API_Midterm_project_Group_10

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1 FEDERAL RESERVES API PROJECT

Presented by group 10: * Đoàn Nguyễn Bảo An (K60CLC5) - 2114533002 * Nguyễn Chí Hiếu (K59CLC7) - 2015535167 * Lâm Hiếu Quyên (K60CLC5) - 2112533043

In the third year of university, we learned a fairly fundamental subject related to monetary theories, which is Monetary Finance. In that subject, the interest rate variable is mentioned a lot by our lecturer, and one of the capital markets that has an important influence on interest rates, thereby affecting the economy, is the Treasury bond market. From the FED's open data source, we scrape data on US Treasury bond yields with many different maturities to monitor the fluctuations of yield levels and apply what we have learned in Monetary Finance to analyzed observed results that we have visualized from colossal data from FED API.

In this project, we will strongly apply liquidity preference theory and some psychology knowledge to explain our observation from the data. This project will greatly relate to the US fluctuations of treasury bond yield and its economic health.

To get started, we have to run the code `!pip install fredapi` as Google Colab doesn't support this library rightaway.

[ ]:
```
# Install fredapi into the notebook workspace
!pip install fredapi
```

```
Requirement already satisfied: fredapi in /usr/local/lib/python3.10/dist-
packages (0.5.1)
Requirement already satisfied: pandas in /usr/local/lib/python3.10/dist-packages
(from fredapi) (1.5.3)
Requirement already satisfied: python-dateutil>=2.8.1 in
/usr/local/lib/python3.10/dist-packages (from pandas->fredapi) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-
packages (from pandas->fredapi) (2023.3.post1)
Requirement already satisfied: numpy>=1.21.0 in /usr/local/lib/python3.10/dist-
packages (from pandas->fredapi) (1.23.5)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-
packages (from python-dateutil>=2.8.1->pandas->fredapi) (1.16.0)
```

1.1 Import necessary libraries

Next, we will import some necessary libraries for initial reviews and analysis of this project.

```
[ ]: import pandas as pd
     import numpy as np
     import matplotlib.pyplot as plt
     import seaborn as sns
     from fredapi import Fred
```

This project would require us to get the API key from Federal Reserves.

```
[ ]: fred_api = '9fd7aa17937d9c1a9685ff966614f8ae'
```

Now, import the `fred` class from `Fred` module for further search and analysis

```
[ ]: fred = Fred(api_key = fred_api)
```

1.2 FINDING DATAS

Using FRED library, we start to search for neccessary data in FRED colossal data source. We are aiming to take treasury bond yield for different maturity period, so our key words are 'market yield treasury'

```
[ ]: Search_result = fred.search('market yield treasury', order_by = 'popularity')
     Search_result.head(5)
```

```
[ ]:                         id realtime_start realtime_end  \
     series id
     BAMLH0A0HYM2  BAMLH0A0HYM2     2023-09-19   2023-09-19
     DGS10                DGS10     2023-09-19   2023-09-19
     DFII10              DFII10     2023-09-19   2023-09-19
     DGS2                  DGS2     2023-09-19   2023-09-19
     DGS1                  DGS1     2023-09-19   2023-09-19

                                                               title  \
     series id
     BAMLH0A0HYM2  ICE BofA US High Yield Index Option-Adjusted S…
     DGS10         Market Yield on U.S. Treasury Securities at 10…
     DFII10        Market Yield on U.S. Treasury Securities at 10…
     DGS2          Market Yield on U.S. Treasury Securities at 2-…
     DGS1          Market Yield on U.S. Treasury Securities at 1-…

                  observation_start observation_end     frequency frequency_short  \
     series id
     BAMLH0A0HYM2        1996-12-31      2023-09-18  Daily, Close               D
     DGS10               1962-01-02      2023-09-15         Daily               D
     DFII10              2003-01-02      2023-09-15         Daily               D
     DGS2                1976-06-01      2023-09-15         Daily               D
     DGS1                1962-01-02      2023-09-15         Daily               D

                     units units_short      seasonal_adjustment  \
     series id
     BAMLH0A0HYM2  Percent           %  Not Seasonally Adjusted
     DGS10         Percent           %  Not Seasonally Adjusted
     DFII10        Percent           %  Not Seasonally Adjusted
     DGS2          Percent           %  Not Seasonally Adjusted
     DGS1          Percent           %  Not Seasonally Adjusted

                  seasonal_adjustment_short               last_updated popularity  \
     series id
     BAMLH0A0HYM2                       NSA  2023-09-19 09:05:14-05:00         93
     DGS10                              NSA  2023-09-18 15:20:07-05:00         91
     DFII10                             NSA  2023-09-18 15:19:04-05:00         85
     DGS2                               NSA  2023-09-18 15:21:07-05:00         80
     DGS1                               NSA  2023-09-18 15:21:09-05:00         78

                                                               notes
     series id
     BAMLH0A0HYM2  The ICE BofA Option-Adjusted Spreads (OASs) ar…
     DGS10         For further information regarding treasury con…
     DFII10        For further information regarding treasury con…
     DGS2          For further information regarding treasury con…
     DGS1          For further information regarding treasury con…
```

The topic we want to choose would relate to the market yield. Thus we would like to get data series of bond yield in the U.S. for maturity of 30 years, 10 years, 5 years, 2 years and 1 year, and then store it in the `bond_yield` DataFrame.

DGS1: 1-year Treasury Bond Yield

DGS2: 2-year Treasury Bond Yield

DGS5: 5-year Treasury Bond Yield

DGS10: 10-year Treasury Bond Yield

DGS30: 30-year Treasury Bond Yield

[ ]:

```python
dgs_id = ['DGS30', 'DGS10', 'DGS5', 'DGS2', 'DGS1']

# Initialize an empty DataFrame
bond_yield = pd.DataFrame()

for id in dgs_id:
    # Get the series
    series = fred.get_series(id)

    # Convert the series to a DataFrame and rename the column
    series_bond_yield = series.to_frame().rename(columns={0: id})

    # Merge the series DataFrame into the main DataFrame
    if bond_yield.empty:
        bond_yield = series_bond_yield
    else:
        bond_yield = bond_yield.merge(series_bond_yield, left_index=True,␣
 ↪right_index=True, how='outer')

bond_yield.reset_index(inplace = True)
bond_yield.columns = ['Date', 'DGS30', 'DGS10', 'DGS5', 'DGS2', 'DGS1']
bond_yield.head()
```

```
[ ]:         Date  DGS30  DGS10  DGS5  DGS2  DGS1
     0 1962-01-02    NaN   4.06  3.88   NaN  3.22
     1 1962-01-03    NaN   4.03  3.87   NaN  3.24
     2 1962-01-04    NaN   3.99  3.86   NaN  3.24
     3 1962-01-05    NaN   4.02  3.89   NaN  3.26
     4 1962-01-08    NaN   4.03  3.91   NaN  3.31
```

1.3 CLEAN DATA

We can see that there might be periods where some of the data are `null`. Let's look through the basic information of DataFrame `bond_yield` and check if `bond_yield` has `null` values or not.

```
[ ]: # Check basic information
     print(bond_yield.info())

     # Check the number of null values of each column
     print(bond_yield.isnull().sum())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 16099 entries, 0 to 16098
Data columns (total 6 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   Date    16099 non-null  datetime64[ns]
 1   DGS30   11643 non-null  float64
 2   DGS10   15413 non-null  float64
 3   DGS5    15413 non-null  float64
 4   DGS2    11821 non-null  float64
 5   DGS1    15413 non-null  float64
dtypes: datetime64[ns](1), float64(5)
memory usage: 754.8 KB
None
Date        0
DGS30    4456
DGS10     686
DGS5      686
DGS2     4278
```

```
DGS1      686
dtype: int64
```

It’s obvious that `bond_yield` DataFrame has `null` values in some columns. For the sake of convenience for later calculations, we wiil drop rows that exist `null` values.

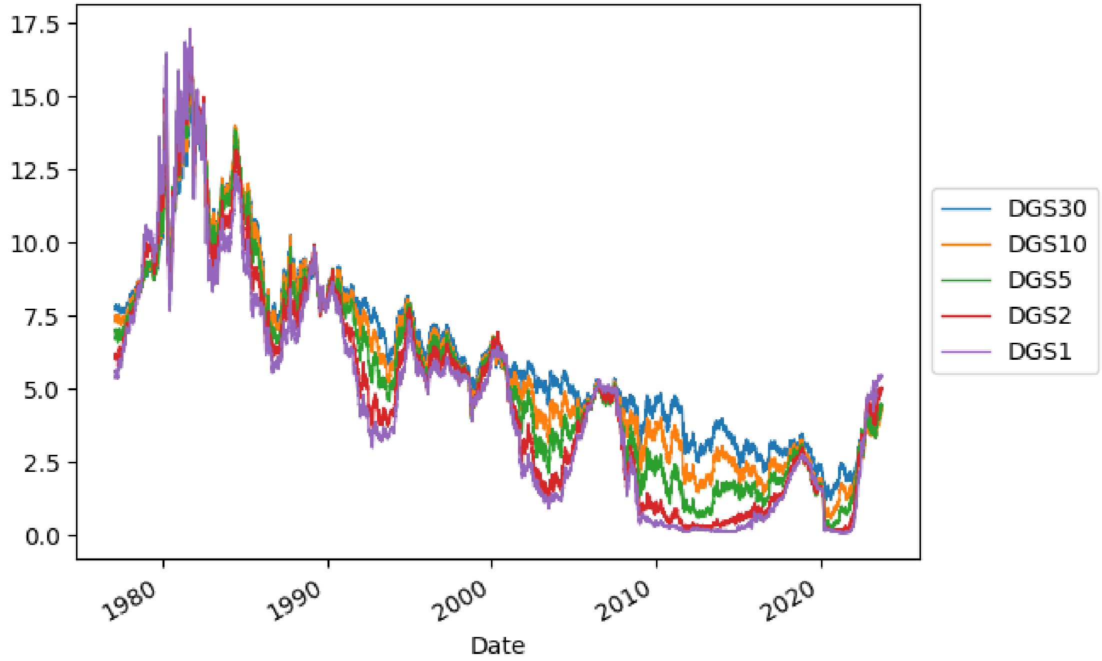
[ ]:
```
# Filter the values
bond_yield = bond_yield.dropna()
bond_yield.head()
```

[ ]:
```
            Date  DGS30  DGS10  DGS5  DGS2  DGS1
3945 1977-02-15   7.70   7.36  6.72  6.04  5.39
3946 1977-02-16   7.67   7.34  6.70  6.02  5.40
3947 1977-02-17   7.67   7.26  6.67  5.99  5.33
3948 1977-02-18   7.76   7.41  6.82  6.06  5.38
3950 1977-02-22   7.77   7.42  6.84  6.09  5.46
```

Now, let’s plot some line for each features

[ ]:
```
# Set the size of the plot
plt.figure(figsize = (8, 6))

# Plot the market yield for 30 years, 10 years, 5 years, 2 years and 1 year␣
 ↪into one figure
bond_yield.plot(x = 'Date', y = ['DGS30', 'DGS10', 'DGS5', 'DGS2', 'DGS1'],␣
 ↪linewidth = 1)

# Put the legend outside the graph
plt.legend(loc='center left', bbox_to_anchor=(1, 0.5))
plt.show()
```

```
<Figure size 800x600 with 0 Axes>
```



1.4 FINDING RECESSION PERIOD

After successfully ploting five line of treasury bond yield for five different maturity period. We are heading to find whether there is available data on US's recession period.

```
[ ]: fred.search('Recession', filter = ('frequency', 'Daily')).head()
```

```
[ ]:                  id realtime_start realtime_end  \
     series id
     USRECD        USRECD     2023-09-19   2023-09-19
     USRECDM      USRECDM     2023-09-19   2023-09-19
     EURORECD    EURORECD     2023-09-19   2023-09-19
     USRECDP      USRECDP     2023-09-19   2023-09-19
     USARECDM    USARECDM     2023-09-19   2023-09-19

                                                            title  \
     series id
     USRECD     NBER based Recession Indicators for the United…
     USRECDM    NBER based Recession Indicators for the United…
     EURORECD   OECD based Recession Indicators for Euro Area …
     USRECDP    NBER based Recession Indicators for the United…
     USARECDM   OECD based Recession Indicators for the United…

               observation_start observation_end     frequency frequency_short  \
     series id
```

```
USRECD          1854-12-01      2023-09-17  Daily, 7-Day              D
USRECDM         1854-12-01      2023-09-17  Daily, 7-Day              D
EURORECD        1960-03-01      2022-08-31  Daily, 7-Day              D
USRECDP         1854-12-01      2023-09-17  Daily, 7-Day              D
USARECDM        1947-02-01      2022-09-30  Daily, 7-Day              D

             units units_short      seasonal_adjustment  \
series id
USRECD     +1 or 0     +1 or 0  Not Seasonally Adjusted
USRECDM    +1 or 0     +1 or 0  Not Seasonally Adjusted
EURORECD   +1 or 0     +1 or 0  Not Seasonally Adjusted
USRECDP    +1 or 0     +1 or 0  Not Seasonally Adjusted
USARECDM   +1 or 0     +1 or 0  Not Seasonally Adjusted

          seasonal_adjustment_short              last_updated popularity  \
series id
USRECD                          NSA  2023-09-18 18:02:03-05:00         54
USRECDM                         NSA  2023-09-18 18:02:02-05:00         36
EURORECD                        NSA  2022-12-09 14:50:02-06:00         19
USRECDP                         NSA  2023-09-18 18:02:02-05:00         30
USARECDM                        NSA  2022-12-09 14:43:02-06:00         21

                                                       notes
series id
USRECD     This time series is an interpretation of US Bu…
USRECDM    This time series is an interpretation of US Bu…
EURORECD   This time series is an interpretation of Organ…
USRECDP    This time series is an interpretation of US Bu…
USARECDM   This time series is an interpretation of Organ…
```

Since we want to get the recession period of the United States, we will choose `series_id = 'USCERD'`. The reason of choosing this is due to our `bond_yield` DataFrame has daily series, so we would choose the recession series also by day. Moreover, since we have filtered the date from `1977-02-15`, thus we would also filter the recession data to start from `1977-02-15`.

[ ]:

```python
# Get the data series and reset index
recession = fred.get_series('USRECD').reset_index()

# Rename the columns
recession.columns = ['Date', 'isRecession']

# Filter the date from 1977-02-15
recession = recession.loc[recession['Date'] > '1977-02-15']

# Change 'isRecession' column from float to int.
recession['isRecession'] = recession['isRecession'].astype(int)
```

```
# Display the data
recession.head()
```

```
[ ]:              Date  isRecession
     44637 1977-02-16            0
     44638 1977-02-17            0
     44639 1977-02-18            0
     44640 1977-02-19            0
     44641 1977-02-20            0
```

Next, we will merge this `recession` DataFrame with the `bond_yield` DataFrame above and name is `bond_yield_with_res`

```
[ ]: bond_yield_with_res = bond_yield.merge(recession, on = 'Date')
     bond_yield_with_res.head()
```

```
[ ]:         Date  DGS30  DGS10  DGS5  DGS2  DGS1  isRecession
     0 1977-02-16   7.67   7.34  6.70  6.02  5.40            0
     1 1977-02-17   7.67   7.26  6.67  5.99  5.33            0
     2 1977-02-18   7.76   7.41  6.82  6.06  5.38            0
     3 1977-02-22   7.77   7.42  6.84  6.09  5.46            0
     4 1977-02-23   7.81   7.48  6.95  6.12  5.50            0
```

Get the basic statistics relating to the `bond_yield_with_res` DataFrame.

```
[ ]: bond_yield_with_res.describe()
```

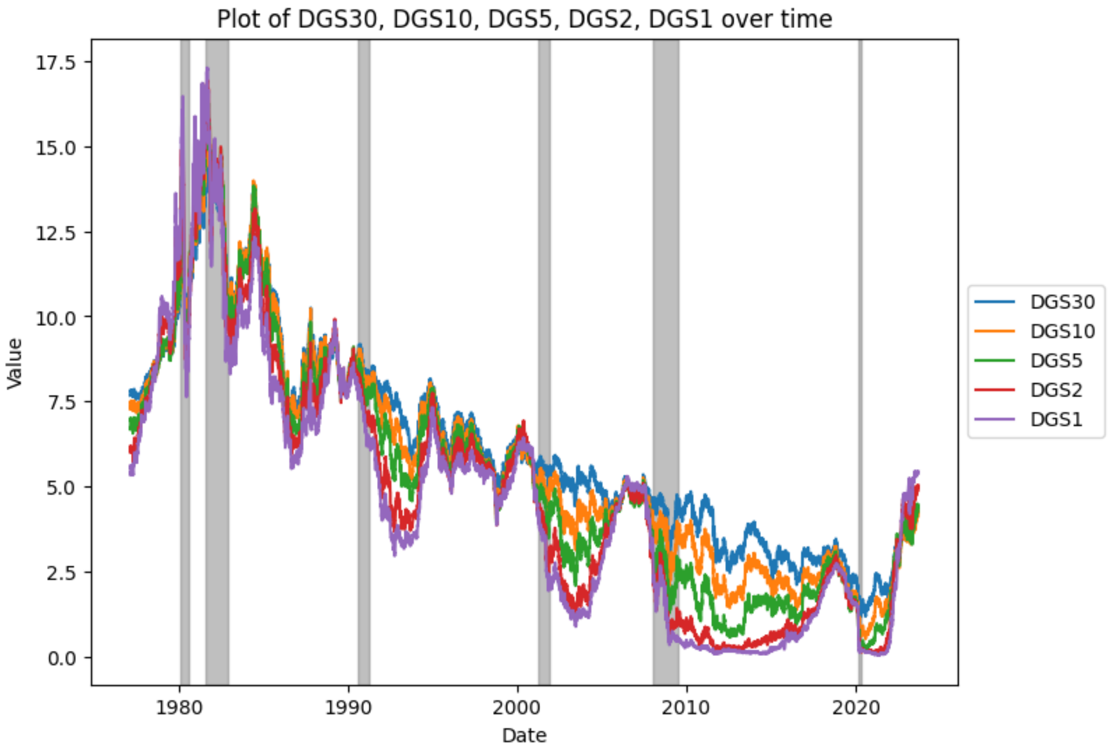
```
[ ]:               DGS30         DGS10          DGS5          DGS2          DGS1  \
     count  11642.000000  11642.000000  11642.000000  11642.000000  11642.000000
     mean       6.249292      5.867187      5.450448      4.985589      4.712900
     std        3.040527      3.333053      3.558380      3.783390      3.813293
     min        0.990000      0.520000      0.190000      0.090000      0.040000
     25%        3.750000      3.010000      2.370000      1.570000      1.270000
     50%        5.690000      5.310000      5.020000      4.720000      4.700000
     75%        8.200000      8.060000      7.810000      7.440000      6.940000
     max       15.210000     15.840000     16.270000     16.950000     17.310000

             isRecession
     count  11642.000000
     mean       0.103333
     std        0.304406
     min        0.000000
     25%        0.000000
     50%        0.000000
     75%        0.000000
     max        1.000000
```

1.5 PLOTTING BOND YIELD MARKED WITH RECESSION PERIOD

Now, highlight the recession period for the previous graph.

[ ]:

```
plt.figure(figsize = (8, 6))

# Plot each column
for column in ['DGS30', 'DGS10', 'DGS5', 'DGS2', 'DGS1']:
    plt.plot(bond_yield_with_res['Date'], bond_yield_with_res[column],␣
 ↪label=column)

# Highlight recession periods
recession_start = None
for i in range(len(bond_yield_with_res)):
    if bond_yield_with_res['isRecession'].iloc[i] == 1:
        if recession_start is None:
            recession_start = bond_yield_with_res['Date'].iloc[i]
    elif recession_start is not None:
        plt.axvspan(recession_start, bond_yield_with_res['Date'].iloc[i],␣
 ↪color='gray', alpha=0.5)
        recession_start = None

plt.xlabel('Date')
plt.ylabel('Value')
plt.title('Plot of DGS30, DGS10, DGS5, DGS2, DGS1 over time')
plt.legend(loc='center left', bbox_to_anchor=(1, 0.5))
plt.show()
```



1.6 NUMBERING RECESSION

For further analysis, we would mark the recession periods with number. For example, the first recession would be marked as ‘Recession number 1’, and continue doing so. If not, mark ‘No recession’

[ ]:

```
recession_number = 0
is_in_recession = False

def label_recession(row):
    global recession_number, is_in_recession
    if row['isRecession'] == 1 and not is_in_recession:
        recession_number += 1
        is_in_recession = True
        return f'Recession number {recession_number}'
    elif row['isRecession'] == 1 and is_in_recession:
        return f'Recession number {recession_number}'
    else:
        is_in_recession = False
        return 'No recession'

bond_yield_with_res['Name of recession'] = bond_yield_with_res.
 ↪apply(label_recession, axis=1)
```

```
bond_yield_with_res.head()
```

```
[ ]:         Date  DGS30  DGS10  DGS5  DGS2  DGS1  isRecession Name of recession
     0 1977-02-16   7.67   7.34  6.70  6.02  5.40            0      No recession
     1 1977-02-17   7.67   7.26  6.67  5.99  5.33            0      No recession
     2 1977-02-18   7.76   7.41  6.82  6.06  5.38            0      No recession
     3 1977-02-22   7.77   7.42  6.84  6.09  5.46            0      No recession
     4 1977-02-23   7.81   7.48  6.95  6.12  5.50            0      No recession
```

Now, filter the recession period

```
[ ]: recession_period = bond_yield_with_res[bond_yield_with_res['Name of recession'].
       ↪str.contains('Recession number')]
     recession_period.head()
```

```
[ ]:           Date  DGS30  DGS10   DGS5   DGS2   DGS1  isRecession  \
     735 1980-02-01  11.23  11.29  11.30  12.04  12.62            1
     736 1980-02-04  11.32  11.40  11.38  12.12  12.67            1
     737 1980-02-05  11.64  11.73  11.80  12.49  12.91            1
     738 1980-02-06  11.78  11.92  11.86  12.42  12.84            1
     739 1980-02-07  11.70  11.71  11.61  12.21  12.68            1

            Name of recession
     735  Recession number 1
     736  Recession number 1
     737  Recession number 1
     738  Recession number 1
     739  Recession number 1
```

1.7 Testify liquidity preference theory and market interest rate critical threshold hypothesis.

Based on research and personal experience combined with learned theories about Monetary Finance. We want to find the periods where the 1-year Treasury bond yield crosses above and exceeds longer-maturity Treasury bonds such as the 2-year and 5-year maturities. In theory, when short-term yields cross longer-term yield lines, it means market expectations are leaning towards future short-term interest rates falling, which in practice is good, but if we understand market psychology more deeply, you will know that at times when short-term yields cut up, it means that the current interest rate increase is too fast or the market has reached a critical threshold in interest rates. That means no one in the market can imagine interest rates could go higher.These are dangerous times for the economy when interest rates are almost at their critical level and the economy can hardly endure those interest rates any longer. To testify our understanding, we plot periods when DGS1(1-year treasury bond yield) exceeds both DGS2(2-year treasury bond yield) and DGS5(5-year treasury bond yield), Recession period and five terms of treasury bond yield. Plot when DGS1 > DGS2 and DGS1 > DGS5

[ ]:

```
highlight = bond_yield_with_res.copy()
highlight['DGS1 > [DGS2, DGS5]'] = ((highlight['DGS1'] > highlight['DGS2']) &␣
  ↪(highlight['DGS1'] > highlight['DGS5']))
highlight = highlight.reset_index(drop = True)
highlight
```

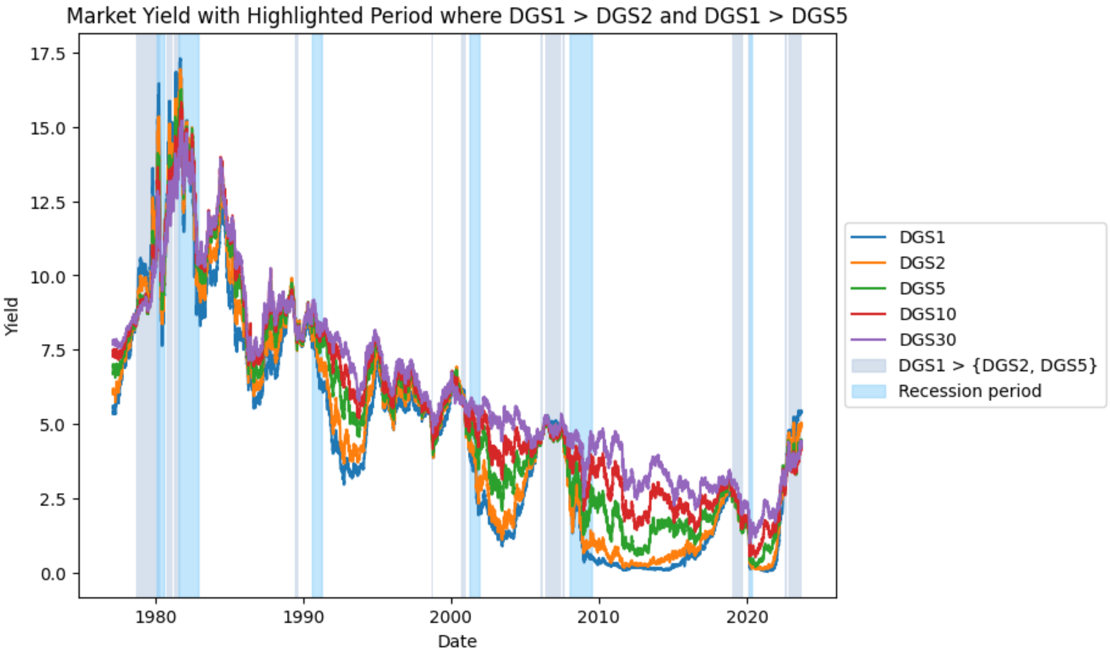
[ ]:

```
            Date  DGS30  DGS10  DGS5  DGS2  DGS1  isRecession  \
0     1977-02-16   7.67   7.34  6.70  6.02  5.40            0
1     1977-02-17   7.67   7.26  6.67  5.99  5.33            0
2     1977-02-18   7.76   7.41  6.82  6.06  5.38            0
3     1977-02-22   7.77   7.42  6.84  6.09  5.46            0
4     1977-02-23   7.81   7.48  6.95  6.12  5.50            0
…          …    …    …   …   …   …          …
11637 2023-09-11   4.37   4.29  4.40  4.97  5.40            0
11638 2023-09-12   4.35   4.27  4.41  4.98  5.42            0
11639 2023-09-13   4.34   4.25  4.39  4.96  5.42            0
11640 2023-09-14   4.39   4.29  4.42  5.00  5.42            0
11641 2023-09-15   4.42   4.33  4.45  5.02  5.43            0

      Name of recession  DGS1 > [DGS2, DGS5]
0          No recession                False
1          No recession                False
2          No recession                False
3          No recession                False
4          No recession                False
…                 …                  …
11637      No recession                 True
11638      No recession                 True
11639      No recession                 True
11640      No recession                 True
11641      No recession                 True

[11642 rows x 9 columns]
```

[ ]:

```
import matplotlib.patches as mpatches

# Set the subplots and figure size
fig, ax = plt.subplots()
fig.set_size_inches(8, 6)

# Set each line
line1, = ax.plot(highlight['Date'], highlight['DGS1'], label='DGS1')
line2, = ax.plot(highlight['Date'], highlight['DGS2'], label='DGS2')
line3, = ax.plot(highlight['Date'], highlight['DGS5'], label='DGS5')
line4, = ax.plot(highlight['Date'], highlight['DGS10'], label='DGS10')
line5, = ax.plot(highlight['Date'], highlight['DGS30'], label='DGS30')
```

```
# Highlight parts where 'DGS1 > [DGS2, DGS5]' are True
for i in range(1, len(highlight)):
    if highlight.loc[i, 'DGS1 > [DGS2, DGS5]']:
        ax.axvspan(highlight.loc[i-1, 'Date'], highlight.loc[i, 'Date'],␣
  ↪facecolor='lightsteelblue', alpha=0.5)
patch_1 = mpatches.Patch(color='lightsteelblue', alpha=0.5, label='DGS1 >␣
  ↪{DGS2, DGS5}')

recession_start = None
for i in range(len(highlight)):
    if highlight['isRecession'].iloc[i] == 1:
        if recession_start is None:
            recession_start = highlight['Date'].iloc[i]
    elif recession_start is not None:
        plt.axvspan(recession_start, highlight['Date'].iloc[i],␣
  ↪color='lightskyblue', alpha=0.5)
        recession_start = None
patch_2 = mpatches.Patch(color='lightskyblue', alpha=0.5, label='Recession␣
  ↪period')

plt.xlabel('Date')
plt.ylabel('Yield')
plt.title('Market Yield with Highlighted Period where DGS1 > DGS2 and DGS1 >␣
  ↪DGS5')

# Add line & patch variables into the handles parameter.
plt.legend(handles=[line1, line2, line3, line4, line5, patch_1, patch_2],␣
  ↪loc='center left', bbox_to_anchor=(1, 0.5))
plt.show()
```



Through the plot above, we can easily see that bond yields of all terms tend to decrease after the period when the DGS1 line crosses longer terms such as DGS2(2-year treasury bond yield) or DGS5(5-year treasury bond yield). This is entirely consistent with the theory of liquidity preference which provides an indicator for future expectations of interest rate movements. Further, if we look at major recessions then You will see that there are often periods where long-term yields cut short-term yields before every recession. This is consistent with the hypothesis about the critical threshold of market interest rates.

1.8 Finding market interest rate expectation at every beginning of each recession period

In our project, We want to observe market expectations of future interest rate movements at the beginning of recession periods based on liquidity preference theory. We will plot the yields for five different Treasury bond maturities on the same chart and will observe what the market expects of interest rates at the beginning of each recession.(* *based on the theory of liquidity preference.*)

[ ]:
```
first_recession_date = recession_period.groupby('Name of recession').first().
  ↪reset_index()

# Drop the 'Name of recession' column and save it to temp
temp = first_recession_date.pop('Name of recession')

# Add 'Name of recession' column back to the last column of the DataFrame
first_recession_date.insert(len(first_recession_date.columns), 'Name of␣
  ↪recession', temp)
```

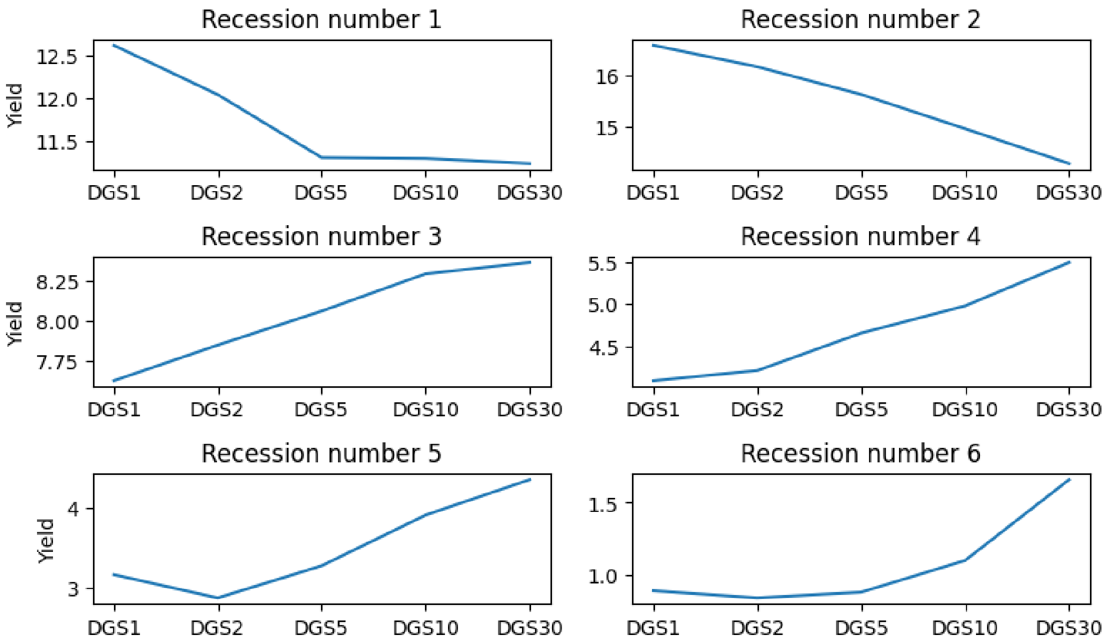
```
# Reset the index
first_recession_date = first_recession_date.reset_index(drop = True)

first_recession_date
```

[ ]:

```
        Date  DGS30  DGS10   DGS5   DGS2   DGS1  isRecession  \
0 1980-02-01  11.23  11.29  11.30  12.04  12.62            1
1 1981-08-03  14.27  14.95  15.62  16.16  16.58            1
2 1990-08-01   8.36   8.29   8.06   7.85   7.63            1
3 2001-04-02   5.49   4.98   4.66   4.22   4.10            1
4 2008-01-02   4.35   3.91   3.28   2.88   3.17            1
5 2020-03-02   1.66   1.10   0.88   0.84   0.89            1

    Name of recession
0  Recession number 1
1  Recession number 2
2  Recession number 3
3  Recession number 4
4  Recession number 5
5  Recession number 6
```

[ ]:

```
# Plot each 2 graphs on one row
fig = plt.figure(figsize=(8, 6))
for index in range(0,len(first_recession_date),2):
    ax = fig.add_subplot(len(first_recession_date)//2+1 ,2,index+1)
    ax.plot(['DGS1', 'DGS2', 'DGS5', 'DGS10', 'DGS30'],
            [first_recession_date.loc[index,'DGS1'],
             first_recession_date.loc[index,'DGS2'],
             first_recession_date.loc[index,'DGS5'],
             first_recession_date.loc[index,'DGS10'],
             first_recession_date.loc[index,'DGS30']])
    ax.set_title(first_recession_date.loc[index,'Name of recession'])
    ax.set_ylabel('Yield')

    if index+1 < len(first_recession_date):
        ax = fig.add_subplot(len(first_recession_date)//2+1 ,2,index+2)
        ax.plot(['DGS1', 'DGS2', 'DGS5', 'DGS10', 'DGS30'],
                [first_recession_date.loc[index+1,'DGS1'],
                 first_recession_date.loc[index+1,'DGS2'],
                 first_recession_date.loc[index+1,'DGS5'],
                 first_recession_date.loc[index+1,'DGS10'],
                 first_recession_date.loc[index+1,'DGS30']])
        ax.set_title(first_recession_date.loc[index+1,'Name of recession'])
plt.tight_layout()
plt.show()
```



Only in recession No. 1(1980) and recession No. 2(1981) did the interterm yield curve show a decline, meaning the market expected a sharp reduction in interest rates in the future.

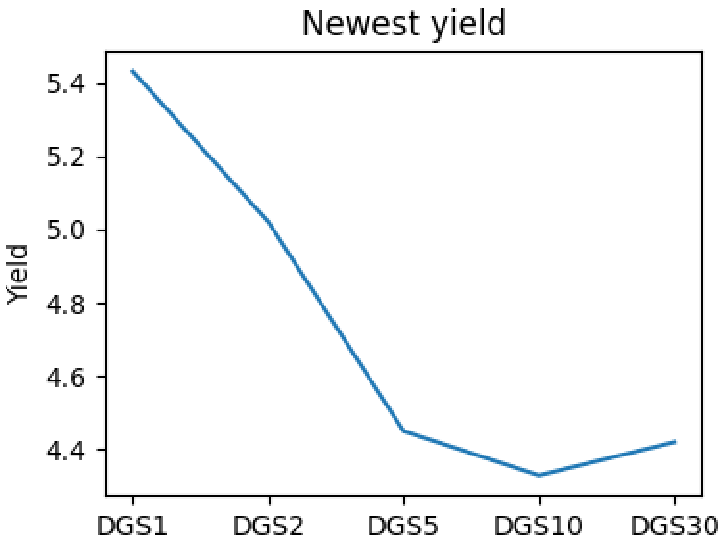
The following two recessions(1990 and 2001) showed a steepening of the inter-term yield curve, meaning the market expected an increase in interest rates in the future. This can be an evidence for US economy power and the recession is only an acute symtom. Or this can be a signal for a higher risk level for US long-term economy.

And in the last two recessions(2008 and 2020). DGS2(2-year treasury bond yield) is lower than DGS1(1-year treasury bond yield), showing that the market expects a short-term interest rate cut but interest rates are still expected to remain stable in the long term.

How about market expectation for future interest rate currently?

[ ]:

```
# Get the latest market bond yield
newest_yield = bond_yield.iloc[-1]

# Drop the 'Date' series
labels = newest_yield.index
values = newest_yield.values
labels = np.delete(labels, 0)
labels = labels[::-1]
values = np.delete(values, 0)
values = values[::-1]

# Plot the graph
plt.figure(figsize = (4, 3))
plt.plot(labels, values, label = labels)
plt.ylabel('Yield')
plt.title('Newest yield')
plt.show()
```



we can see that there is a steep decline in yield for longer-maturity, which means that the market is expecting market interest rate would fall in the future(*based on liquidity preference theory*). And according to the market psychology, US economy has reached its critical threshold and any further increase in interest rate can do great harm the the world's biggest economy.

1.9 OBSERVE M2 MONEY STOCK AND TREASURY BOND YIELD FLUCTUATIONS.

we also learned that FED can influence the social money supply through buying and selling securities on the open market. FED can increase the money supply by buying bonds and reduce the money supply through selling bonds. We will observe whether fluctuations in government bond yields have any impact on M2 money supply? But first we need to look for available data about M2 money stock of the US.

```
[ ]: m2_monthly = fred.get_series(series_id = 'M2SL')
     m2_monthly
```

```
[ ]: 1959-01-01       286.6
     1959-02-01       287.7
     1959-03-01       289.2
     1959-04-01       290.1
     1959-05-01       292.2
                    …
     2023-03-01     20876.1
     2023-04-01     20712.1
```

```
2023-05-01    20841.7
2023-06-01    20890.0
2023-07-01    20902.7
Length: 775, dtype: float64
```

We will first clean the data as our analysis is dating from 1977. Then we transform the format of data from billion dollars to % growth rate Year over Year by divide each month obsolute money stock to that equivalent data of the previous year.

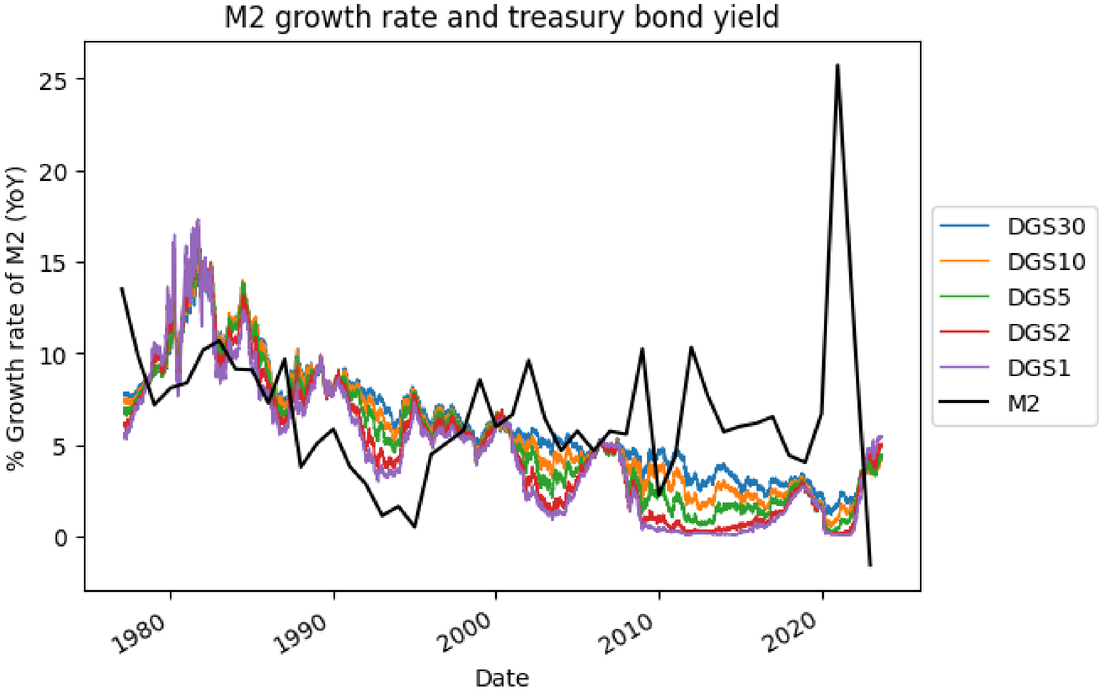
```
[ ]: # Filter the date with the format YYYY-01-01
     m2_monthly_jan = m2_monthly[m2_monthly.index.month == 1]

     # Calculate the growth rate
     m2_growth_rate = ((m2_monthly_jan - m2_monthly_jan.shift(1)) * 100 /␣
      ↪m2_monthly_jan.shift(1)).astype(float).round(3)

     # Filter the date from 1977-01-01
     m2_growth_rate = m2_growth_rate[m2_growth_rate.index >= '1977-01-01']

     # View the results
     m2_growth_rate.head()
```

```
[ ]: 1977-01-01    13.501
     1978-01-01     9.827
     1979-01-01     7.181
     1980-01-01     8.100
     1981-01-01     8.377
     dtype: float64
```

Finally, we plot the % Growth rate of M2 stock and five maturities of treasury bond.

```
[ ]: # Set the size of the plot
     plt.figure(figsize = (8, 6))

     # Plot the market yield for 30 years, 10 years, 5 years, 2 years and 1 year␣
      ↪into one figure
     bond_yield.plot(x = 'Date', y = ['DGS30', 'DGS10', 'DGS5', 'DGS2', 'DGS1'],␣
      ↪linewidth = 1)

     # Plot the M2 growth rate
     m2_growth_rate.plot(color = 'black', label = 'M2')

     # Put the legend outside the graph
     plt.legend(loc='center left', bbox_to_anchor=(1, 0.5))
     plt.ylabel('% Growth rate of M2 (YoY)')
     plt.title('M2 growth rate and treasury bond yield')
     plt.show()
```

```
<Figure size 800x600 with 0 Axes>
```



We can observe that when interest rates are cut down on a large scale, or when a large amount of bonds are purchased, the money supply increases at a fairly high rate in the following years. However, the two variables interest rate and money supply fluctuate with a lag or delay when interest rates usually fluctuate first. Through this observation, we can see that influencing the treasury bond market can adjust the money supply, thereby affecting the economy. From 2009 to 2014, the FED implemented quantitative easing, buying a large amount of treasury bonds, causing interest rates on the market to drop to low levels, thereby increasing the money supply at a very high speed to pull US economy from the quagmire of the 2008 crisis. And in 2020, FED injected a lot of money to the economy causing interest rate decrease sharply.

This is the end of our project. Thank you for reading.