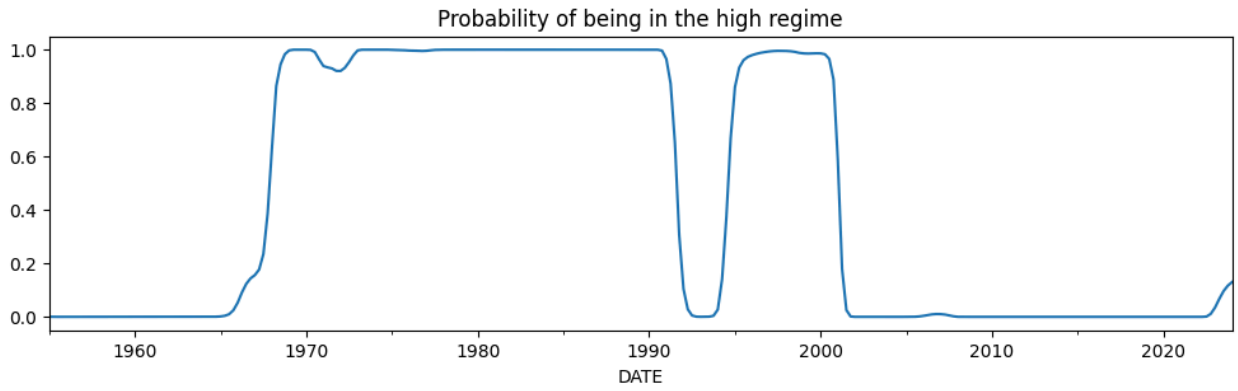
0.07
This was the lowest interest rate set by the Fed.



In the following scatter plot, we see somewhat of a general trend in rates they typically decrease after high rate peaks. Therefore, we shall see if models are able to predict and learn from the trends demonstrated here. Overall in the scatterplot, we see varying peaks and valleys over time reflecting high and low interest rate environments. More recently we have seen a shift, however toward lower rates at least compared to the 1980s and 90s.

In the following section, we will dive into Markov's regression model and examine what sort of regimes the rates fall under. Not only will we be classifying the interest rate regime, but we also will be able to examine the duration of the periods of each.

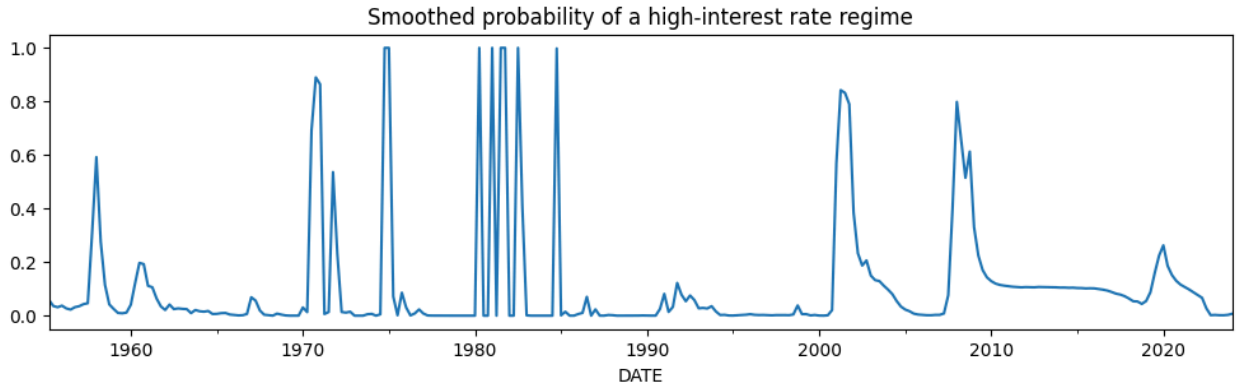
Here, I decided to pick two regimes to reflect a level of high and low interest rates, and sort the values accordingly.



Here we see a graph of the different interest rate regimes according to the Markov regression statistics.

[81.15152537 48.19996908]

This reflects the interest rate regime time frame for each rate, whether a high or low regime. Here, we see the high interest rate regimes in the last 81 quarters compared to 48 low interest rate regimes. Therefore, this demonstrates the period in which either regime was dominant compared to the other and the duration of said period in quarters.

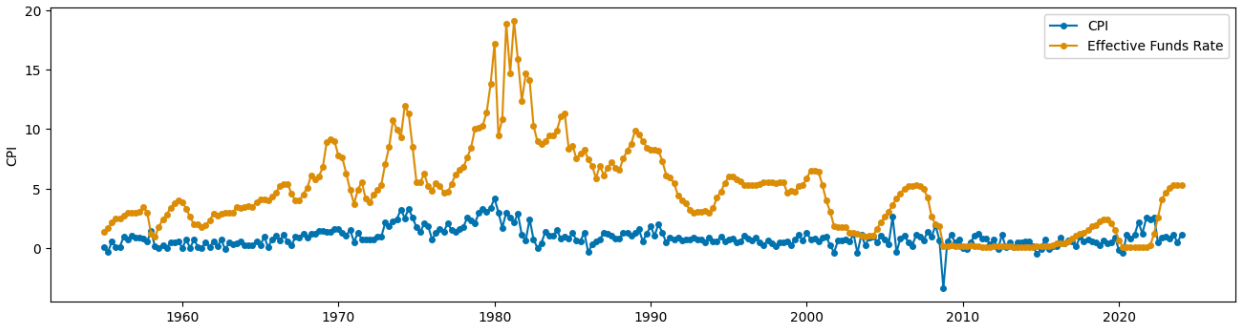


Here, we see the high interest rate regime graph and the probability of said interest rate regime.

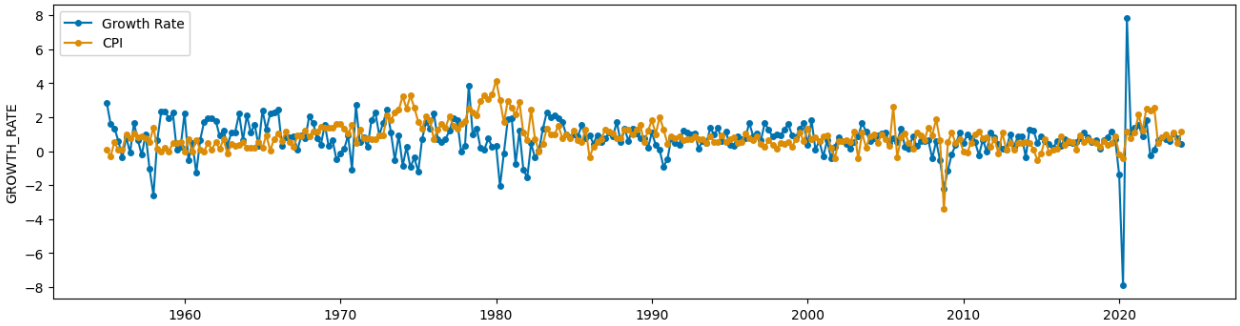
Interestingly, we see that over the 1970s-1980s we see massive peaks in sequence for the most part one after another. This makes sense as over this period the US was fighting stagflation and in response, the fed at the time decided to tackle inflation. However, more recently we have seen almost no peaks other than before the recession and in the most recent example after the COVID crisis.

[1.94354615 12.86990975 1.57230878]

Here, we measured three different regimes and the durations for each. High, Middle, and Low.

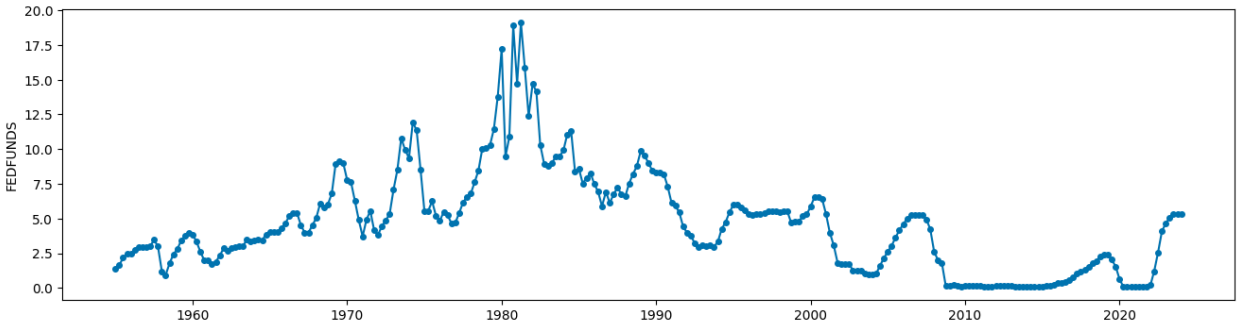


In this graph here, we are examining the impact the Fed funds rate has on inflation, as setting interest rates is one of the Fed's main tools to control inflation by altering the money supply in the economy for the country. Generally, we see when rates are higher, inflation typically decreases, as seen in the 1980s, for example. However, we see a deviation from this in the 2000s-2010 as a response to the financial crisis as we see rates follow a decline in inflation. This was most likely due to the Fed being late in lowering rates leading up to the 2008 financial crisis. More recently after the pandemic, we see a clear trend of the Fed increasing rates following a stint of inflation. This delayed response was most likely due to the recovery from the pandemic and the unstable economic prospects at the time. The Fed was also unsure if the inflation during that time frame was going to stick or if it was transitory due to the massive shock caused by the pandemic worldwide.

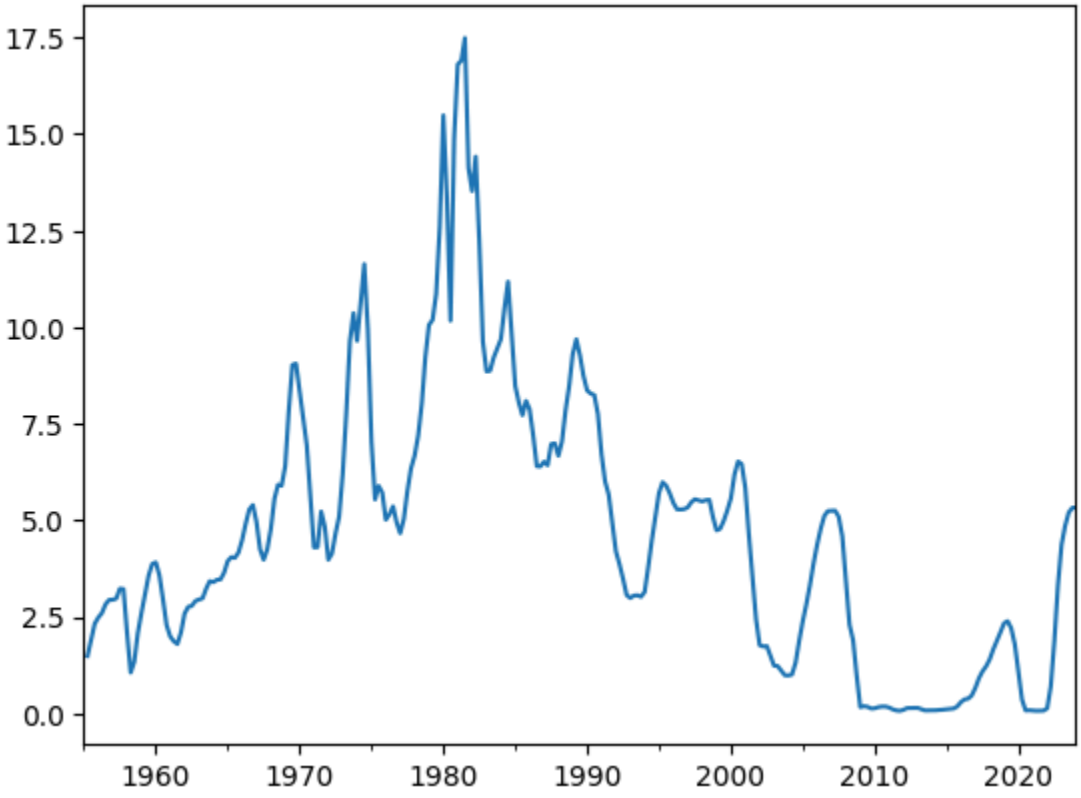


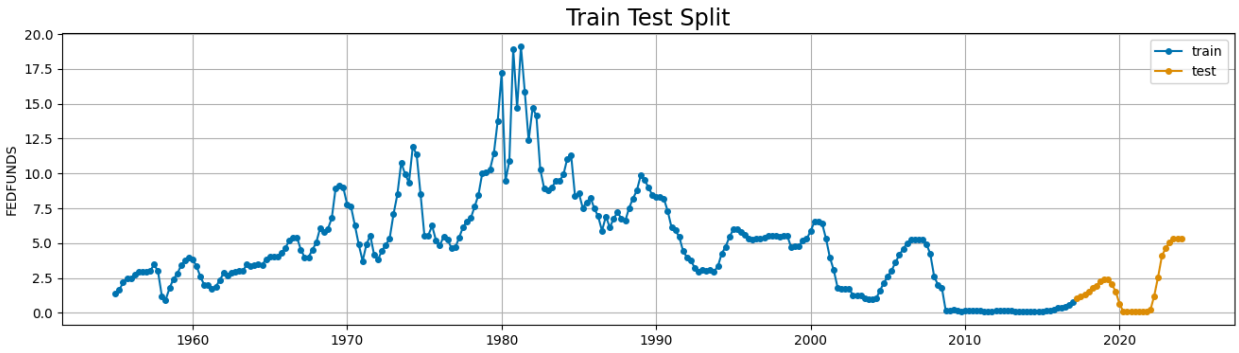
Here we see that in lower rate regimes we typically see higher economic or GDP output compared to when rates are at higher levels. For example when rates were very high in the 1970s-1980s we see an overall decline in economic output than when we are in lower rate eras. More recently, we have seen lower volatility when compared to previous years in terms of both growth rate and inflation. However more recently we have seen sharp inclines and declines in each due to the COVID pandemic that caused very low levels of output and inflation, followed by high levels of economic growth and then high inflation. We also interestingly see massive growth in the 1960s compared to the level of inflation for the period.

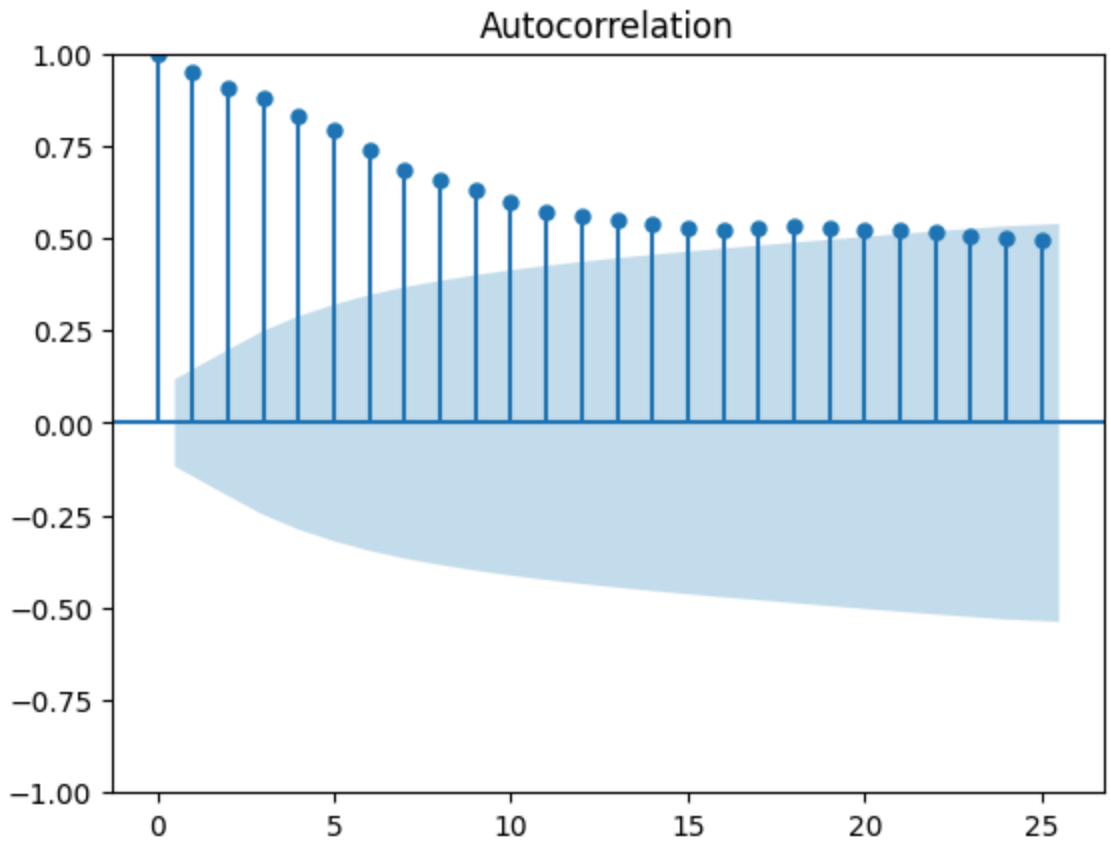
Effective Funds Rate



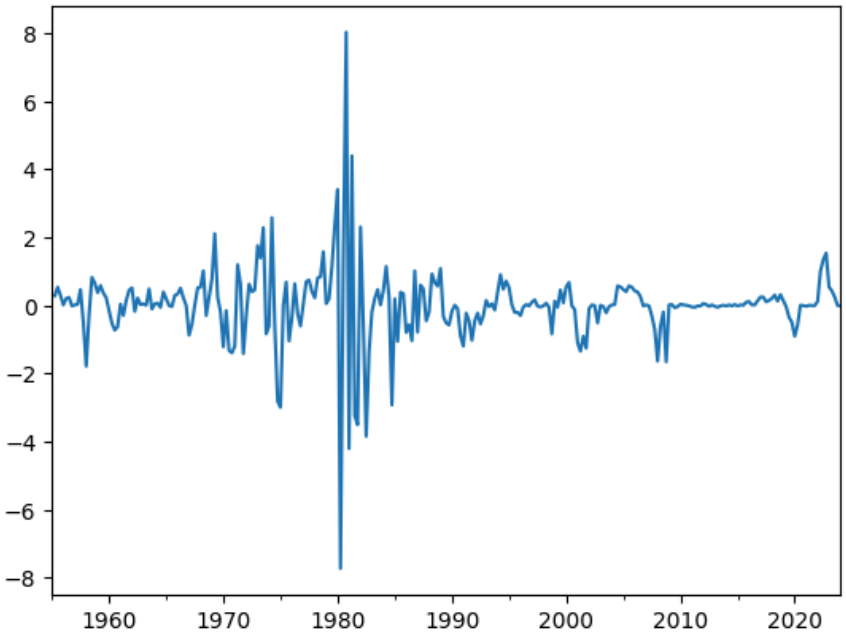
Here we are mapping the entire effective fund's rate from 1955 Q1 to 2024 Q1.

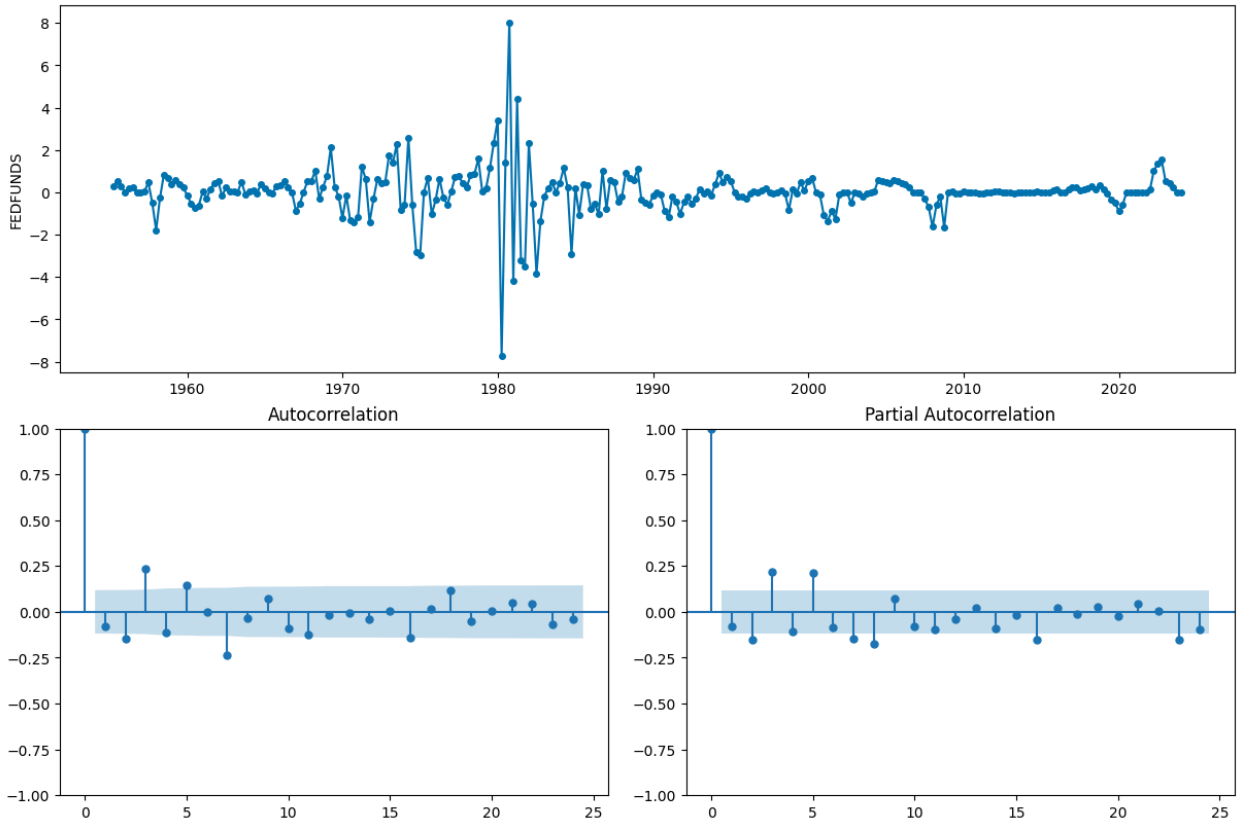






Here, we see a general trend of rates decreasing over time. This represents that the effective funds rate is correlated to itself, as all the values are somewhat correlated to the first value.





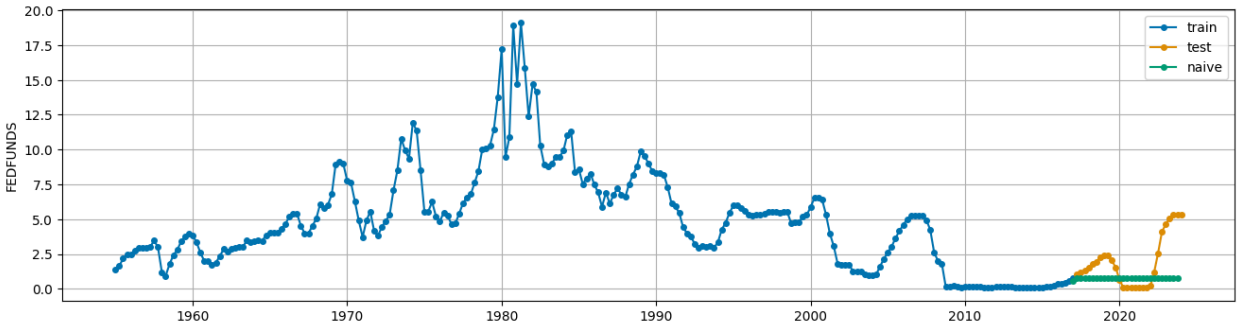
Now after differencing the data the data is no longer correlated and we removed the trend.

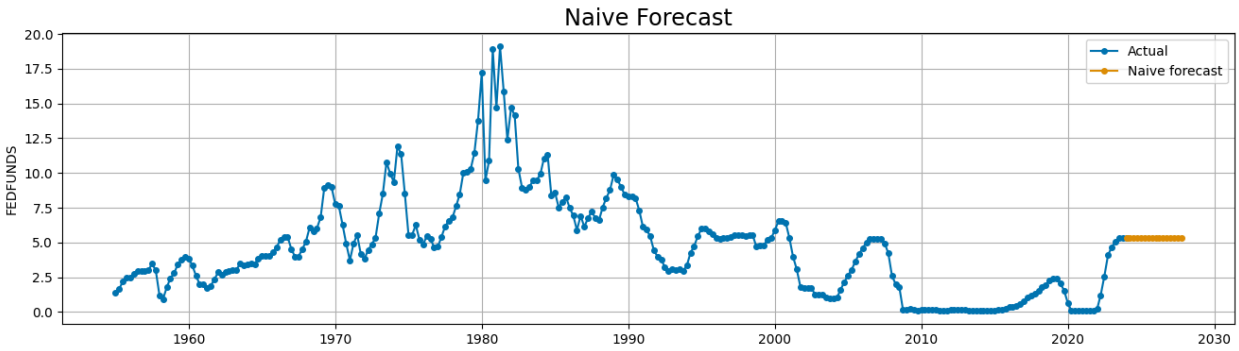
Fed Funds Rate Naive Model

Here we will create a naive forecast using the last value as our baseline model. Therefore, any subsequent models that we use will have to perform than if the fed made no change to rates at all. As we know in relative the fed has already cut rates at this period, but that will not be included.

MAE= 2.732196140513685

Here we see that the naive forecast is not at all in anyways able to predict the test data. This is shown by its 273% mean absolute error percentage.



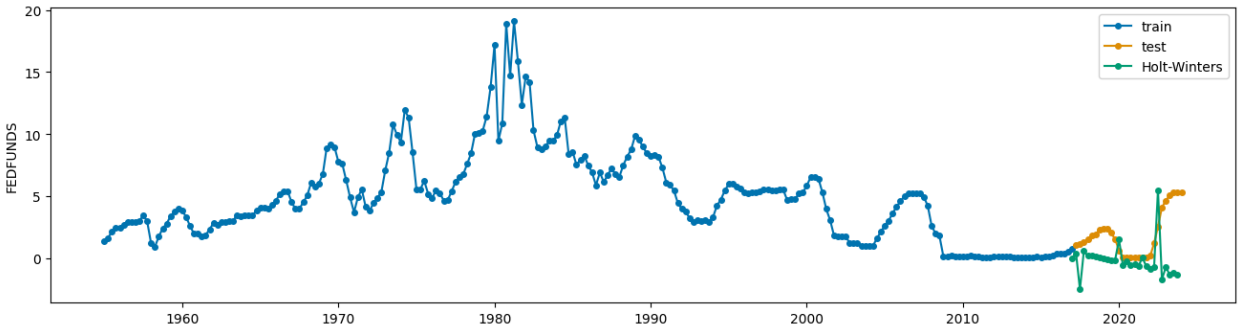


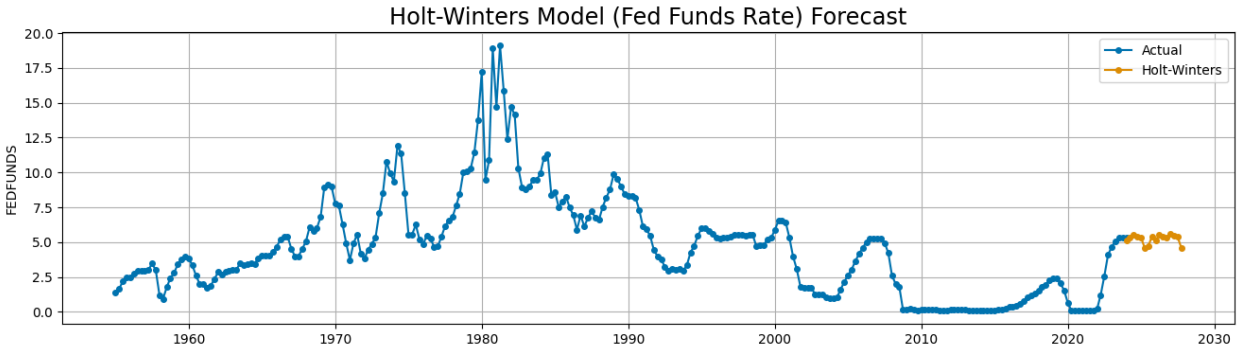
This here is our base model, which reflects that the naive forecast will predict that the last rate will last for the foreseeable future and will not change. We will compare our future models to this to see how accurate our following models will be.

Fed Funds Holt-Winters Model

The Holt-Winters model is an extension of the exponential smoothing model, by taking into account seasonality, trend, and steps. Here we chose 10 steps as it lowered the mae to the lowest level. I also decided to make the trend additive as it generally follows a downward trend recently as shown in the scatterplot, but for the seasonal parameter, I decided to classify it as multiplicative as the seasons themselves vary in size depending on the regime as exemplified in the 1970s-1980s compared to more recent times.

MAE= 2.8774035739101995

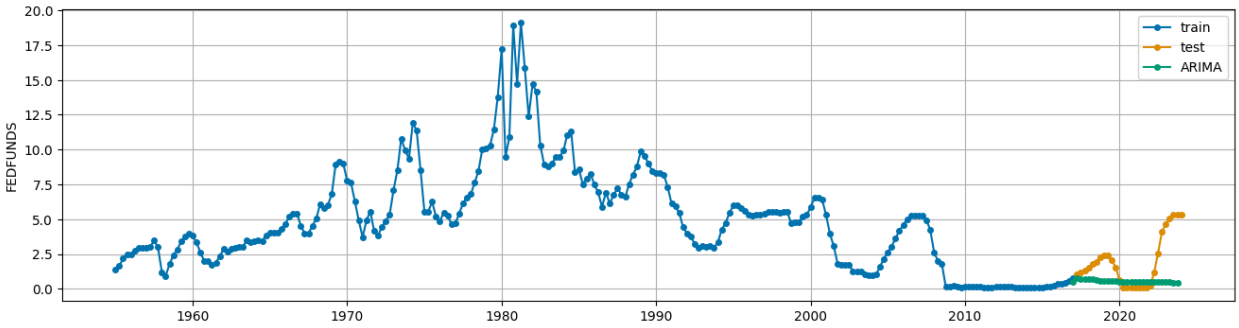


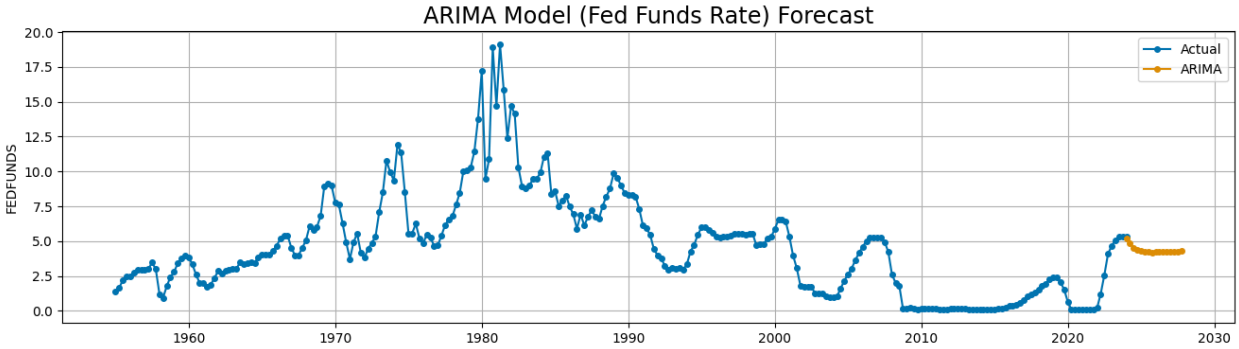


In this graph here we see that the Holt-Winters model predicts a downward trend in the coming quarters, although it goes back up and then back down. It possibly is oversimplifying the trends. This can be proven to be somewhat correct as the mae is very high and worse than the baseline model. It seems the model is unable to predict more gradual trends.

Fed Funds ARIMA Model

MAE= 1.8811905860121807

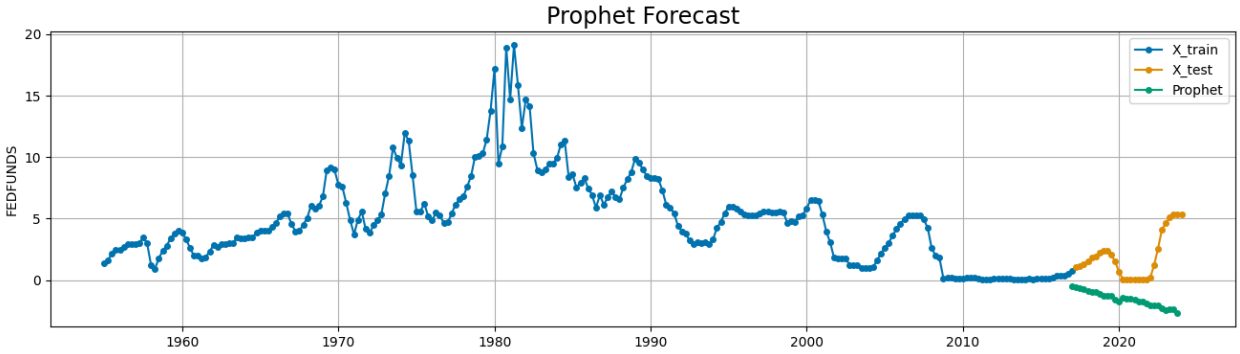


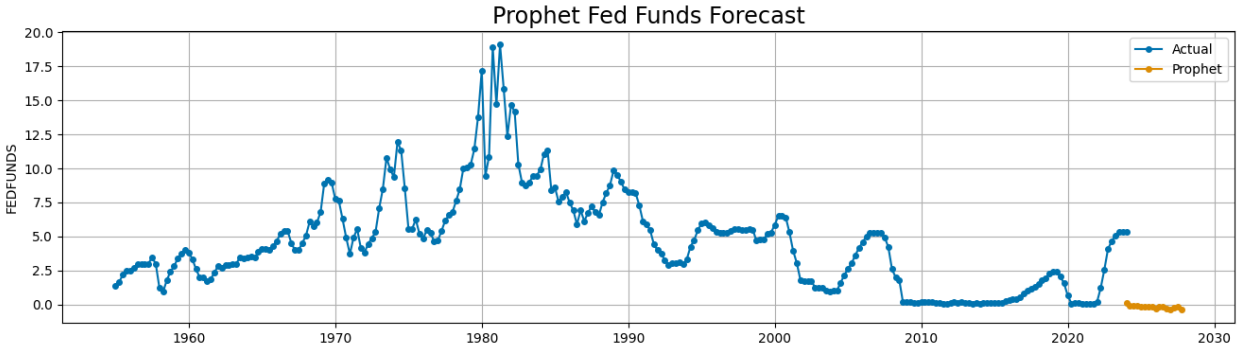


Here we see our best model yet outperforming our baseline. Although it is interesting how the model initially is able to predict a downward shift in rates in the coming quarters or fed meetings, after a certain point it seems that the model believes the fed will hold rates after. Maybe here the model is too gradual.

Fed Funds Prophet Model

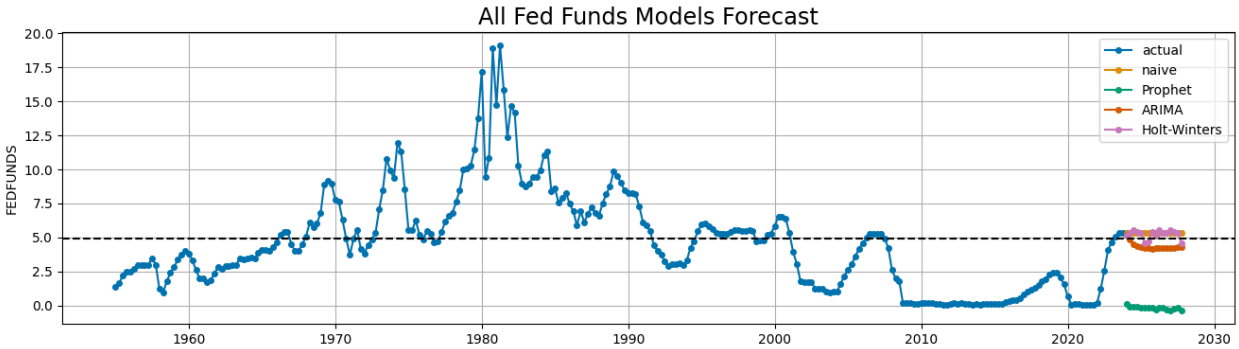
MAE= 6.752474100107571





All the previous models were models we tested in class. I thought it would be interesting to incorporate an outside model that I found while searching in hugging face. The model that made the most sense I thought was Facebook's prophet model, due to its easy use and its ability to pick up trends and apply them well. However it is important to note that the prophet model is typically used for more directly seasonal targets such as modeling ahead of holidays. Here, we see that the model heavily underperforms all the other models and its mae was absolutely worse than our baseline, meaning it is not a model that could be used to predict future fed funds rates.

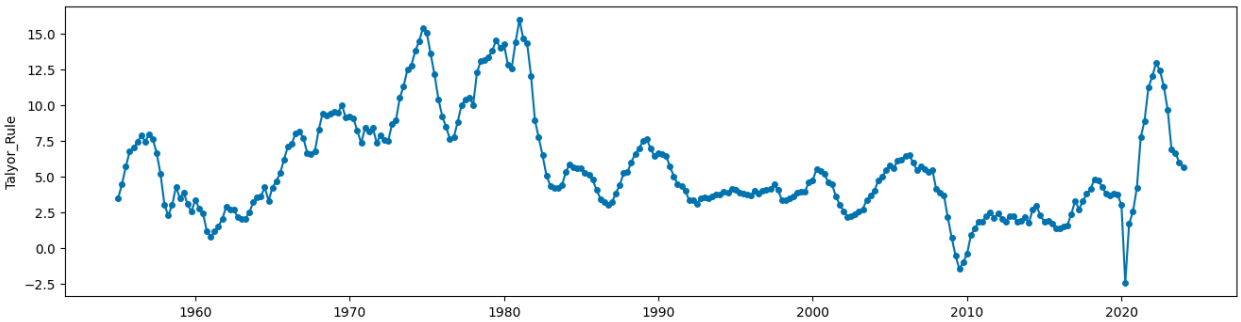
Fed Funds Overall All Models

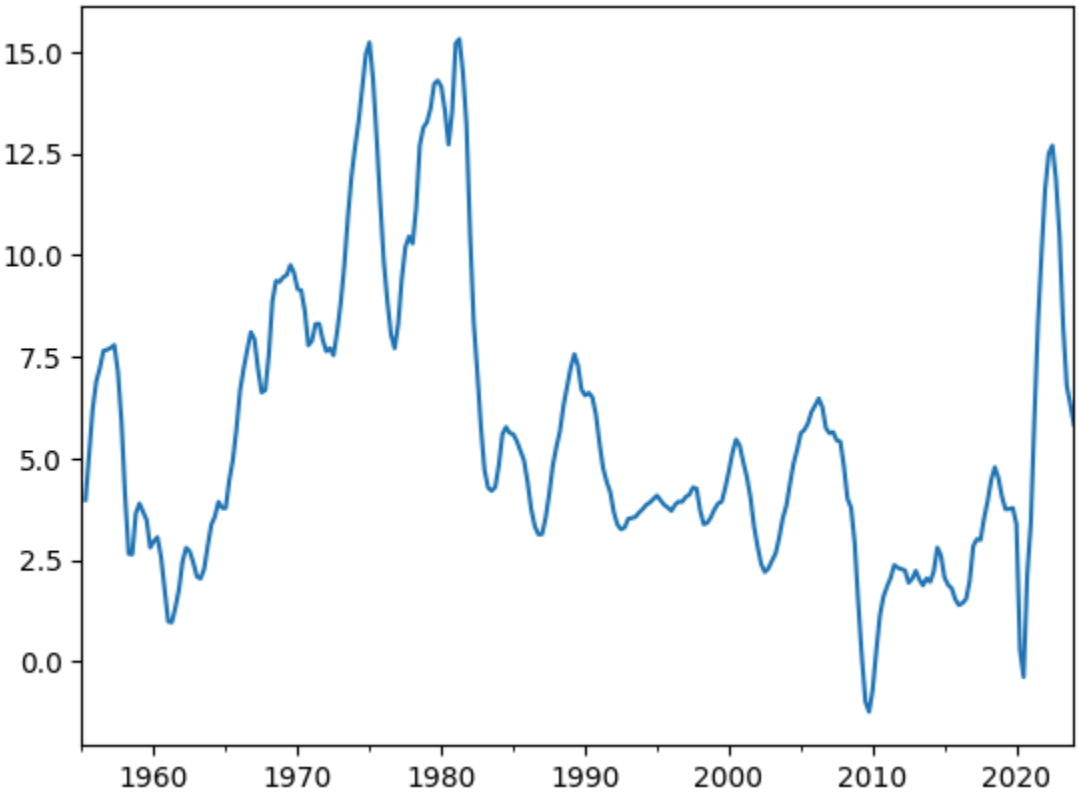


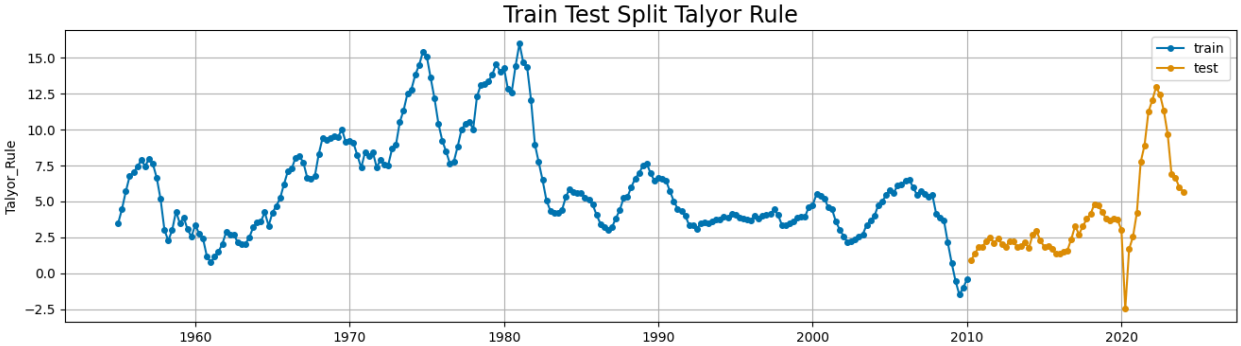
Here we see all the models reflected and also added the mean line of all the rates. Overall, the best performing model was the ARIMA model and it predicts a downward trend in the coming quarters although it flattens out. All the other models did not really outperform the baseline. Even then the arima model slightly outperformed the baseline when examining the train and test variables of the data.

Taylor Rule

Now will be examining the same models but in comparison to the Taylor rule to see if there is any overlap in the direction of the predictive models for the future.





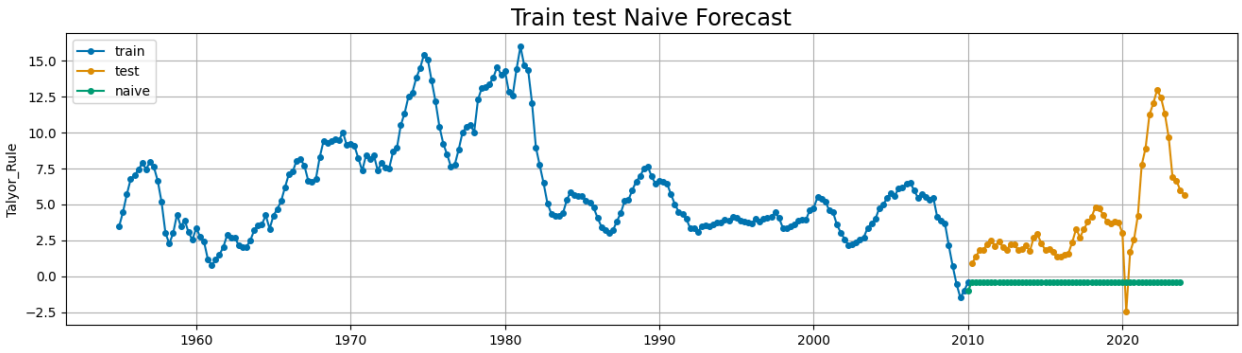


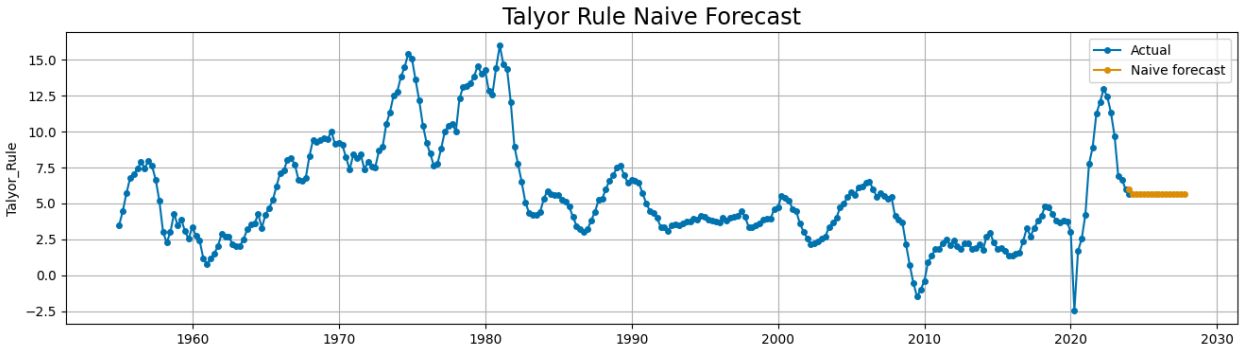
Talyor Naive

As done for the fed funds rate, in this report our baseline model will be the naive forecaster using the last value as our main form to compare models.

MAE= 1.1579201426540193

Here we see the naive forecaster has a very high mae, which makes sense as it is just predicting that rates will not change in the future.



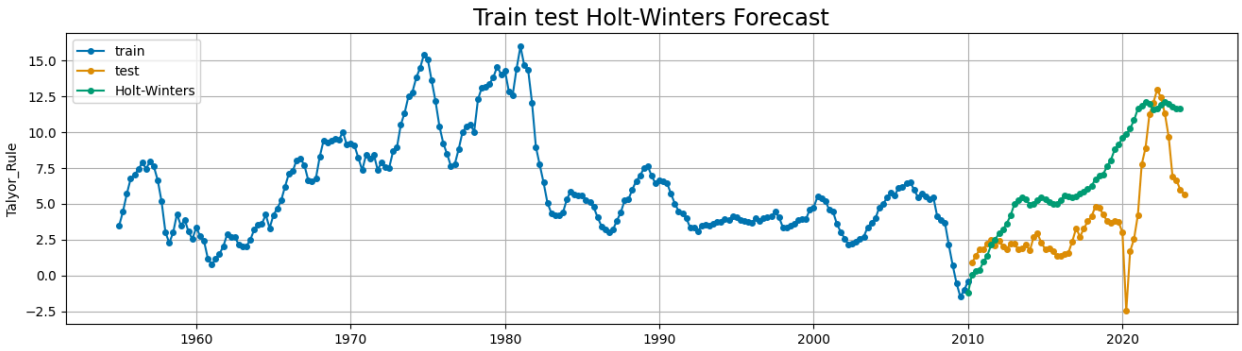


Talyor Rule: Holt-Winters Model

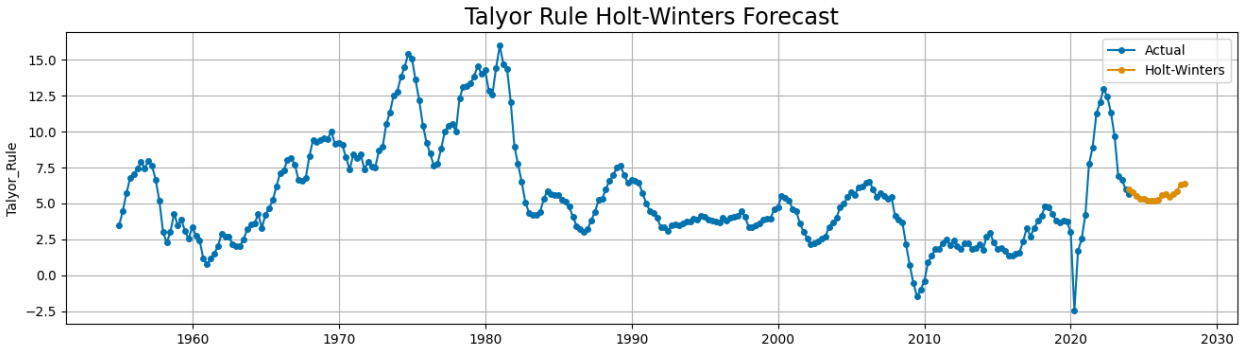
Due to the Talyor Rule calling for negative rates in more recent years the multiplicative feature is unable to be done.

MAE= 1.186993984696811

Here, we see the Holt-Winters model performs roughly the same as the baseline in terms of mae. Therefore, this model may not be the ideal choice in predicting the upcoming Talyor Rule metrics.



Here we see a lot more movement from the model compared to the last as it is trying to understand and predict the test variables. We can see the model does not do a good job at matching the test data.



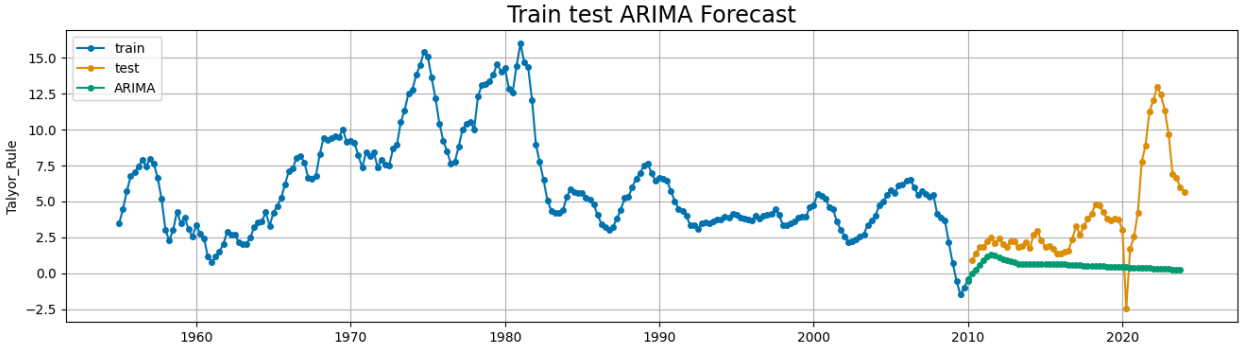
This is what the Holt-Winters model predicts once it was fed all the data. As we can see it predicts that there will be a slight dip in rates followed by an increase.

Talyor Rule: ARIMA Model

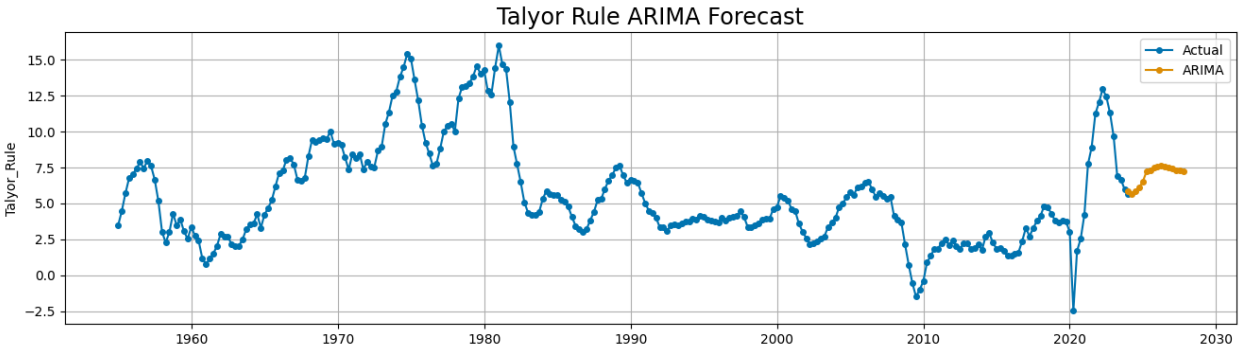
Next we will examine the auto arima model

MAE= 0.7931110335712804

Here the model performs better than our baseline, although still not very well overall.



Here we see initially the model is able to track and follow what the test data did, but it hits a certain point and again flattens out.

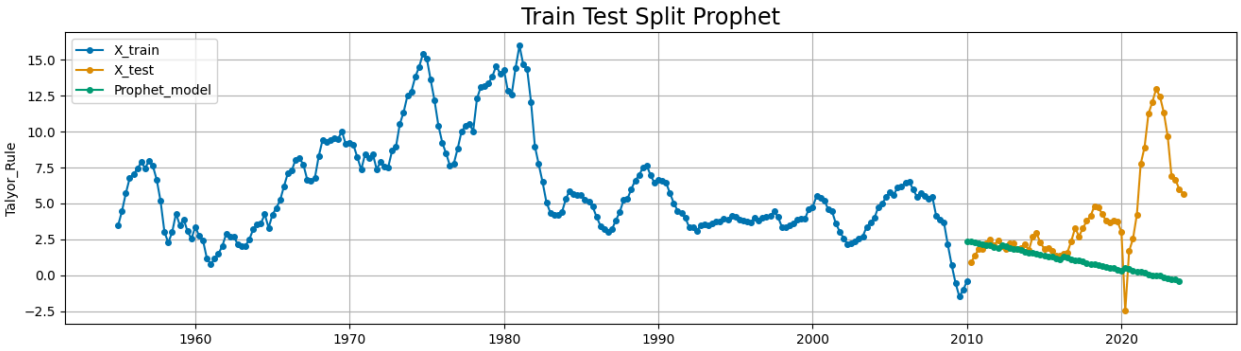


In this instance we see the model predicts that the data will initially decrease and then after some time increase again.

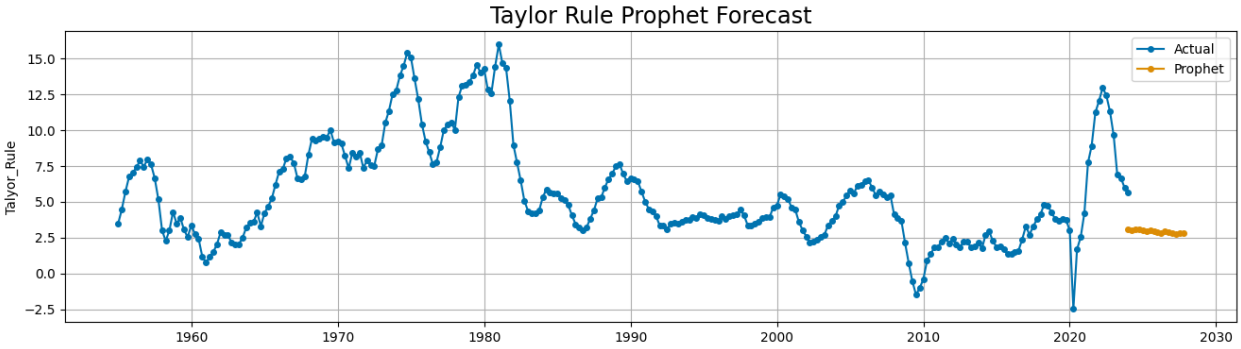
Taylor Prophet Model

MAE= 0.5923532028405355

Here we see the prophet model is the best in reference to having the lowest mae compared to the other models.

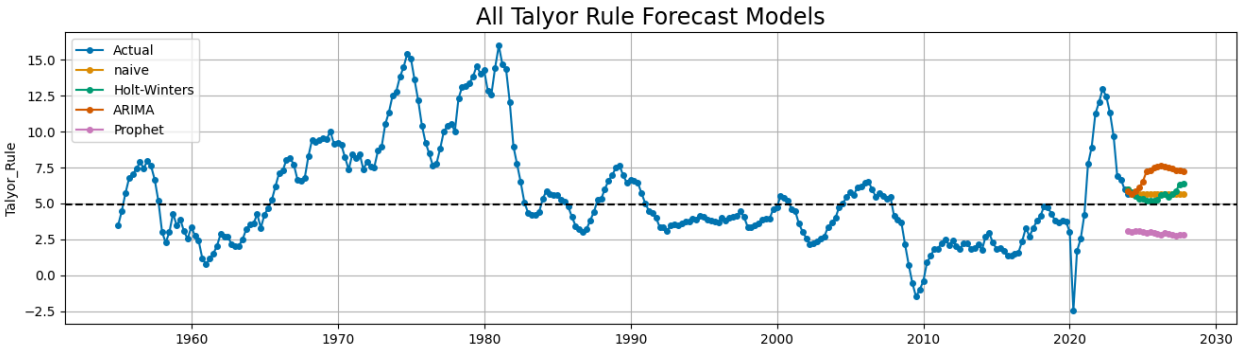


Here we see the prophet model is able to predict the general downward trend of the Taylor Rule over time, although it fails to pick up and match the test data.



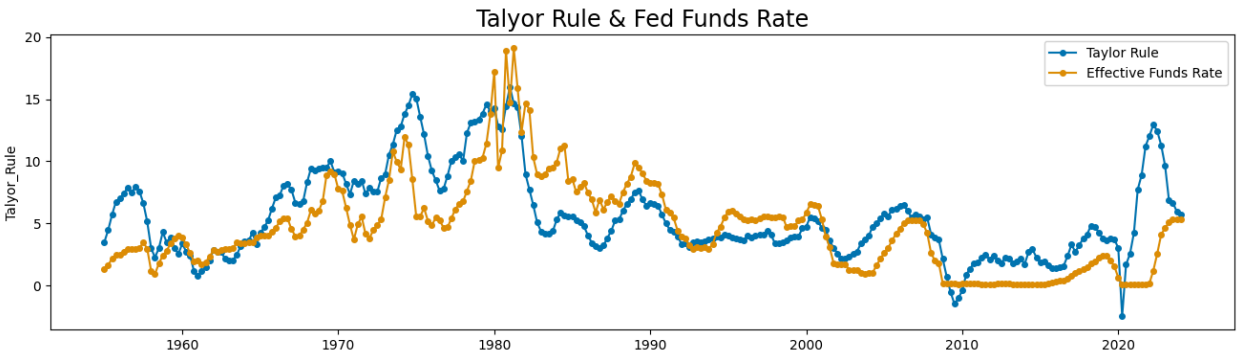
Here we see the model just reflects a general downward trend of the Taylor Rule in the coming quarters.

All Talyor Role Predictive Models



For the most part, all the models initially predict a downward trend in the Talyor Rule in the coming quarters although they also predict an upward trend after that.

Taylor Rule Paired with the Fed Funds Rate

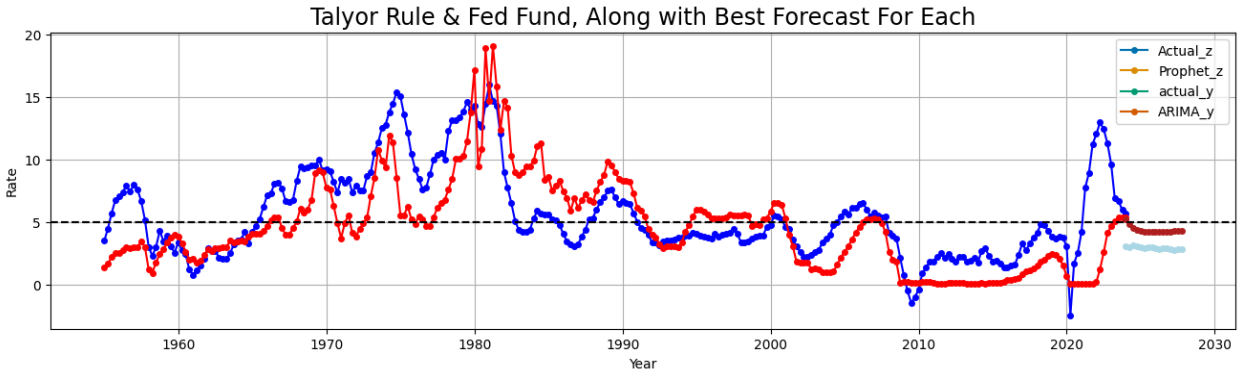


In this instance, I thought it would be interesting to circle back to the original point made in the beginning of the report. In this report, we are trying to examine the comparison between the Fed funds rate and the Taylor Rule. We are trying to examine what insight the relationship of each can provide, by modeling predicted values for each 4 years in advance and evaluating if there is any overlap.

In this example, we see the historical overlap. Typically, we see the Talyor rule and the fed funds rate move in the same direction. Although at times the Taylor rule moves at a faster pace. For example, as the

2001 dot dom bubble, we see that the Taylor Rule moves upward in a steeper manner compared to the fed funds rate. This may indicate that the Fed was slow to hike rates after the dot com bubble. Another example is after covid the Talyor rule shot up after a steep decline, indicating that the shock created by the pandemic had inflationary characteristics following. The comparison between the two reflects again that the Fed may have been slow to act in response to the current economic indicators.

Moving forward let's examine if the Taylor Rule's predictive models move in steeper directions compared to the fed funds rate.



In this graph above we see the best-performing models from each of the Taylor Rule and the Fed Funds rate. For the Taylor Rule, the best performing model was the prophet model compared to the baseline of the naive forecaster that just replciated the fed not making a rate adjustment for the next 4 years. Whereas, with the Fed Funds Rate we saw the best performing model was the ARIMA model when again compared to the naive forecaster.

Overall, we see a general downward trend in the rates in the coming years. This is also expected as the Fed has already started to cut rates and most recently the central bank of Europe cut its rate to 3%. It is interesting to note that each model is relatively flat after an initial decrease. Also, the fact that each model performed poorly in predicting the test variable although it outperformed the baseline. Therefore, take this model with a grain of salt as the fed funds rate and the Taylor rule aren't truly seasonal as holiday deals.

Next Steps & Discussion

The most accurate models that performed better on the baseline maybe could be altered with more to further perfect each model's ability to predict upcoming trends. It seems we are entering a downward rate environment. It will be interesting to see how long this upcoming trend will last, as with recent policy proposal of tariffs may negatively impact this forecast and revert rates to increase or maintain at the current levels. The recent CPI report of 2.7% could also signify that inflation has yet to go, it will be interesting to see what the Fed does in the next meeting in December if they decide to cut the rates or hold at current levels.

Key Findings 1.) We examined the varying success of different models. For the most part, overall, ARIMA was the best-performing model, factoring in how it performed for both the Fed Funds Rate and also the Talyor Rule. However, when examining individual model performance we saw that the best model for predicting the Fed Funds Rate was the ARIMA model, whereas for the Talyor Rule, it was the Prophet model by Facebook. 2.) Overall, we saw the impact that rates have on inflation, GDP, and the duration of the interest rate regimes. It exemplified how interest rates are a powerful tool for tackling inflation, along with its massive impact on economic output, specifically how lower interest rate regimes typically followed

economic downturns and vice versa for high interest rate regimes. 3.) Overall it seems very difficult to predict the future of rates as a lot of economic indicators are needed as inputs, solely examining historical changes and adjustments may not be enough.

Future Projects and Improvements Future projects could examine the economic indicators that influence interest rates such as unemployment, CPI, Real_GDP, and Potential GDP. The model could evaluate how these features interacted with impacted the fed funds rate along with its impact on the Taylor Rule. In doing so one is breaking the Taylor Rule down into its compartmental parts and predicting how changes in those may further impact the models we created. It would be interesting to understand the weights assigned to each and how that may impact the performance of future models. Another interesting factor could be to examine other tools that the Fed has at its disposal and how those may alter the Fed's decision to cut or hold rates. To further understand the grasp of the tools they have available and when they decide to enact certain monetary policies compared to others.

In reference to improvements in the models in this report, one could further fine-tone the hyperparameters of each model. Another aspect could be to apply the Markov regression model to try and predict whether the upcoming interest rate regime will be high or low. Finally, overall, another area of improvement could be to examine specific periods rather than the entire historical trend and train the data based on certain historical periods.