Stat 157 Final Project

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Question Statement:

Give an 80% confidence interval for when the FED will lower the federal fund rate.

Resolution criteria:

The solution will come about once the Fed announces its decision to lower the interest rate in the Federal Open Market Committee (FOMC) meetings from the highest rate in the current series. We will resolve the forecast based on the lower value in the range.
https://www.federalreserve.gov/monetarypolicy/openmarket.htm

Domain knowledge:

Financial Markets: Interest rates are used to determine the prices of a variety of financial instruments (stocks, CDs, etc.), including bonds and loans, in the financial markets.

Monetary Policy: Interest rates are a tool used by central banks to carry out monetary policy. Central banks can affect economic activity, inflation, the availability of money, and credit by changing interest rates.

Banking and Lending: The cost of borrowing money, which has an impact on both consumer and business spending, is largely determined by interest rates. Interest rates are another tool used by banks and other financial institutions to set the cost of loans and other financial products.

Risk and Return: The risk and return characteristics of various investments are also reflected in interest rates. Lower-risk investments typically have lower interest rates, whereas higher-risk investments typically have higher interest rates to make up for the additional risk to investors.

Background research:

Interest rates are defined as the amount of money that a borrower has to pay to a lender for borrowing money. It is usually expressed as a percentage of the borrowed amount and is charged over a specific period. The interest rate is one of the essential tools used by central banks and other financial institutions to control the economy's money supply. Inflation is defined as the rate at which prices for goods and services rise over time. Beginning in 2021, inflation kept increasing and reached 9.1 percent on July 13, 2022, a record high. By raising interest rates, the Fed can reduce the money supply, making borrowing more expensive and slowing down spending. This can help reduce inflationary pressures in the economy. Since March 16, 2022, the Federal Open Market Committee has increased interest rates nine times, with individual increases ranging between 25 and 75 basis points. Following the Fed's decision, investors' confidence declined, and fears of an economic recession led to the 2022 stock market decline. "If interest rates move higher, stock investors become more reluctant to bid up stock prices because they look less attractive versus bonds that pay more competitive yields today," says Rob

Haworth, senior investment strategy director at U.S. Bank Wealth Management. The pessimistic emotion in the market is ongoing in 2023, and there are numerous public concerns related to interest rates, such as: when will the interest rates go down?

Key Considerations and Framework:

To forecast the time when the interest rate will drop, we consider using reference classes, and trend extrapolation to give an overall confidence interval for the time. Then estimate the uncertainty associated with each reference class and use the estimation we get from the trend to proceed with the final forecast.

We use inflation as a primary reference due to the strong correlation between inflation and interest rates. Analyzing various scenarios for the Fed's potential decision-making processes and exploring past instances when the Fed raised interest rates to control inflation, we find that the primary goal for the Fed to charge the interest rate is to control inflation. We would research professional projections of inflation online and give a possible time based on the projection. Therefore, looking at the time when inflation reaches the target range of 2-3% is a key consideration in forecasting when the Fed will lower the interest rate.

In addition to inflation, we also consider current bank failures, the Fed policymakers' statements, and the historical tendencies of interest rates. Bank failures indicate a possible economic recession. In order to prevent an economic recession, the Fed can reduce the interest rate. From the Fed policymakers' statements, we also get insights about how the policymakers might react to the economic conditions and make changes to the interest rate. Looking at the historical patterns of the federal fund rate helps us identify these specific changes, such as how long the interest rate might stay flat at its peak and how long it might take to fall after reaching the peak.

After that, we analyzed the historical trend of interest rates and followed it to predict a future trend. We ranked the importance of each reference class and then did a computer simulation. We also evaluate the uncertainty of factors in our forecasting process and gain confidence intervals based on that. Finally, we combine our computer simulation and uncertainty, generating our final answer to our question: when will the Fed lower the federal fund rate in the current series?

Forecasting Skills: Part One - Reference Class

Reference Class 1: Inflation

There is a close relationship between inflation and interest rates, and one of the core reasons the Fed raises interest rates is to control inflation. From the chart of inflation and interest rates, we observe that when the Fed raises the interest rate to 1.21% in June 2022, the trend of inflation reverses and begins to drop. In February 2023, the interest rate was raised to 4.57%, and inflation dropped to 6%. This trend suggests a close correlation between interest rates and inflation. The Fed has a target range for inflation which is 2-3%. Hence, we would first analyze the time that inflation will reach the target range and then forecast the drop time of interest rates based on it.

According to the website Statista, the projected inflation for the last quarter of 2023 is 4.5% and for the first quarter of 2024 is 2.3%, and the rate will maintain around 2% in the year 2024. From this projection, inflation would reach the Fed's target around the end of 2023. According to the OECD, which has one of the world's largest and most reliable sources of statistical, economic, and social data, inflation is expected to fall gradually for the next following months in 2023 and range between 2%-3% at the beginning of 2024. The projection of inflation from these public resources suggests that people are expecting a positive development in the economy. The unemployment rate has remained in the range of 3-4% since February 2022; hence, we believe that the impact of the unemployment rate on the decreasing trend in inflation is low for the current economic situation. Based on experts' forecasts of inflation, we expect inflation to reach the target range in [September 2023, December 2023].

Reference Class 2: Market Activity - Bank Failure

We also consider the risk associated with raising interest rates to control inflation. In 2005, the Fed raised interest rates rapidly in response to a combination of factors, including concerns about inflation and an overheating housing market. By increasing the federal funds rate, the Fed hoped to slow down borrowing and spending and curb inflation. The Fed's actions resulted in higher borrowing costs, including higher mortgage rates. This eventually led to a housing market crash in 2008 and the global financial crisis. For now, the rise in interest rates has already led to huge negative ramifications for financial markets, including equities, bonds, and banks. According to Michael Mackenzie, "The Fed is very unlikely to challenge markets with a surprise move after bond volatility surged to the highest since 2008." Due to the risk of leading to a great recession, even if inflation hasn't reached the target line, it is still possible that the Fed will stop raising interest rates and start to drop interest rates due to other market activities.

The current bank failure is one of such activities that would affect policymakers' decisions. Silicon Valley Bank and Signature Bank collapsed in March 2023, while the last bank failure in the US was in 2008. According to notes from the Federal Reserve's March policy meeting March 21-22, the current bank crisis might push the US economy into a recession later this year (Mena & Goodkind, 2023). However, policymakers voted for a smaller interest rate increase to 4.75% - 5%, which came just days after the failures of the two banks, because "given high inflation and the strength of the recent economic data, they would have considered a [half percentage point] increase in the target range to have been appropriate in the absence of the recent developments in the banking sector," according to the minutes (*FOMC minutes*).

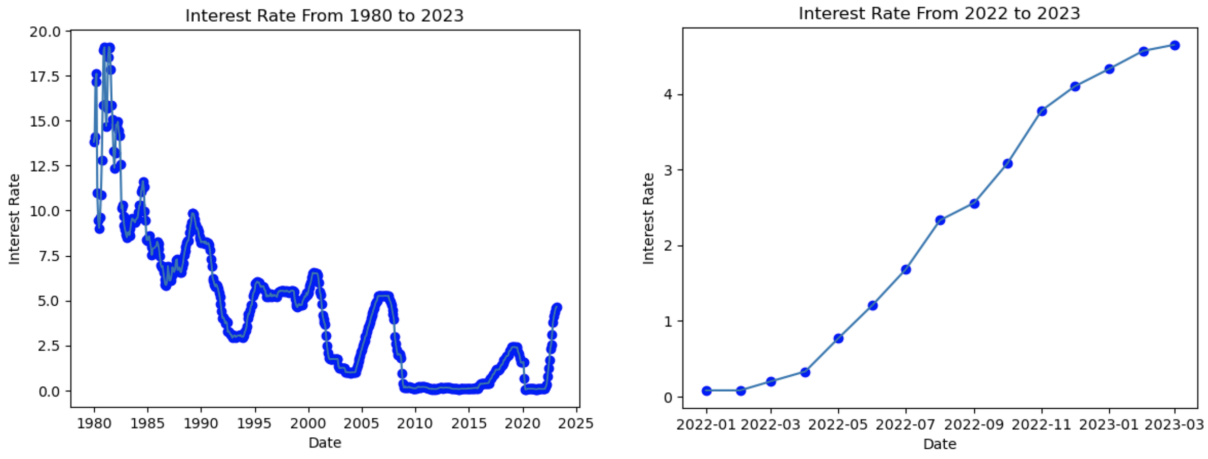
However, on May 1, 2023, the news bank collapse of First Republic Bank happened. According to Norada Real Estate Investment, "a bank run on one of these vulnerable institutions could cause a ripple effect"(Santarelli, 2023). Bank failure leads to a broader panic and a loss of confidence in the banking system, leading to a recession or even a financial crisis. "The federal government's promise to back all depositors in these banks is a step in the right direction to help prevent a wider panic." Federal Reserve Bank of New York President John Williams, one of the member of Federal Open Market Committee (FOMC), noted that recent stress in the banking

sector will likely weigh on economic activity. The banking stress, coupled with slowing inflation and a cooling labor market, signals the imminent end of the Fed's rate-hiking campaign (Mena & Goodkind, 2023).

We would forecast that the Fed will lower the interest rates due to bank stress in the next one month to four months (June to September), in which period the FED might meet again and announce their new policy.

Reference Class 3: Fed's Statements and Public Analysis of Fed's Movement
By looking at the current FOMC's opinions, we have a more clear idea of how things will go: Williams once emphasized that "it is still too early to gauge the magnitude and duration of these effects, and I will be closely monitoring the evolution of credit conditions and their potential effects on the economy" (*FOMC minutes*). In April, Fed policymakers gave guidance for one more interest-rate hike this year in May, followed by a pause. Williams confirmed this, saying that this projection is a "reasonable starting point" (*FOMC minutes*). The pause is because the Fed might need a period of time to gauge the effects of the rate hikes. In the latest FOMC meeting on May 3rd, the Fed raised its benchmark interest rate by 25 basis points, leaving the target Fed funds rate at 5.0% to 5.25%. The announcement confirms the guidance and suggests that this change is possibly the last increase of the current series because "it no longer includes the phrase 'the Committee anticipates that some additional policy firming may be appropriate' in order to get the annual inflation rate down to the bank's 2% target" (Nicholas Jasinski). In Part 2, we will closely examine how long the pause will be before lowing the Fed funds rate.

Forecasting Skills: Part Two - Trend Extrapolation: Analyzing the Historical Data on Interest Rates



From the line plot on the left above, we can see that the interest rate reached a maximum of 19.1% in June 1981. There was a re-hike twice that reached the second maximum from 1980 to 1982. Prior to 1990, the Fed had previously lowered rates in less than three months after they peaked, but these were all done at extremely high rates between 9.84 and 19.10. The interest rate

was so high before 1990 because the Fed didn't explicitly target a set federal funds rate at that time.

There was a re-hike once in July 2000, which reached a higher maximum rate of 6.54%. From June to November 2000, the rate remained stable at around 6.50 for six months. From December 2000 until December 2003, the interest rate kept falling until it reached the minimum of 0.98%. Then there was a steady upward interest rate trend from July 2004 until June 2006. From July 2006 to July 2007, the interest rate remained stable at 5.25% for a year. From August 2007 until December 2008, interest rates declined to 0.16%. The interest rate has remained stable in the 0.07% to 0.22% range for the next seven years (Dec 2008 to Nov 2015).

Interest rates climbed between November 2015 and April 2019, peaking at 2.42%. Interest rates remained stable at around 2.4% for 7 months, from January 2019 to July 2019. Since then, it has been down to 0.65% in March 2020. The downward trend was maintained for nine months. From April 2020 until February 2022, the interest rate has been maintained at 0.05% to 0.1% for about two years.

The line plot on the right above shows there is an increased relationship for the interest rate from March 2022 to March 2023. Based on the past trend and the recent year's trend, we predict that the trend will still go up in the next two months and then stay flat in the next four months. We expect the trend to go down in September 2023.

Based on the past trend and the recent year's trend, we predict that the trend will still go up in the next two months and then stay flat in the next four months. This is due to the gradual flattening of rate increases in the last four months. Then, we expect the trend to go down in September 2023.

Forecasting Skills: Part Three - Combining Forecasts

In this section, we will combine our analysis of each reference class, assess the importance and uncertainty of each of them, and perform a simulation.

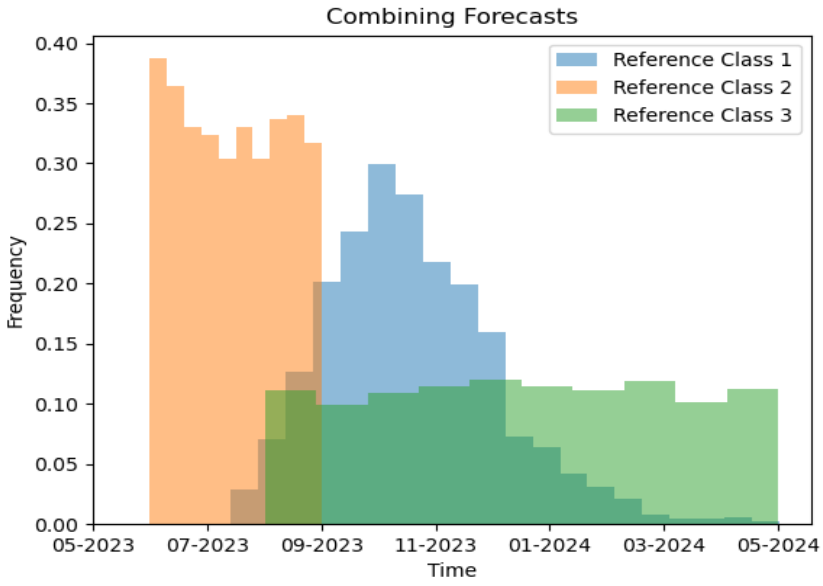
For the lowering of interest rates due to the achievement of target inflation, we assume the Fed will immediately respond to the target inflation rate to lower the federal fund rate. We assign a gamma distribution for the time that inflation will reach the target range, and the time of the lowering of the interest rate should follow the same distribution. The parameters we assign to the gamma distribution are 14 for alpha and 0.4 for beta. Alpha represents the number of events that must occur before the distribution can be completed. We chose 14 because according to the overall forecasts of inflation, we believe it will reach the target range in the next 14 months, starting in May. According to our estimation from experts' forecasts, we believe the distribution for the probability that inflation will drop will be concentrated around 4-7(September to December). Therefore, we assign a small value to the scale parameter beta to make the distribution match our estimation. The mean of the gamma distribution is around 6 (November).

We use OLS to find how strong the correlation between inflation and interest rates is. The p-value we get from the model is 0.036, which is less than 0.05, suggesting that the coefficient we find for interest rate has statistical significance at a 5% significance level. Hence, we believe that inflation has the highest importance among all the factors that affect the Fed's decision on determining interest rates. Therefore, we would assign 65% of the weight to the distribution of the time when inflation will reach the target range.

For the lowering of interest rates due to bank stress, we assume it to follow a uniform distribution with parameters 1 to 4, since we assign the event of the lowering of interest rates due to bank stress with a uniform distribution from the next 1 month to 4 months (June to September, in which period the FED might meet and announce their new policy). We would assign 25% of the weight to the lowering of the fed funds rate due to bank failure because the back stress is growing and the outcome of the recession is unbearable.

For the lowering of the interest rate based on the analysis of Fed officials' statements and historical trends, we estimate that the interest rate would drop after 3-12 months from now, which means it follows a uniform distribution with parameters 3 to 12. This is because the Fed is very likely to keep interest rates at peak levels for at least 3 months. Out of the 6 periods of rate hikes since 1990, the Fed maintained peak rate levels for a minimum of 3 months, an average of 8 months, and a maximum of 17 months before initiating rate cuts. By looking at more recent data since 2000, we can see that the longest pause is from July 2006 to July 2007, when the interest rate remained stable at 5.25% for 12 months. Therefore, we could take 3 as the lower parameter and 12 as the upper parameter in our uniform distribution. Since the economy experienced COVID in the recent 3-5 years and no similar situation happened in the past, historical trends in the past 20-30 years are not very helpful in predicting the question. Since the current economic situation is different from the previous, we would like to assign 10% of the weight to historical trends.

Then, we draw 1000 random samples from each distribution, add them up using the equation 0.65 * Reference Class 1+0.25 * Reference Class 2 + 0.1 * Reference Class 3, and get a 80% confidence interval. Reference class 1 represents the lowering interest rate at the time inflation reaches the target range. Reference class 2 represents the Fed lowering rates due to economic pressure (bank failure). Reference class 3 represents the Fed lowering rates after the pause period, which we estimate from the historical trend of interest rates. The final confidence interval we get from the computer simulation is [3.88, 6.37], which is associated with [09-2023, 11-2023].



Conclusion

Looking at the historical trend over the past 43 years, we observe that the overall trend of interest rates is declining. After the Fed explicitly targeted a set federal funds rate, interest rates have been going up and down below 7%. Combining the recent year's trend, we predict the interest rate will go up in [04-2023, 05-2023], stay flat for three months to a year, and go down after the pause time.

We have identified three reference classes for consideration, which include: the possible time at which inflation is expected to reach the Fed's target range, the economic pressures such as bank failures that may impact the Fed's decision-making process, and the duration of any potential pauses in interest rate adjustments. Overall, there is a high probability of the Fed considering lower interest rates by the end of 2023. The 80% confidence intervals we get from each reference class are [3.83, 7.49], [1.3, 3.76], and [3.96, 11.14] respectively. The number represents the number of months since May 2023. The weight we assigned to each reference class is 0.65, 0.25, and 0.10. According to the section on combining forecasts, the computer simulation results in a final 80 % confidence interval of [3.88, 6.37], which is associated with [09-2023, 11-2023].

Therefore, our final 80% confidence interval for when the FED will lower the federal fund rate is [09-2023, 11-2023].

Citation

Barrons. (2023, May 3). *Fed raises rates by quarter-point and hints at pause*. Barron's. Retrieved May 3, 2023, from https://www.barrons.com/livecoverage/fed-may-meeting-rate-decision-powell-speech-today/card/fed-raises-rates-by-quarter-point-to-highest-since-2007-QFMhdMkPIU0ebuR0HoqE

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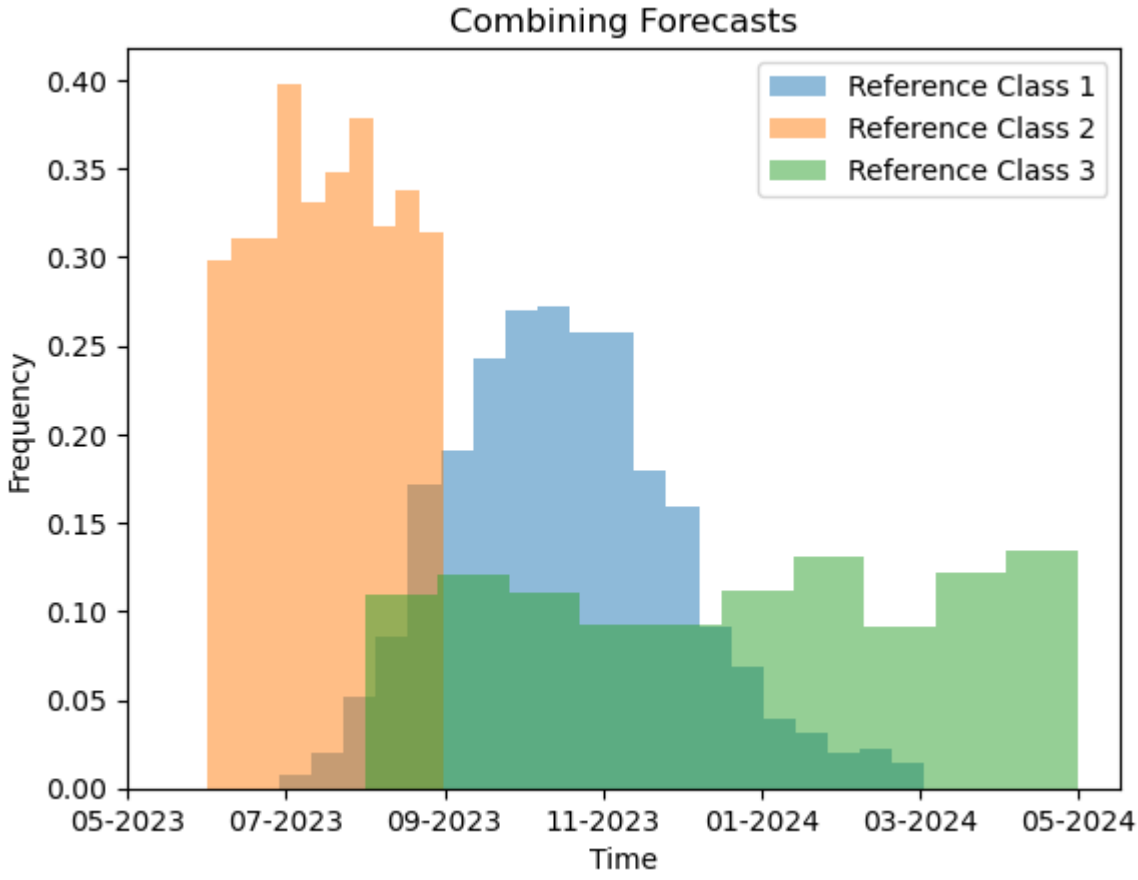
In [120…
```
import numpy as np
import pandas as pd
from matplotlib import pyplot as plt
from scipy.stats import norm
import scipy.stats as stats

import statistics
import random
from scipy.stats import skewnorm
from datetime import date, timedelta

from datetime import date
from dateutil.relativedelta import relativedelta

import requests
from urllib.parse import urlencode
import statsmodels.api as sm
```

In [121…
```
import numpy as np
import matplotlib.pyplot as plt

# generate two random datasets
data_1 = np.random.gamma(14, 0.4, 1000)
data_2 = np.random.uniform(1, 4, size=1000)
data_3 = np.random.uniform(3, 12, size = 1000)
# data_3 = np.random.gamma(20, 0.2, 1000)

# create a figure and an axis object
fig, ax = plt.subplots()

# create histograms for each dataset
ax.hist(data_1, density = True, bins=20, alpha=0.5, label='Reference Class 1
ax.hist(data_2, density = True, alpha=0.5, label='Reference Class 2')
ax.hist(data_3, density = True, alpha=0.5, label='Reference Class 3')


month_starts = [0,2,4,6,8,10,12]
month_names = ['05-2023','07-2023','09-2023','11-2023','01-2024','03-2024','

ax.set_xticks(month_starts)
ax.set_xticklabels(month_names)


# add labels, a title, and a legend
plt.xlabel('Time')
plt.ylabel('Frequency')
plt.title('Combining Forecasts')

plt.legend()

# show the plot
plt.savefig("CF")
plt.show()
```



In [122…
```
sum(data_3)/len(data_3)
```

Out[122]: 7.6166412093298375

In [123…
```
def CI(data):
    LB = np.quantile(data, 0.1)
    UB = np.quantile(data, 0.9)
    print("The 80% confidence interval is: ", "[", LB,",", UB, "]")
```

In [124…
```
CI(data_1) #inflation
```

```
The 80% confidence interval is:  [ 3.776854589175453 , 7.346886809288413 ]
```

In [125…
```
CI(data_2) #bank
```

```
The 80% confidence interval is:  [ 1.3372321492425256 , 3.6611429964517557
]
```

In [126…
```
CI(data_3) #Pause period
```

```
The 80% confidence interval is:  [ 3.945880184147575 , 11.286207038038247 ]
```

In [127…
```
simulate_rv = 0.65 * data_1 + 0.25 * data_2 + 0.1 * data_3
```

In [128…
```
CI(simulate_rv)
```

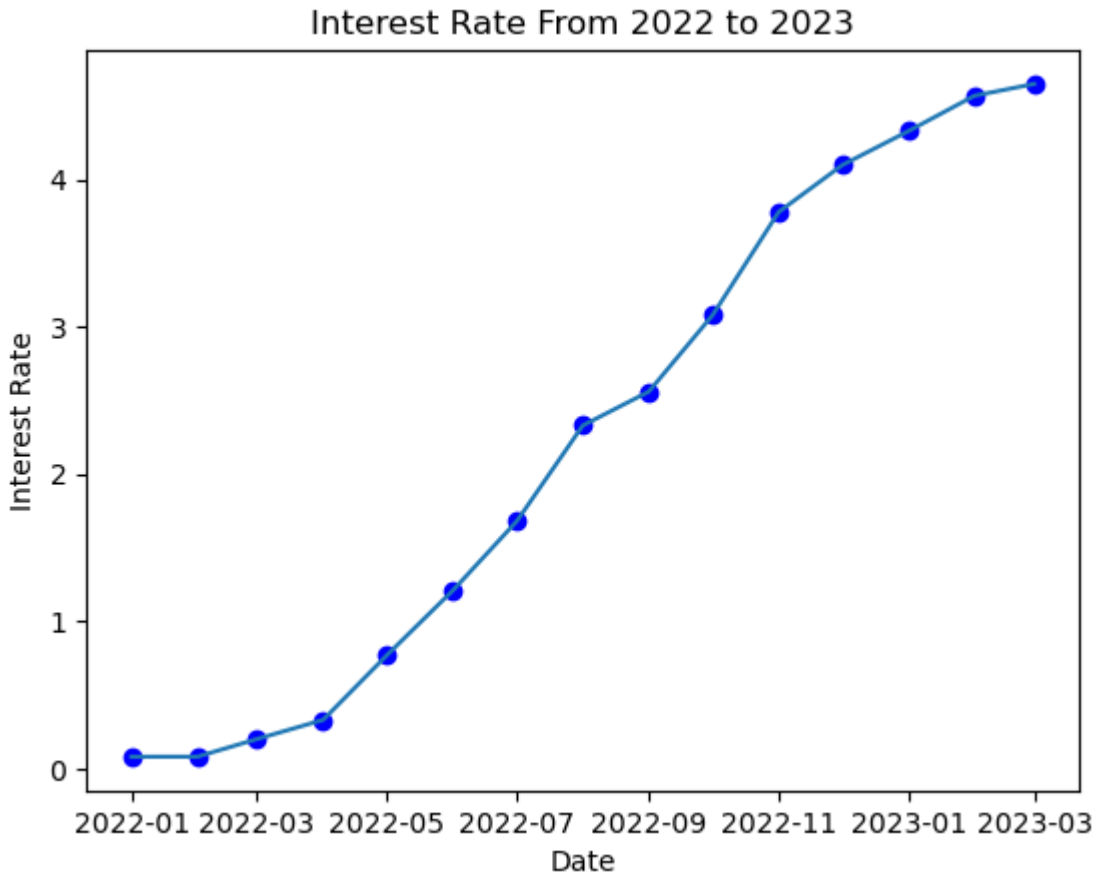
```
The 80% confidence interval is:  [ 3.766408447225963 , 6.23384334820309 ]
```

Trend Analysis

In [132…
```
# create function to fetch url
def fetch(base_url, endpoint, params, url_only=False):
    # forms API request
    url_params = urlencode(params)
    url = f"{base_url}{endpoint}?{url_params}"

    # For testing purposes only, do not delete
    if url_only:
        return url

    # fires off the request
    res = requests.get(url)

    # checks if the request encounters an error
    if res.status_code not in range(200, 299):
        raise Exception(f"Fetch request failed (Error: {res.status_code})")

    # return the content of the response
    return res.json()

# interest rate
base_url = "https://api.stlouisfed.org"
endpoint = "/fred/series/observations"
params_INRATE2223 = {"series_id": "FEDFUNDS",
                "observation_start": "2022-01-01",
                "observation_end": "2023-03-01",
                "frequency": "m",
                "units": "lin",
                "api_key": "def6304c831db7878e2c72abccb14f35",
                "file_type": "json"
               }

res_json_INRATE = fetch(base_url, endpoint, params_INRATE2223)

# process json data and store it as a dataframe
INRATE2223 = pd.DataFrame(res_json_INRATE["observations"])[["date","value"]]
INRATE2223.rename(columns={"value": "interest rate"}, inplace=True)
#INRATE.head()
INRATE2223["interest rate"] = INRATE2223["interest rate"].astype(float)
```

In [137…
```
#Plot for interest rate from 2018-2023
INRATE2223["date"] = pd.to_datetime(INRATE2223["date"])
plt.plot(INRATE2223["date"], INRATE2223["interest rate"])
plt.scatter(INRATE2223["date"], INRATE2223["interest rate"], c='blue')
plt.xlabel("Date")
plt.ylabel("Interest Rate")
plt.title("Interest Rate From 2022 to 2023")
```

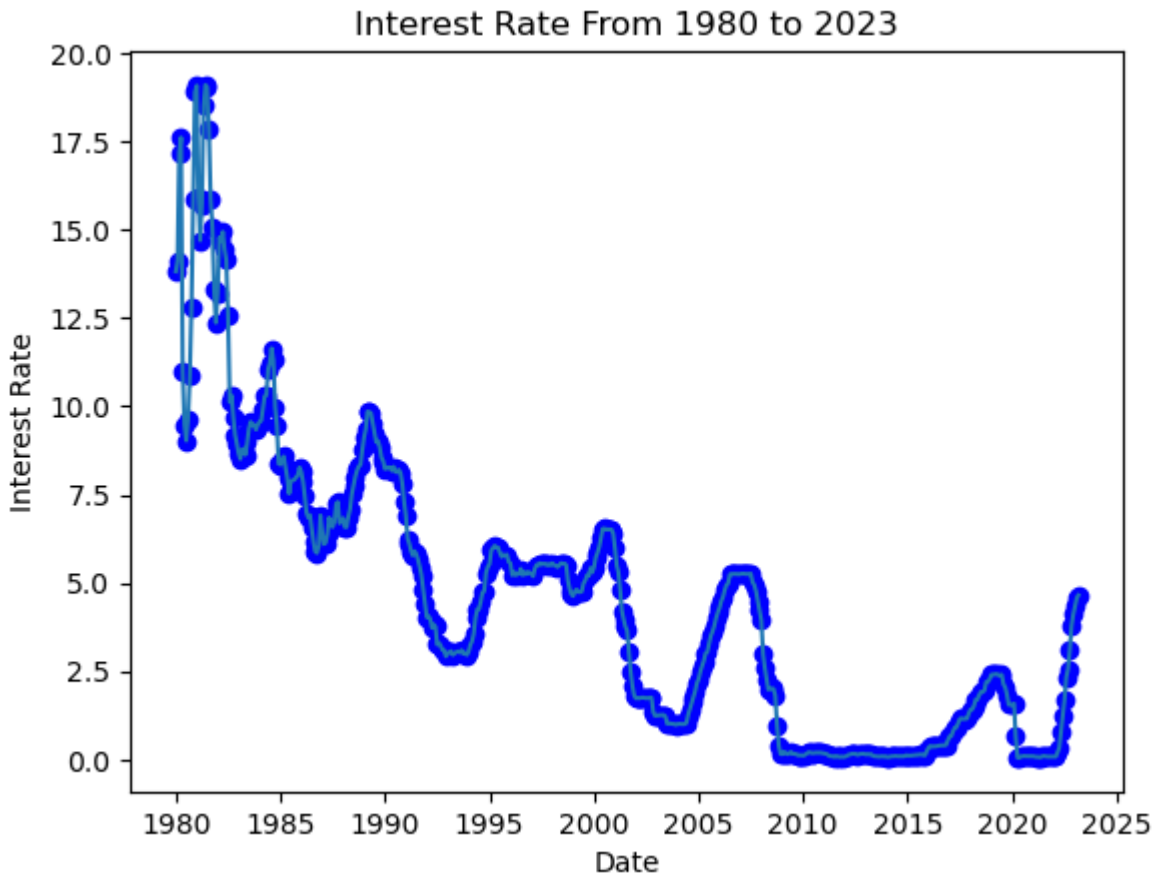
Out[137]:
```
Text(0.5, 1.0, 'Interest Rate From 2022 to 2023')
```



In [140…
```
#interest rate
base_url = "https://api.stlouisfed.org"
endpoint = "/fred/series/observations"
params_INRATE8023 = {"series_id": "FEDFUNDS",
                 "observation_start": "1980-01-01",
                 "observation_end": "2023-03-01",
                 "frequency": "m",
                 "units": "lin",
                 "api_key": "def6304c831db7878e2c72abccb14f35",
                 "file_type": "json"
                }

res_json_INRATE = fetch(base_url, endpoint, params_INRATE8023)

# process json data and store it as a dataframe
INRATE8023 = pd.DataFrame(res_json_INRATE["observations"])[["date","value"]]
INRATE8023.rename(columns={"value": "interest rate"}, inplace=True)
#INRATE.head()
INRATE8023["interest rate"] = INRATE8023["interest rate"].astype(float)
```

In [141…
```
INRATE8023["date"] = pd.to_datetime(INRATE8023["date"])

plt.plot(INRATE8023["date"], INRATE8023["interest rate"])
plt.scatter(INRATE8023["date"], INRATE8023["interest rate"], c='blue')
plt.xlabel("Date")
plt.ylabel("Interest Rate")
plt.title("Interest Rate From 1980 to 2023")
```

Out[141]: Text(0.5, 1.0, 'Interest Rate From 1980 to 2023')



In [ ]: