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ICT Department

Macro-economic analysis and impact on U.S. Treasury Yields

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Contents

1 Introduction

Treasury yields are among the key indicators of modern finance. They represent the interest rate that the U.S. government pays to borrow money over a specific period by issuing and selling treasury securities [1, 2]. This report examines U.S. Treasury yields in relation to three macroeconomic elements: the Consumer Price Index (CPI), the unemployment rate, and the Federal Funds Effective Rate (FEDFUNDS), over the period from 2002 to 2025. Two critical events in this period are highlighted: the Global Financial Crisis in 20082008 and the COVID-19 pandemic of 2020–2021.

2 Economic Context

2.1 Historical background

To discover the most general and closest insights to reality, the period from 2002 to 2025 is chosen because it covers multiple economic cycles, including pre- and post-global financial crisis dynamics, the prolonged low interest rate environment, the COVID-19 pandemic, and the recent rise in interest rates since 2022. Among these critical financial events, the Global Financial Crisis and the COVID-19 pandemic caused major disruptions to the financial system.

2.1.1 The Global Financial Crisis (2007-2009)

From late 2007 to mid-2009, the global financial crisis (or Great Recession) unfolded, beginning with the peak and subsequent decline of U.S. home prices in 2007. A drastic fall in housing prices was a sign of rising mortgage defaults and greater losses for security holders, serving as the initial shock to the financial markets [7]. As fundamental components of the financial system, U.S. Treasury yields were inevitably affected. Further analysis and detailed insights will be presented in this report.

2.1.2 The COVID-19 Pandemic (2020-2021)

After ten years since the Great Recession, the worldwide financial system suffered from another crisis caused by the COVID-19 pandemic. To avoid the propagation of the virus, quarantines, bans and lock-downs had been applied, causing lengthy disruptions to enterprises and industries. As a result, the bond markets also went through major changes, along with investor behavior [8]. This report will examine how the pandemic reshaped them.

2.2 The role of Treasury yields

Treasury yields are vital indicators of the overall economy as well as investor confidence. The shift in treasury yields can shape other interest rates including mortgage interest rates, auto loans and business loans [3]. From investors' perspective, rising yields are associated with expectations of stronger economic growth, while falling yields are commonly seen as predictors of economic recession [4]. Such signals provide valuable guidance for investment decision-making.

2.3 The general impact of macro-economic elements

CPI, unemployment rate and FEDFUNDS are selected as key macro-economic variables due to their significant influence on treasury yields. According to Rub´ın [5], the result shows that a rise in inflation (the growth rate of CPI) leads to an increase in the yield curve at high maturities. The paper also illustrates the effect of FEDFUNDS on treasury yields, by finding its connection at short maturities. Another publication from the Federal Reserve Bank of Cleveland [6] states that there appears to be a positive relationship between unemployment surprises and the 2-year Treasury yield. However, this relationship is largely driven by a few outliers, specifically in June 2016, January 2019, and July 2019. Once these observations are excluded, the relationship is no longer strong or statistically significant.

3 Data collection and preprocessing

To conduct this analysis, quantitative time-series data was systematically collected from an authoritative public source. The entire data retrieval process was automated using a Python script to ensure accuracy, efficiency, and reproducibility. The detailed methodology is described below.

3.1 Data Source and Tools

The data source is from the **Federal Reserve Economic Data (FRED)** database, a comprehensive repository maintained by the Federal Reserve Bank of St. Louis. FRED is widely recognized in academic and professional circles for providing reliable, long-term economic and financial data from a multitude of U.S. and international sources.

Access to the FRED database was achieved using the library `pandas-datareader` in Python, which allows direct API calls to retrieve specified data series within a defined timeframe.

3.2 Data Scope and Variables

The temporal scope of the collected data spans from **January 1, 2002 to September 13, 2025**. This period was chosen to encompass multiple economic cycles, including the lead-up to the 2008 financial crisis, the subsequent recovery, the COVID-19 pandemic, and the recent inflationary period. The variables collected are categorized into two groups: core macro-economic indicators and U.S. Treasury yields across various maturities.

3.2.1 Macro-economic Indicators

Three key monthly indicators were selected to represent the broader health of the U.S. economy:

- **Civilian Unemployment Rate (UNRATE):** Represents the percentage of the total labor force that is unemployed but actively seeking employment.

- **Federal Funds Effective Rate (FEDFUNDS):** The interest rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight. It serves as a primary tool for monetary policy.

- **Consumer Price Index for All Urban Consumers (CPI):** A measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. It is a key indicator of inflation.

3.2.2 U.S. Treasury Yields

To analyze the yield curve, daily data for U.S. Treasury constant maturity rates were collected for a comprehensive set of eleven different maturities:

- **Short-term maturities:** 1-month (DGS1MO), 3-month (DGS3MO), and 6-month (DGS6MO).

- **Medium-term maturities:** 1-year (DGS1), 2-year (DGS2), 3-year (DGS3), 5-year (DGS5), and 7-year (DGS7).

- **Long-term maturities:** 10-year (DGS10), 20-year (DGS20), and 30-year (DGS30).

The 10-year Treasury yield is often used as a benchmark for many other interest rates, while the relationship between short-term and long-term yields (the yield curve) is a critical indicator of economic expectations.

3.3 Data Aggregation and Storage

After retrieving each data series from the FRED database, they were merged into a single dataset. The monthly macroeconomic data was aligned with the daily Treasury yield data, with appropriate handling for differing frequencies (e.g., forward-filling monthly data to align with daily records).

The final dataset was exported to a Comma-Separated Values (CSV) file named `macro_treasury_full_2000.csv`. This structured file serves as the primary input for the subsequent data analysis phase of this report.

3.4 Data preprocessing

The variable `Date` was initially stored as an object type. To enable temporal operations and facilitate the extraction of components such as year and month for time-series visualizations, the variable was converted into a `datetime` format using the *pandas.to_datetime()* function.

4 Data Analysis

The data, spanning from 2002 to 2025, was analyzed to uncover the relationships between macroeconomic indicators and U.S. Treasury yields. The analysis begins with descriptive statistics and a correlation overview, followed by a detailed examination of time-series trends and the yield curve's behavior during significant economic events, notably the 2008 Global Financial Crisis (GFC) and the COVID-19 pandemic.

To explore the relationship between macroeconomic variables and U.S. Treasury yields, the monthly yield curves for that year are illustrated to show the trends. The yield curve, which depicts Treasury yields across different maturities, serves as a key indicator of market expectations [11]. In the analysis, because the values of `UNRATE` and `FEDFUNDS` differ greatly from those of `CPI`, **CPI Year on Year (CPI YoY)** is used for data visualization. The formula for CPI YoY is:

$$\text{CPI\_YoY}_t = \frac{\text{CPI}_t - \text{CPI}_{t-12}}{\text{CPI}_{t-12}} \times 100$$

4.1 Descriptive Statistics and Correlation

To understand the relationship between these variables, a correlation matrix based on their annual average values, as shown in Figure 1.
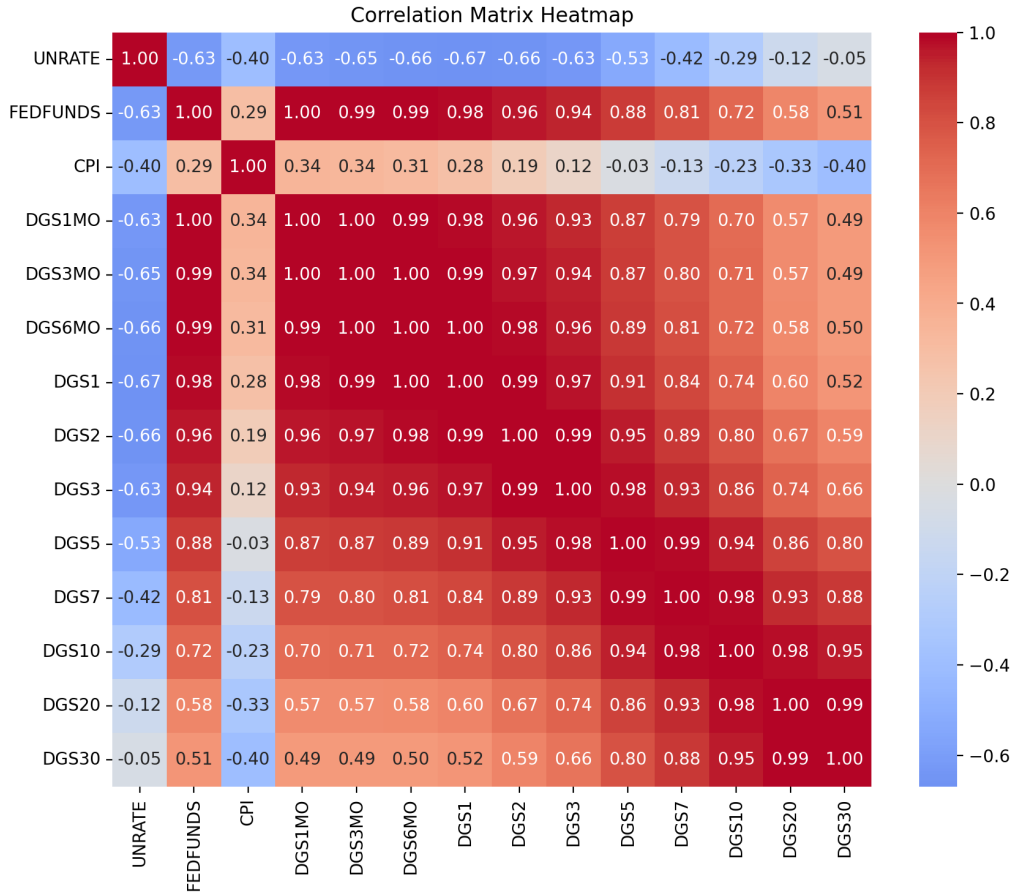

Figure 1: Correlation Matrix of Annual Average Macroeconomic variables and Treasury Yields

The heatmap reveals several key relationships:

- **Strong Positive Correlation among Yields:** All Treasury yields, from `DGS1MO` to `DGS30`, are highly positively correlated with each other (correlation coefficients often > 0.90). This confirms that yields across different maturities tend to move in the same direction, reflecting broad market sentiment and monetary policy.

- **FEDFUNDS and Short-Term Yields:** The `FEDFUNDS` rate shows an extremely strong positive correlation with short-term Treasury yields like `DGS1MO` (0.99), `DGS3MO` (0.99), and `DGS1` (0.98). This is expected, as these yields are most directly influenced by the Federal Reserve's target policy rate.

- **Unemployment and Interest Rates:** `UNRATE` exhibits a moderate negative correlation with both `FEDFUNDS` (-0.40) and most Treasury yields. This aligns with economic theory: during periods of high unemployment, the Federal Reserve typically lowers interest rates to stimulate economic activity, pushing down government bond yields.

- **Inflation (CPI):** The relationship with the Consumer Price Index (`CPI`) is more complex. It shows a weak negative correlation with unemployment (-0.40) and a moderate positive

correlation with long-term yields like `DGS10` (0.70) and `DGS30` (0.49). This suggests that while inflation and long-term yields tend to rise together, the relationship is not as direct as that between the Fed's policy rate and short-term yields.

4.2 Time-Series Trends and Key Economic Events

4.2.1 Macro-economic variables

Analyzing the variables over time gives important context, especially during major economic crises. Before the crisis, unemployment stayed near 4.7% in 2006–2007 (Figure 2) but climbed dramatically once the GFC began. The figure 2 shows two major peaks: **9.61%** in the 2008 financial crisis and a sharper spike in 2020 during the COVID-19 lockdowns, reflecting severe shocks to the job market.

In both cases, the Federal Reserve lowered the `FEDFUNDS` rate to nearly zero in 2009 and 2021 (Figure 3) to support the economy. According to a press released from Forbes [10], *lower FED rates encourage economic activities because banks are more likely to lend cash than let it sit on the sidelines earning meager returns.*
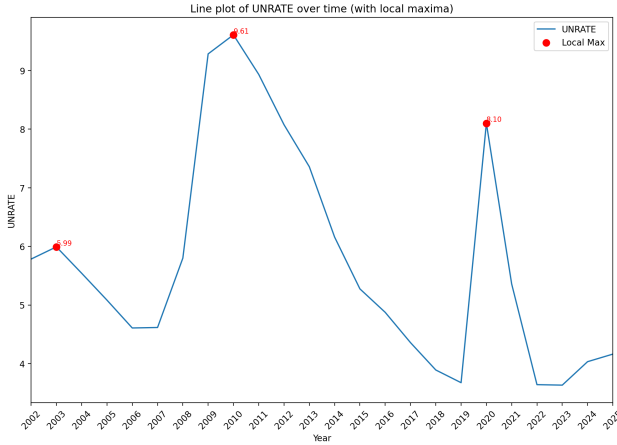

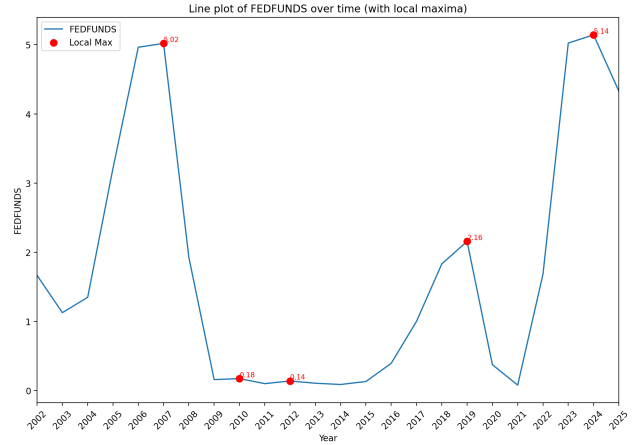Figure 2: Unemployment Rate (UNRATE) Over Time

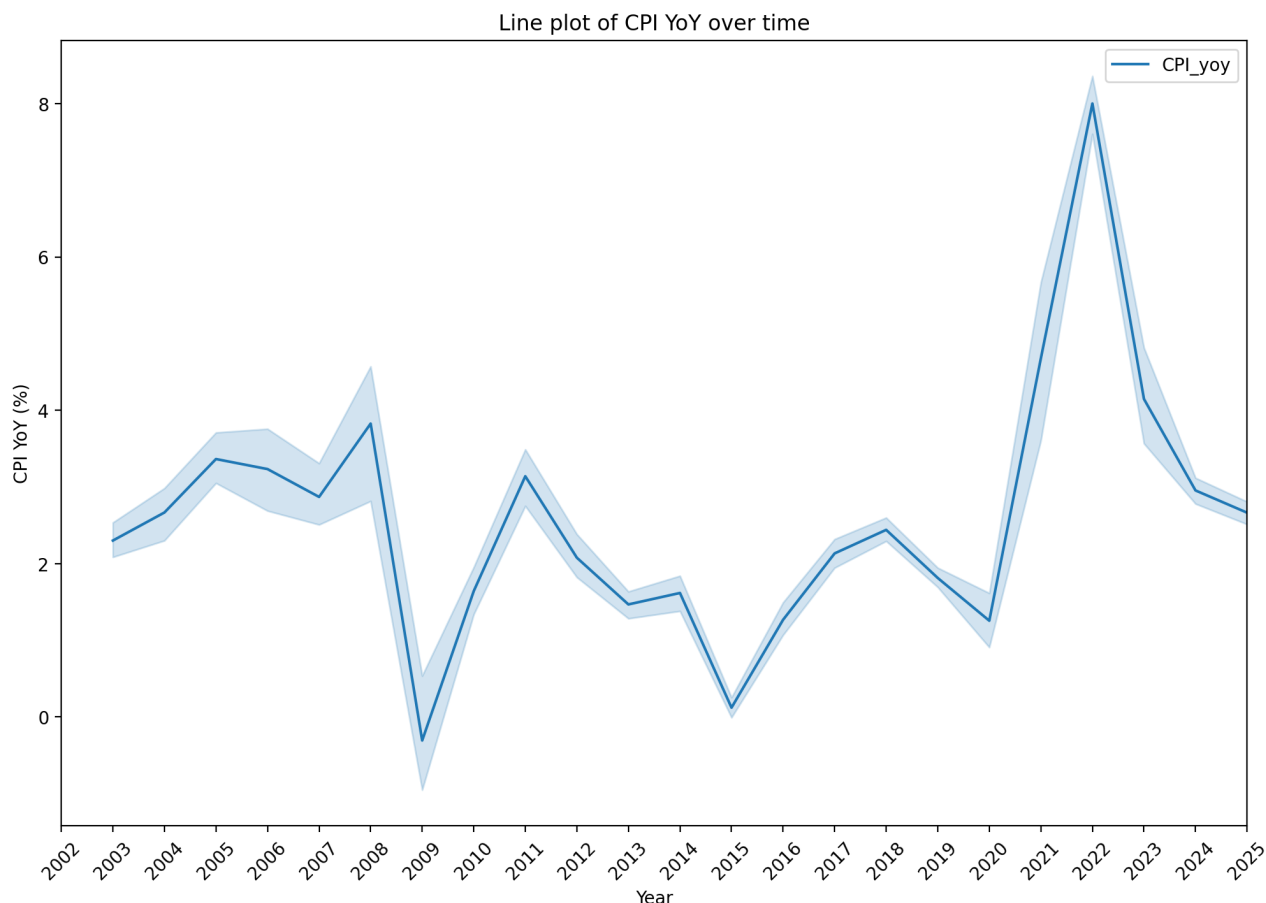Figure 3: Federal Funds Rate (FEDFUNDS) Over Time

Figure 4: CPI YoY Over Time

Figure 4 shows the year-over-year change in the Consumer Price Index (CPI YoY). The series highlights two major disruptions: a sharp decline during the 2008 Global Financial Crisis, when inflation briefly turned negative, and a spike above 8% in 2021–2022 following the COVID-19 pandemic. These fluctuations illustrate how inflationary dynamics can shift rapidly in response to macroeconomic shocks, and set the stage for understanding monetary policy responses.

4.2.2 The Global Financial Crisis

Figure 5 indicates that the U.S. Treasury yield curves across months in 2007 were flat, with only slight upward slopes in the early months and a tendency toward flattening or even inversion later in the end of the year. This pattern signaled weakening market expectations for future growth, a classic precursor to economic downturns. At the same time, FEDFUNDS remained stable at around 5.25% before the Federal Reserve began to cut rates in the second half of 2007, reflecting growing concerns about economic conditions. The unemployment rate (UNRATE) hovered around 4.5% in the first half but showed a gradual increase toward 5% by year-end, indicating early signs of labor market weakness. CPI YoY fluctuated significantly, starting near 2% and doubled by late 2007, showing higher inflation. The figure is evidence of stress that the financial system in 2007 suffered from, ahead of the 2008 Global Financial Crisis.
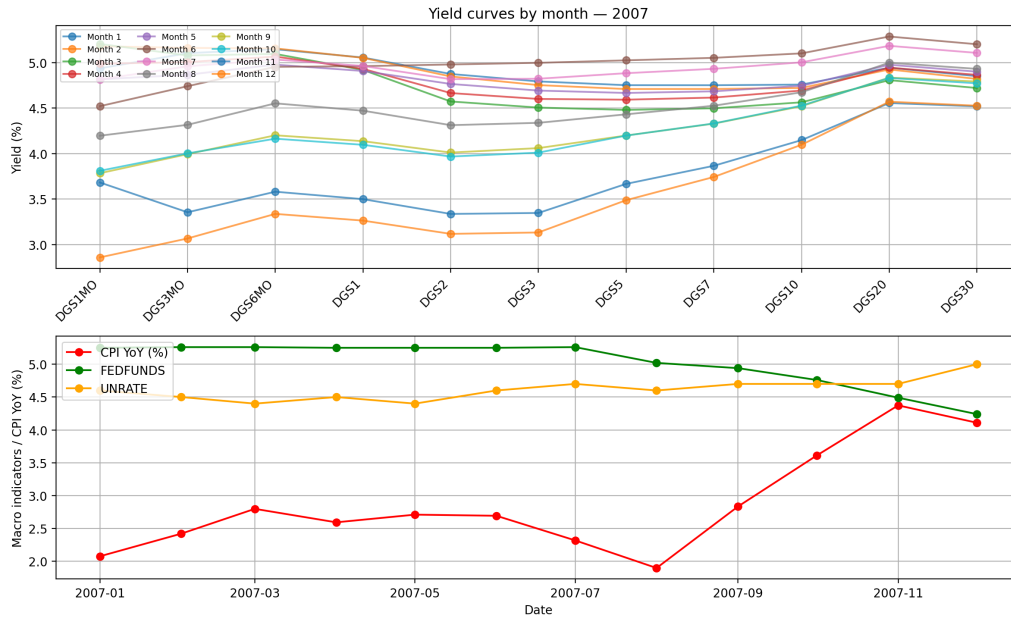
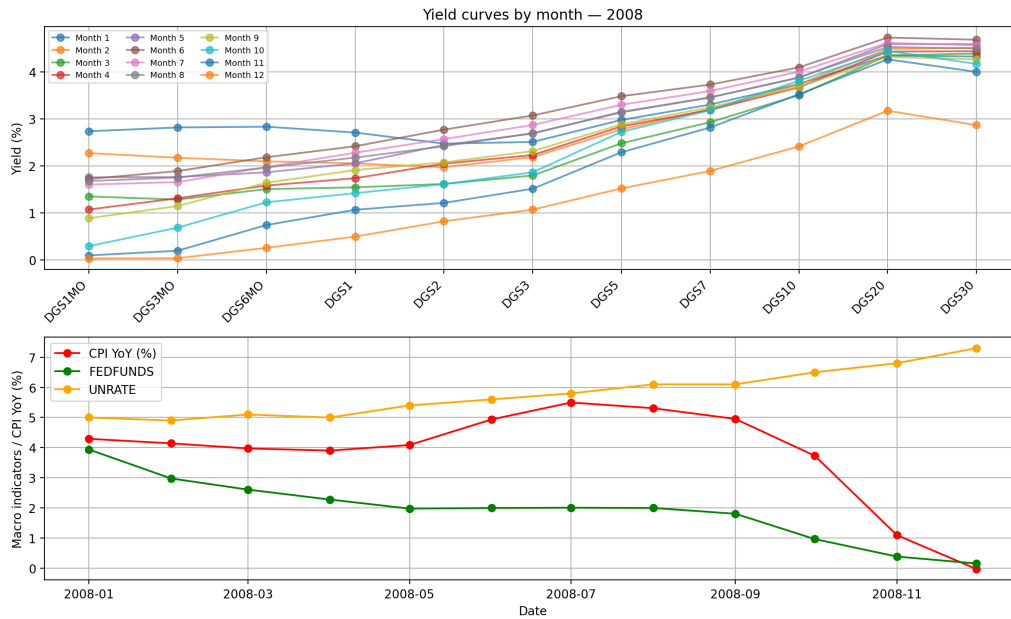Figure 5: Yield Curve and Macro Indicators in 2007

Figure 6: Yield Curve and Macro Indicators in 2008

In 2008, figure 6 shows that U.S. Treasury yield curves became steep. Short-term yields (1M to 6M) fell close to zero as investors moved to safe short-term bonds, especially at the end of 2008, while long-term yields (10Y to 30Y) stayed much higher. The Federal Reserve cut the policy rate sharply, from about 4% at the beginning of the year to almost zero in December, to combat the financial crisis. At the same time, unemployment increased from about 5% to over 7%, showing that the job market was getting worse. Inflation (CPI YoY) first rose above 5% in mid-2008 but then quickly fell to near zero by the end of the year as demand collapsed. In general, the figure reflects the deep impact of the global financial crisis and the strong response

of the Fed.

4.2.3 The COVID-19 Pandemic and Subsequent Inflation

The economic shock from the pandemic in 2020 was severe. As shown in Figure 7, short-term Treasury yields collapsed to near zero starting in April, while longer-term yields remained closer to 2%. This steepening of the yield curve reflected the Federal Reserve's aggressive monetary easing, including cutting the FEDFUNDS rate to zero in early 2020. At the same time, unemployment (UNRATE) spiked dramatically, peaking at 14.8% in April before gradually declining over the rest of the year. Meanwhile, inflation pressures (CPI YoY) hovered near zero for most of 2020. Together, these patterns highlight how the Fed's rapid intervention stabilized financial markets even as the real economy endured stress from the pandemic.

In 2021, the U.S. economy moved from crisis response toward recovery. As shown in Figure 8, the Federal Reserve kept the FEDFUNDS rate near zero for the entire year, which kept short-term yields anchored at the lower bound. Long-term Treasury yields, however, rose modestly as growth expectations improved, resulting in a steeper yield curve compared to 2020. Year-over-year CPI inflation (CPI YoY) accelerated sharply, climbing from below 2% in January to more than 7% by December. Meanwhile, unemployment (UNRATE) declined steadily from around 6% to under 4%, signaling a strong labor market recovery.
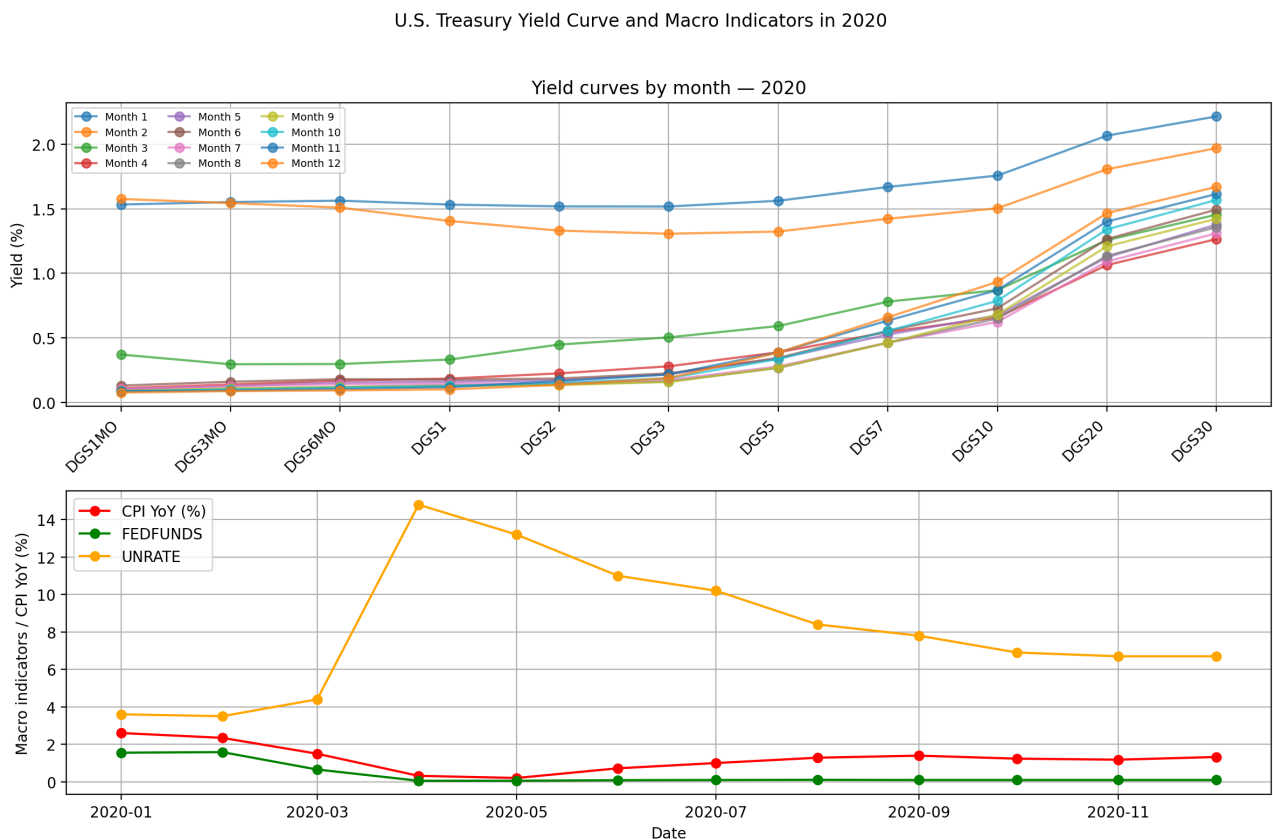

Figure 7: Yield Curve and Macro Indicators in 2020
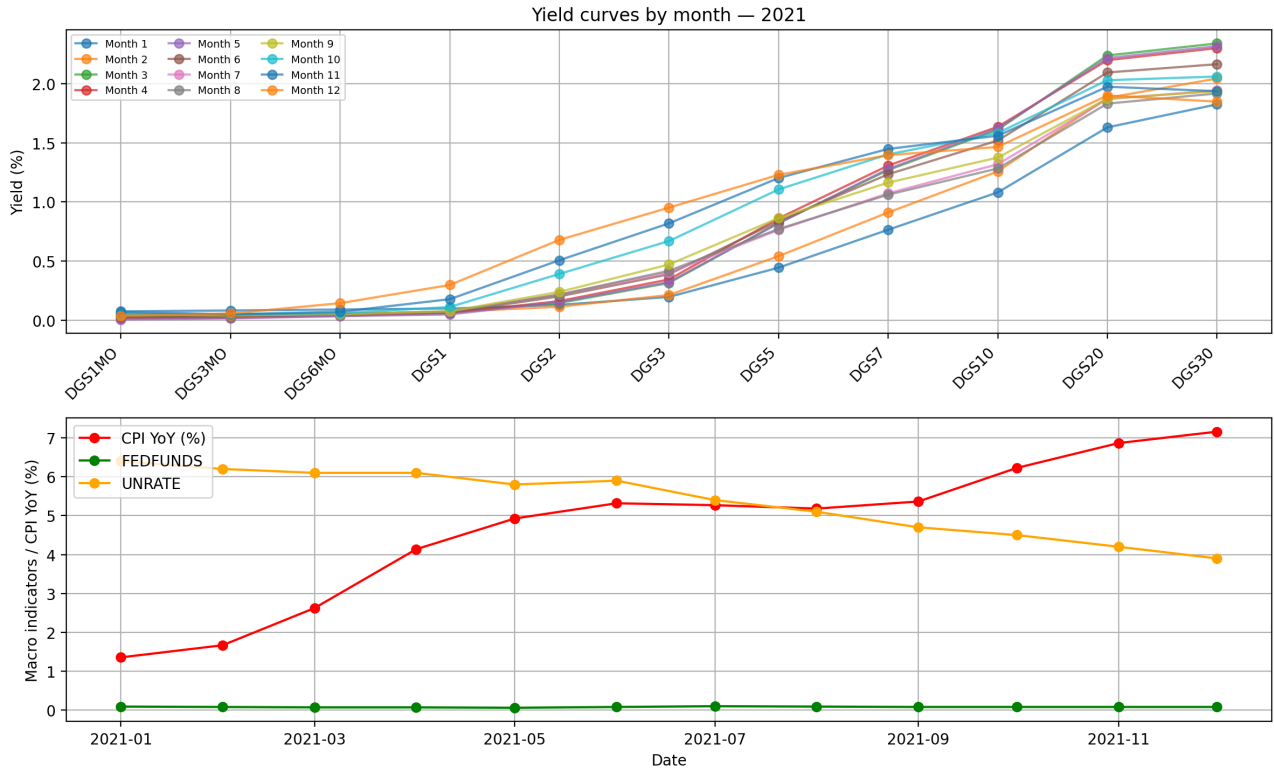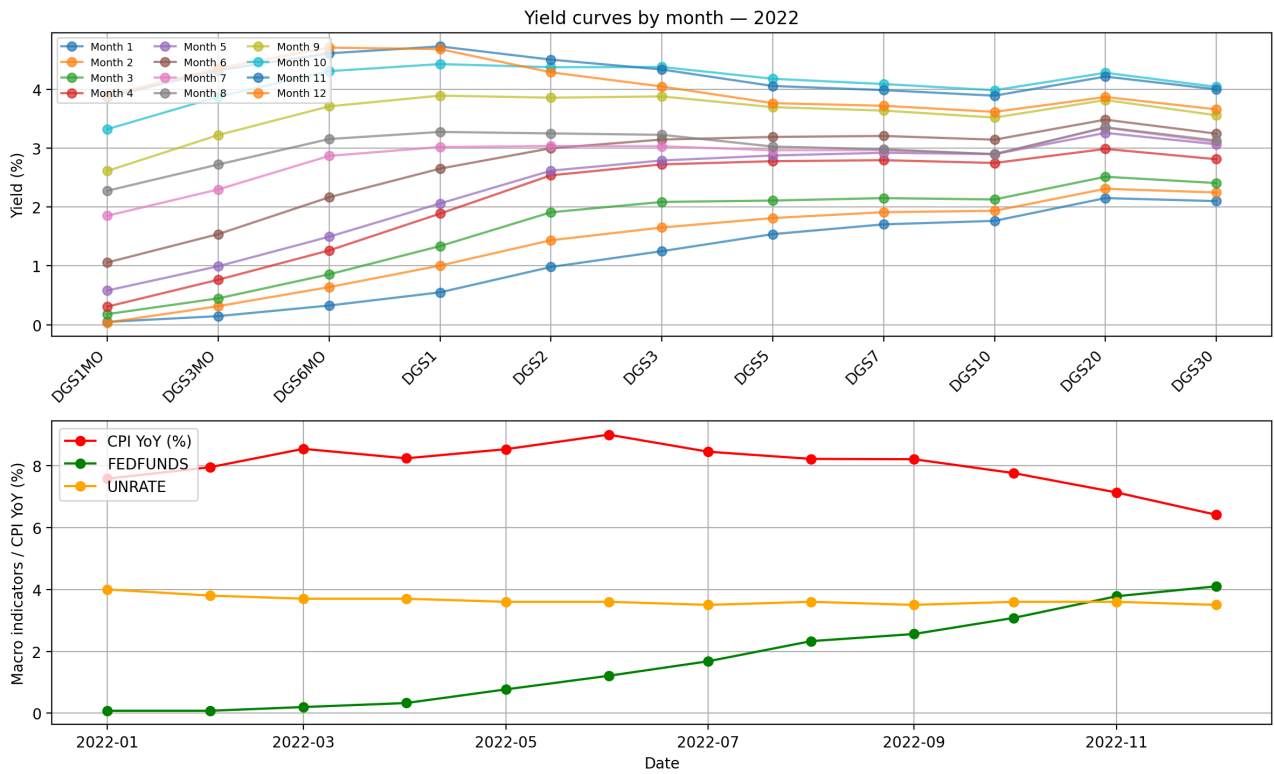
Figure 8: Yield Curve and Macro Indicators in 2021

Figure 9: Yield Curve and Macro Indicators in 2022

The year 2022 marked a turning point in U.S. monetary policy. As shown in Figure 9, the `FEDFUNDS` rate, which had remained near zero in 2021, climbed steadily throughout the year, ending above 4%. At the same time, (`CPI YoY`) peaked above 9% in mid-2022 before easing slightly toward the end of the year, while unemployment (`UNRATE`) remained relatively stable around 3.5–4%. By late 2022, the yield curves had the tendency to be inverted, which is a signal that markets expected future economic slowdown as a consequence of the Fed's tightening.

4.3 Advanced Visualizations and Economic Indicators

4.3.1 The Yield Spread as a Recession Indicator

The spread between the 10-year and 2-year Treasury yields is a widely monitored indicator of economic health. An inverted spread (falling below zero) has historically preceded recessions. Figure 10 confirms this pattern. The spread inverted in 2006-2007 before the GFC and briefly in 2019 before the COVID-19 recession. Most notably, a deep and persistent inversion began in mid-2022, corresponding with the Fed's fight against inflation.

Figure 10: US Treasury Yield Spread (10-Year vs. 2-Year)

4.3.2 Relationship Between Inflation and Long-Term Yields

The scatter plot in Figure 11 explores the relationship between the average annual CPI and the 10-year Treasury yield. The regression line shows a slightly negative relationship, which is counter-intuitive as higher inflation typically warrants higher yields to compensate investors. This result highlights the complexity of the 2002-2025 period. It includes long stretches of low inflation and low rates (post-GFC), where the relationship holds, but is confounded by crisis periods where other factors, like "flight-to-safety" demand for bonds or aggressive central bank intervention, dominate yield movements.
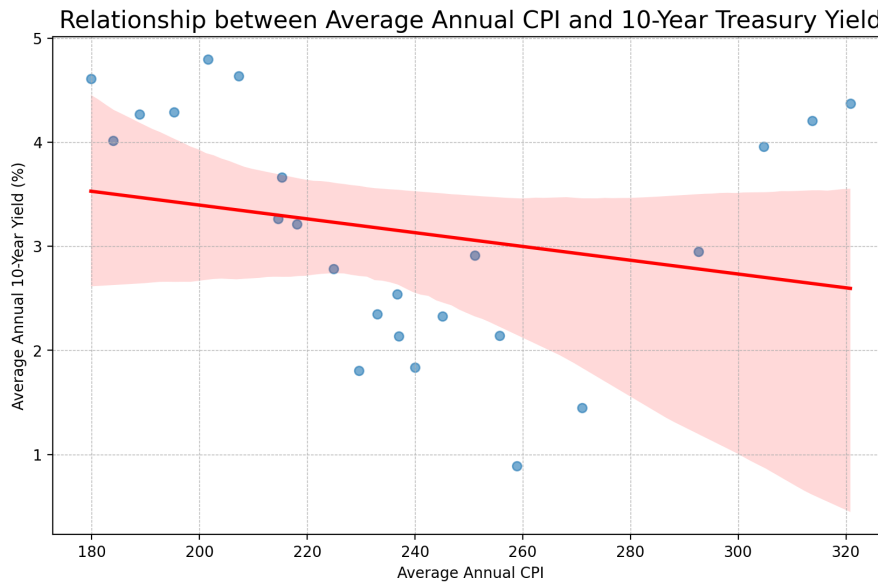
Figure 11: Relationship between Average Annual CPI and 10-Year Treasury Yield

4.3.3 The Dynamic Surface of the Yield Curve

Finally, the 3D surface plot (Figure 12) provides a comprehensive visualization of the yield curve's evolution over the entire period. It captures the shape, level, and slope simultaneously. The plot clearly shows two distinct "high-rate mountains" before 2008 and after 2022, separated by a long, low "valley" corresponding to the era of near-zero interest rates following the GFC. The twisting of the surface illustrates the shifts between normal (upward sloping), flat, and inverted curves, powerfully summarizing the economic cycles of the past two decades.
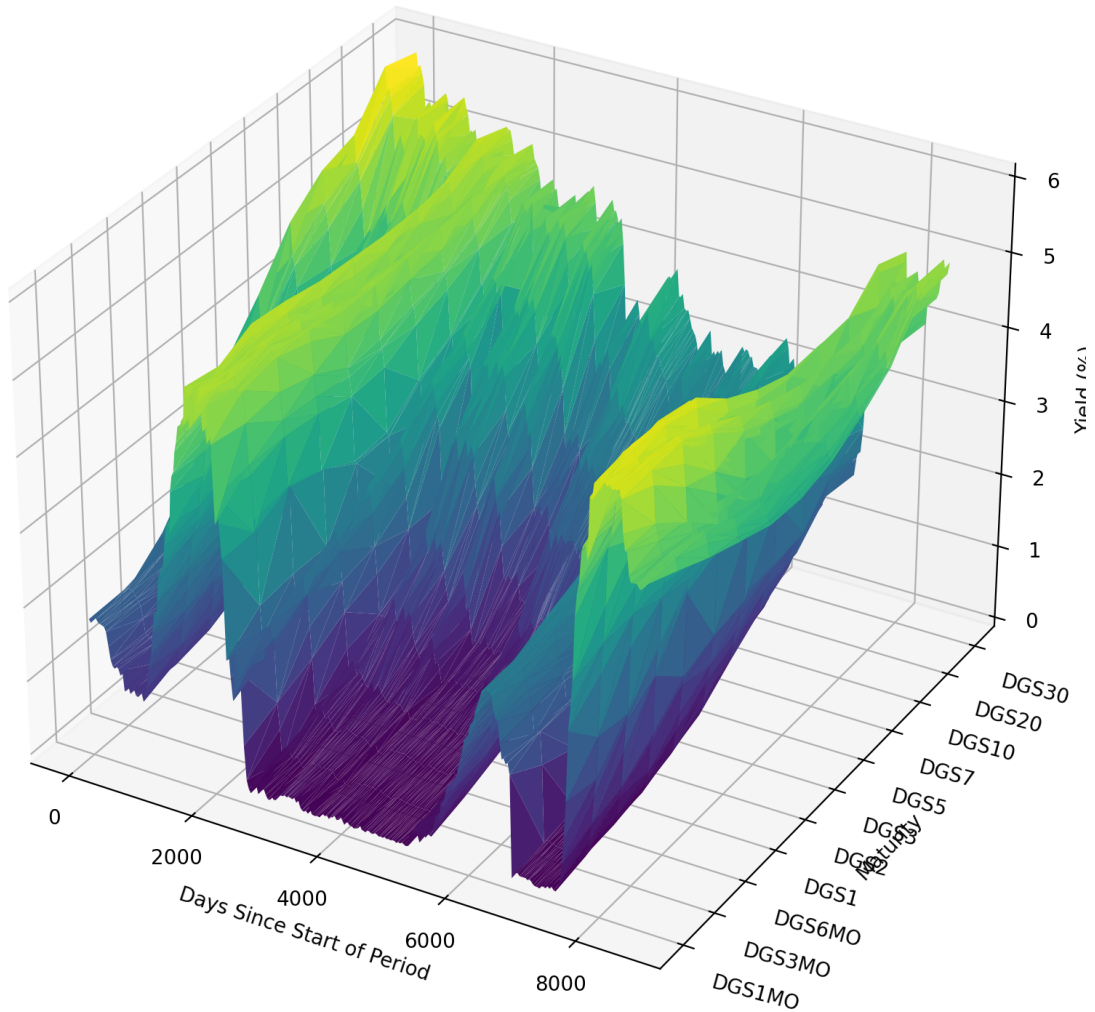
Figure 12: 3D Surface of the U.S. Treasury Yield Curve (2002-2025)

5 Discussion

The analysis highlights the close interactions between U.S. Treasury yields and key macroeconomic indicators (CPI, unemployment, and FEDFUNDS) over the period 2002–2025. Several important insights include:

1. **Crisis Dynamics:** Both the 2008 Global Financial Crisis and the COVID-19 pandemic caused sharp dislocations in yield curves, with short-term rates collapsing due to aggressive monetary easing while long-term yields remained relatively elevated. These patterns underscore how Treasury yields act as a real-time barometer of financial stress and policy responses.

2. **Inflation vs. Yields:** While economic theory suggests higher inflation should push yields upward, the data reveal a more nuanced relationship. During the 2008 Global Financial Crisis, bond demand surged due to a flight-to-safety effect, suppressing long-term yields despite inflationary pressures.

3. **Yield Curve Inversion as a Signal:** The persistence of inverted yield curves since mid-2022 signals that markets anticipate slower growth ahead, even as inflationary pressures remain elevated.

4. **Policy Implications:** The findings emphasize the importance of timely and flexible monetary policy. While rate cuts effectively stabilized markets during crises, prolonged periods of ultra-low interest rates also introduced distortions, complicating the interpretation of yield curve dynamics.

6   References

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