Predicting interest rates from Federal Reserve documents

Preprocessing I (Vol. 2)

FE 690: Machine Learning in Finance
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```
import os
import sys
IN_COLAB = 'google.colab' in sys.modules
IN_COLAB
```

```
    True
```

```
if IN_COLAB:
  from google.colab import drive
  drive.mount('/content/drive', force_remount=True)
```

```
    Mounted at /content/drive
```

```
#if IN_COLAB:
#  # Uninstall existing versions:
#  !pip uninstall bs4 -y
#  !pip uninstall textract -y
#  !pip uninstall numpy -y
#  !pip uninstall pandas -y
#  !pip uninstall requests -y
#  !pip uninstall tqdm -y
#  !pip uninstall nltk -y
#  !pip uninstall quandl -y
#  !pip uninstall scikit-plot -y
#  !pip uninstall seaborn -y
#  !pip uninstall sklearn -y
#  !pip uninstall torch -y
#  !pip uninstall transformers -y
#  !pip uninstall wordcloud -y
#  !pip uninstall xgboost -y
#
#  # Install packages:
#  !pip install bs4==0.0.1
#  !pip install textract==1.6.3
#  !pip install numpy==1.19.4
#  !pip install pandas==1.1.4
#  !pip install requests==2.24.0
```

```
#  !pip install tqdm==4.51.0
#  !pip install nltk==3.5
#  !pip install quandl==3.5.3
#  !pip install scikit-plot==0.3.7
#  !pip install seaborn==0.11.0
#  !pip install sklearn==0.0
#  !pip install torch==1.7.1+cu101 torchvision==0.8.2+cu101 -f https://download.pytorch.org/whl/torch_stable.html
#  !pip install transformers==3.5.0
#  !pip install wordcloud==1.8.0
#  !pip install xgboost==1.2.1
#  os.kill(os.getpid(), 9)



# Python libraries
import datetime as dt
import re
import pickle
from tqdm.notebook import tqdm
import time
import logging
import random
from collections import defaultdict, Counter
from lxml import etree
from dateutil.relativedelta import *

# Data Science modules
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.ticker as ticker
import seaborn as sns; sns.set()
plt.style.use('ggplot')

# Import Scikit-learn moduels
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer
from sklearn.metrics import accuracy_score, f1_score, plot_confusion_matrix
from sklearn.pipeline import Pipeline, FeatureUnion
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression, Perceptron, SGDClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn import model_selection
from sklearn.model_selection import GridSearchCV, cross_val_score, cross_validate, StratifiedKFold, learning_curve, RandomizedSearchCV
import scikitplot as skplt

# Import nltk modules and download dataset
import nltk
from nltk.corpus import stopwords
from nltk.util import ngrams
from nltk.tokenize import word_tokenize
```

```
nltk.download('stopwords')
nltk.download('punkt')
nltk.download('wordnet')

stop = set(stopwords.words('english'))

# Import Pytorch modules

import torch
from torch import nn, optim
import torch.nn.functional as F
from torch.utils.data import (DataLoader, RandomSampler, SequentialSampler, TensorDataset)
from torch.autograd import Variable
from torch.optim import Adam, AdamW
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Unzipping corpora/wordnet.zip.
```

```
# Set display preference (Optional)
plt.rcParams["figure.figsize"] = (18,9)
plt.style.use('fivethirtyeight')
sns.set(style='white', context='notebook', palette='deep')

pd.options.display.max_rows = 20
pd.options.display.max_seq_items = 50
pd.set_option('display.max_colwidth', 200)


if IN_COLAB:
  employment_data_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/Employment/'
  cpi_data_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/CPI/'
  fed_rates_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/FEDRates/'
  fx_rates_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/FXRates/'
  gdp_data_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/GDP/'
  ism_data_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/ISM/'
  sales_data_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/Sales/'
  treasury_data_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/MarketData/Treasury/'
  fomc_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/FOMC/'
  preprocessed_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/'
  train_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/train_data/'
  output_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/result/'
  keyword_lm_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/LoughranMcDonald/'
  glove_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/GloVe/'
  model_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/models/'
  graph_dir = '/content/drive/My Drive/Colab Notebooks/proj2/src/data/graphs/'
else:
```

```
else:
  employment_data_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/Employment/'
  cpi_data_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/CPI/'
  fed_rates_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/FEDRates/'
  fx_rates_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/FXRates/'
  gdp_data_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/GDP/'
  ism_data_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/ISM/'
  sales_data_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/Sales/'
  treasury_data_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/MarketData/Treasury/'
  fomc_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/FOMC/'
  preprocessed_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/preprocessed/'
  train_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/train_data/'
  output_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/result/'
  keyword_lm_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/LoughranMcDonald/'
  glove_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/GloVe/'
  model_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/models/'
  graph_dir = 'C:/Users/theon/GDrive/Colab Notebooks/proj2/src/data/graphs/'
```

FOMC Meeting Minutes

Chairpersons

```
# FOMC Chairperson's list
chairpersons = pd.DataFrame(
    data=[["Volcker", "Paul", dt.datetime(1979,8,6), dt.datetime(1987,8,10)],
          ["Greenspan", "Alan", dt.datetime(1987,8,11), dt.datetime(2006,1,31)],
          ["Bernanke", "Ben", dt.datetime(2006,2,1), dt.datetime(2014,1,31)],
          ["Yellen", "Janet", dt.datetime(2014,2,3), dt.datetime(2018,2,3)],
          ["Powell", "Jerome", dt.datetime(2018,2,5), dt.datetime(2022,2,5)]],
    columns=["Surname", "FirstName", "FromDate", "ToDate"])
chairpersons
```

	Surname	FirstName	FromDate	ToDate
0	Volcker	Paul	1979-08-06	1987-08-10
1	Greenspan	Alan	1987-08-11	2006-01-31
2	Bernanke	Ben	2006-02-01	2014-01-31
3	Yellen	Janet	2014-02-03	2018-02-03
4	Powell	Jerome	2018-02-05	2022-02-05

```
def get_chairperson(x):
    if type(x) is str:
```

```
        try:
            x = dt.datetime.strftime(x, '%Y-%m-%d')
        except:
            return None

    chairperson = chairpersons.loc[chairpersons['FromDate'] <= x].loc[x <= chairpersons['ToDate']]
    return list(chairperson.FirstName)[0] + " " + list(chairperson.Surname)[0]
```

Calendar

```
# Pickle
file = open(fomc_dir + 'fomc_calendar.pickle', 'rb')
fomc_calendar = pickle.load(file)
file.close()
# Comma-Delimited
# fomc_calendar = pd.read_csv(fomc_dir + 'fomc_calendar.csv')
fomc_calendar
```

	date	unscheduled	forecast	confcall
0	1980-01-09	False	False	False
1	1980-02-05	False	False	False
2	1980-02-22	False	False	True
3	1980-03-07	False	False	True
4	1980-03-18	False	False	False
...	...	...	...	...
441	2021-06-16	False	True	False
442	2021-07-28	False	False	False
443	2021-09-22	False	True	False
444	2021-11-03	False	False	False
445	2021-12-15	False	True	False

446 rows × 4 columns

```
fomc_calendar = fomc_calendar.loc[fomc_calendar['date'] >= dt.datetime(1982, 9, 27)]
fomc_calendar.set_index('date', inplace=True)
fomc_calendar.head()
```

date	unscheduled	forecast	confcall
1982-10-05	False	False	False
1982-11-16	False	False	False
1982-12-21	False	False	False

Add Chairpersons to Calendar

```
fomc_calendar['ChairPerson'] = fomc_calendar.index.map(get_chairperson)
fomc_calendar
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """Entry point for launching an IPython kernel.
```

date	unscheduled	forecast	confcall	ChairPerson
1982-10-05	False	False	False	Paul Volcker
1982-11-16	False	False	False	Paul Volcker
1982-12-21	False	False	False	Paul Volcker
1983-01-14	False	False	True	Paul Volcker
1983-01-21	False	False	True	Paul Volcker
...	...	...	...	...
2021-06-16	False	True	False	Jerome Powell
2021-07-28	False	False	False	Jerome Powell
2021-09-22	False	True	False	Jerome Powell
2021-11-03	False	False	False	Jerome Powell
2021-12-15	False	True	False	Jerome Powell

403 rows × 4 columns

Market Data

Target FED Rate

Source: Federal Reserve Bank of New York (https://apps.newyorkfed.org/markets/autorates/fed%20funds)

```
filename = fed_rates_dir + 'ffs-01172000-02092020.csv'

fedrates = pd.read_csv(filename, header=0, names=('Date', 'Vol', 'EFFR', '1st','25th' ,'75th' ,'99th' ,'Target' ,'Low' ,'High','Std.' ))
fedrates.index = pd.to_datetime(fedrates.Date, format="%d/%m/%Y")
fedrates.dropna(inplace=True, axis=0, subset=['Date', 'Target'])
fedrates.drop(columns=['Date', 'Vol', 'EFFR', '1st','25th' ,'75th' ,'99th','Low' ,'High','Std.'], inplace=True)

fedrates['Low'] = None
fedrates['High'] = None

for i in range(fedrates.shape[0]):
    target = fedrates['Target'][i]
    if '-' in target:
        fedrates['Low'][i] = re.findall(r'([0-9.]+)-', target)[0]
        fedrates['High'][i] = re.findall(r'-([0-9.]+)', target)[0]
    else:
        (fedrates['Low'][i], fedrates['High'][i]) = (target, target)

fedrates
```

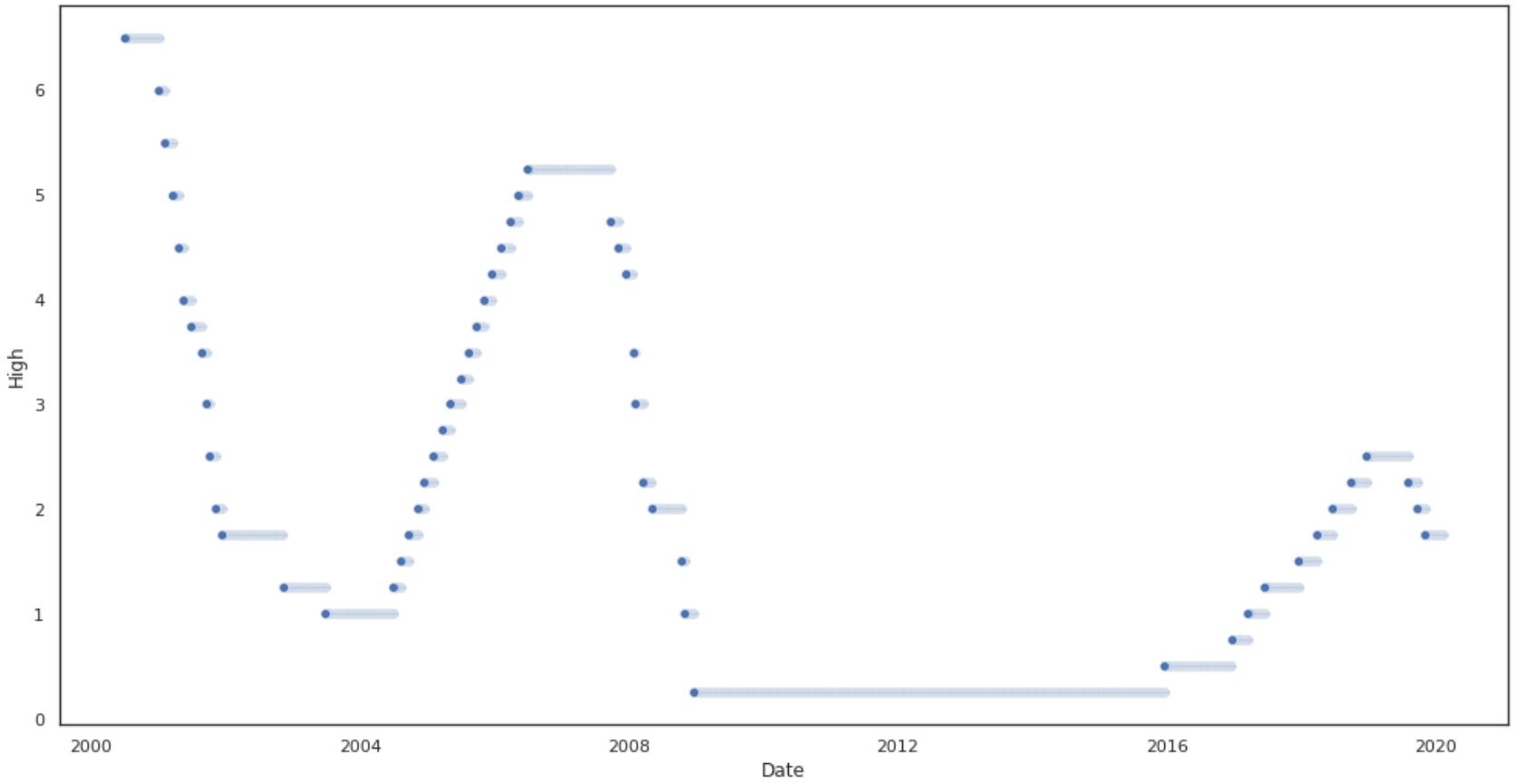
Date	Target	Low	High
2020-02-06	1.50-1.75	1.50	1.75
2020-02-05	1.50-1.75	1.50	1.75
2020-02-04	1.50-1.75	1.50	1.75
2020-02-03	1.50-1.75	1.50	1.75
2020-01-31	1.50-1.75	1.50	1.75
...	...	...	...
2000-07-10	6.5	6.5	6.5
2000-07-07	6.5	6.5	6.5
2000-07-06	6.5	6.5	6.5
2000-07-05	6.5	6.5	6.5
2000-07-03	6.5	6.5	6.5

4925 rows × 3 columns

```
fedrates.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 4925 entries, 2020-02-06 to 2000-07-03
Data columns (total 3 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   Target  4925 non-null   object
 1   Low     4925 non-null   object
 2   High    4925 non-null   object
dtypes: object(3)
memory usage: 153.9+ KB
```

```
plt.figure(figsize=(15,8))
ax = sns.scatterplot(data=(fedrates["High"].apply(lambda x: float(x))))
```



Looks good, but FRB of New York has historical data only from 2000.

So, download from FRB of St. Louis (https://fred.stlouisfed.org/searchresults?nasw=0&st=FED%20Rate&t=rate%3Bfederal%3Binterest%20rate&ob=sr&od=desc&types=gen).

Download the following three files in csv:

- Federal Funds Target Range - Upper Limit
- Federal Funds Target Range - Lower Limit
- Federal Funds Target Rate (DISCONTINUED)

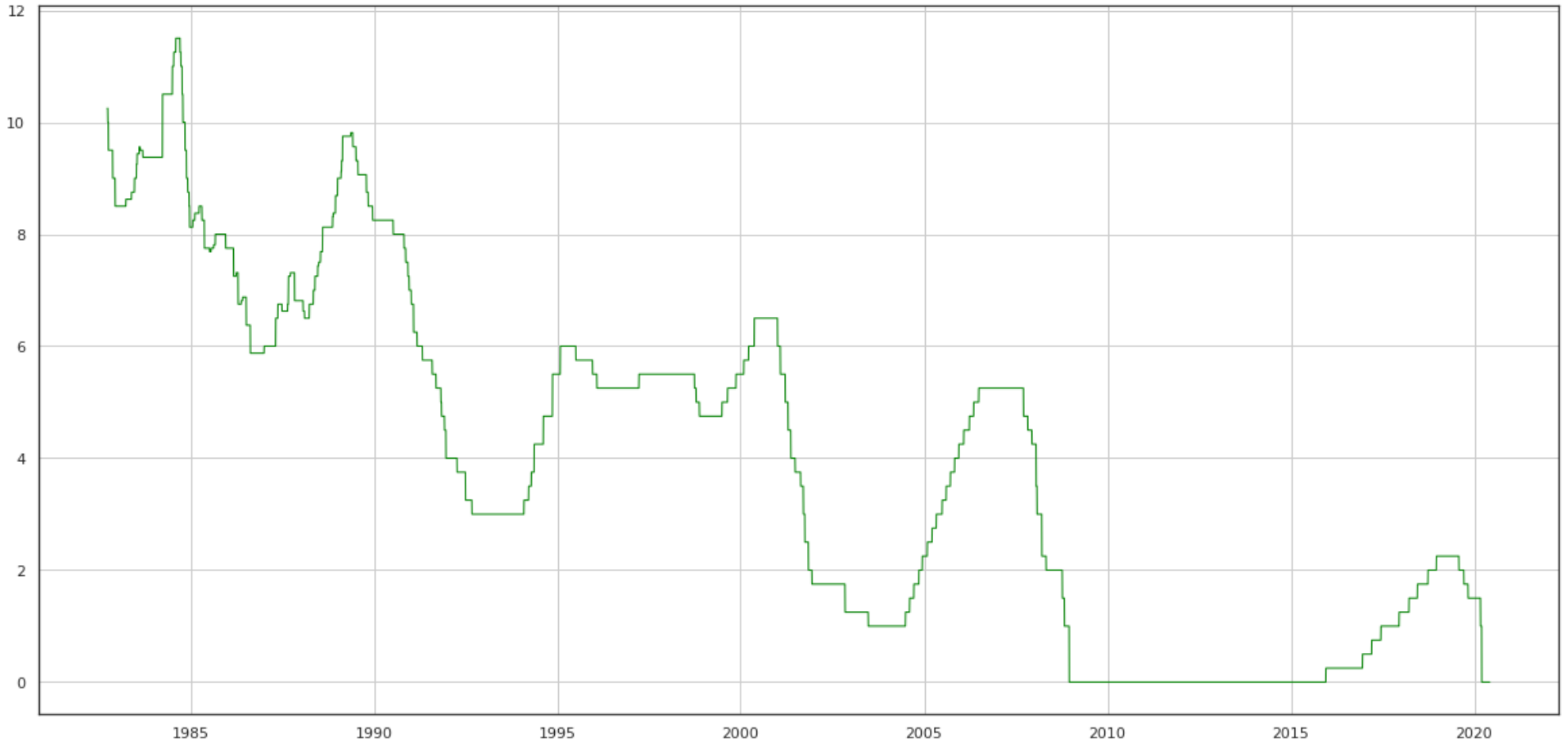
```
filename_till08 = fed_rates_dir + 'DFEDTAR.csv'
filename_from08u = fed_rates_dir + 'DFEDTARU.csv'
filename_from08l = fed_rates_dir + 'DFEDTARL.csv'

fedtar = pd.read_csv(filename_till08, names=['Date', 'Rate'], header=0)
fedtaru = pd.read_csv(filename_from08u, names=['Date', 'Rate'], header=0)
fedtarl = pd.read_csv(filename_from08l, names=['Date', 'Rate'], header=0)
fedrate_df = pd.concat([fedtar, fedtarl], axis=0)
fedrate_df.index = pd.to_datetime(fedrate_df.Date, format="%Y-%m-%d")
fedrate_df.drop(columns=['Date'], inplace=True)
fedrate_df['Rate'] = fedrate_df['Rate'].map(lambda x: np.float(x))
fedrate_df['diff'] = fedrate_df['Rate'].diff()

fedrate_df
```

Date	Rate	diff
1982-09-27	10.25	NaN
1982-09-28	10.25	0.00
1982-09-29	10.25	0.00
1982-09-30	10.25	0.00
1982-10-01	10.00	-0.25
...	...	...
2020-05-30	0.00	0.00
2020-05-31	0.00	0.00
2020-06-01	0.00	0.00
2020-06-02	0.00	0.00
2020-06-03	0.00	0.00

13765 rows × 2 columns

```
fig, ax = plt.subplots()
ax.plot(fedrate_df.index, fedrate_df['Rate'].values,
        c = 'green',
        linewidth= 1.0)
ax.grid(True)
```

```
ax.grid(true)
plt.show()
```



Effective FED Rate

```
filename = fed_rates_dir + 'DFF.csv'
dff = pd.read_csv(filename, header=0)
dff = dff.set_index(pd.to_datetime(dff['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
dff['diff'] = dff['DFF'].diff()
dff
```

DATE	DFF	diff
1954-07-01	1.13	NaN
1954-07-02	1.25	0.12
1954-07-03	1.25	0.00
1954-07-04	1.25	0.00
1954-07-05	0.88	-0.37
...	...	...
2020-05-30	0.05	0.00
2020-05-31	0.05	0.00

```
# Use every 30th row as it has too many data points
dff_30 = dff.iloc[::30, :]
print(dff_30.shape)

fig, ax = plt.subplots()
ax.plot(dff_30.index.values, dff_30['DFF'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```

```
(803, 2)
```

Economic Indices

GDP

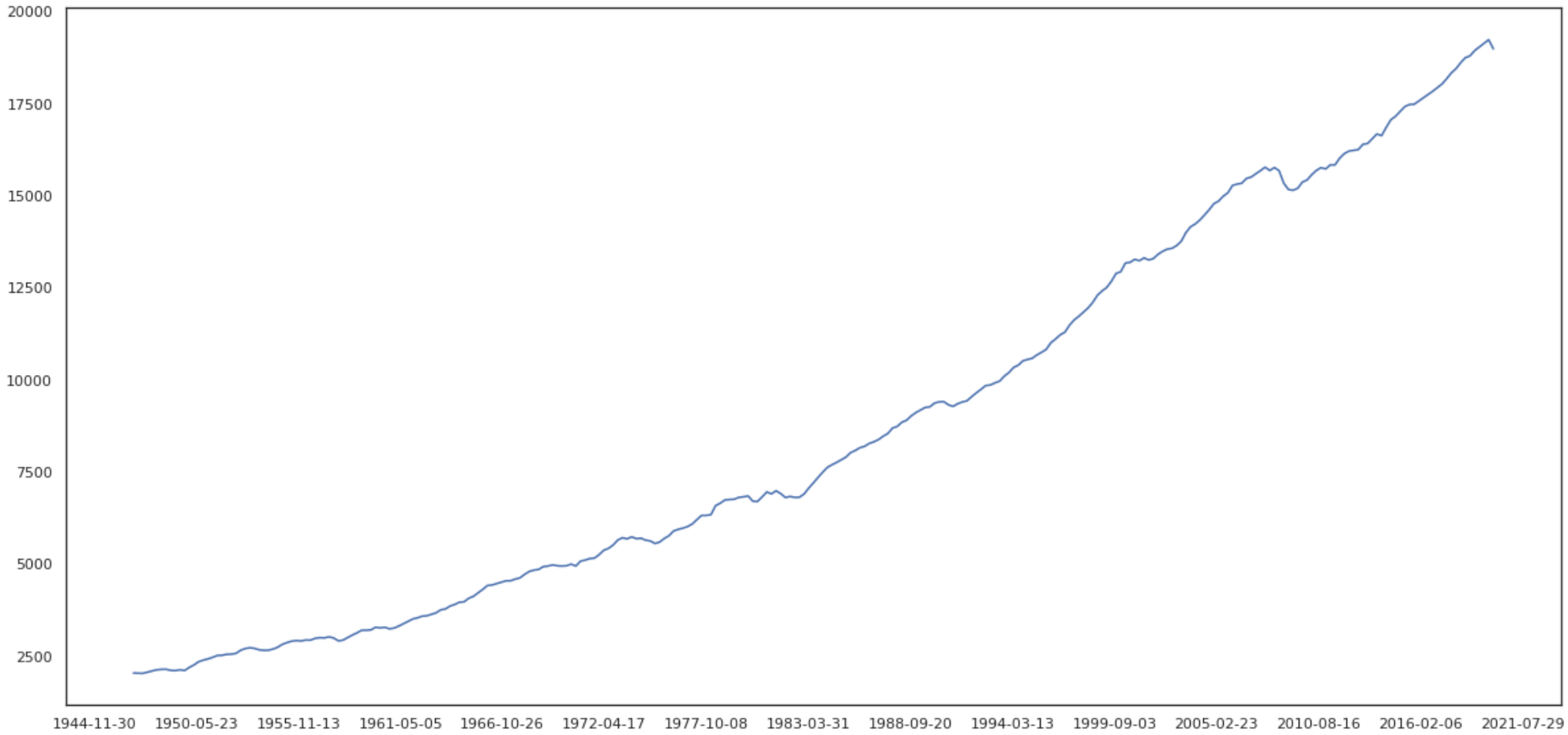
```
# Billions of Chained 2012 Dollars, Seasonally Adjusted Annual Rate
filename = gdp_data_dir + 'GDPC1.csv'

gdpc1 = pd.read_csv(filename, header=0)
gdpc1 = gdpc1.set_index(pd.to_datetime(gdpc1['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
gdpc1['diff_prev'] = gdpc1['GDPC1'].diff() / gdpc1['GDPC1'].shift(1) * 100
gdpc1['diff_year'] = gdpc1['GDPC1'].diff(periods=4) / gdpc1['GDPC1'].shift(4) * 100
gdpc1
```

DATE	GDPC1	diff_prev	diff_year
1947-01-01	2033.061	NaN	NaN
1947-04-01	2027.639	-0.266691	NaN
1947-07-01	2023.452	-0.206496	NaN
1947-10-01	2055.103	1.564208	NaN
1948-01-01	2086.017	1.504256	2.604742
...	...	...	...
2019-01-01	18927.281	0.765207	2.652241
2019-04-01	19021.860	0.499697	2.278320
2019-07-01	19121.112	0.521779	2.073335
2019-10-01	19221.970	0.527469	2.334074
2020-01-01	18974.702	-1.286382	0.250543

293 rows × 3 columns

```
fig, ax = plt.subplots()
ax.plot(gdpc1.index.values, gdpc1['GDPC1'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
```

```
plt.show()
```



Potential GDP

```
# Billions of Chained 2012 Dollars, Not Seasonally Adjusted
filename = gdp_data_dir + 'GDPPOT.csv'

gdppot = pd.read_csv(filename, header=0)
gdppot = gdppot.set_index(pd.to_datetime(gdppot['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
gdppot['diff_prev'] = gdppot['GDPPOT'].diff() / gdppot['GDPPOT'].shift(1) * 100
gdppot['diff_year'] = gdppot['GDPPOT'].diff(periods=4) / gdppot['GDPPOT'].shift(4) * 100
gdppot
```

DATE	GDPPOT	diff_prev	diff_year
1949-01-01	2105.424751	NaN	NaN
1949-04-01	2133.335241	1.325647	NaN
1949-07-01	2162.374385	1.361209	NaN
1949-10-01	2190.094474	1.281928	NaN
1950-01-01	2219.369859	1.336718	5.411977
...	...	...	...
2029-10-01	22899.670000	0.431070	1.749088
2030-01-01	22997.870000	0.428827	1.742254
2030-04-01	23096.170000	0.427431	1.732649
2030-07-01	23194.760000	0.426867	1.725246

```
fig, ax = plt.subplots()
ax.plot(gdppot.index.values, gdppot['GDPPOT'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```

Personal Consumption: PCE

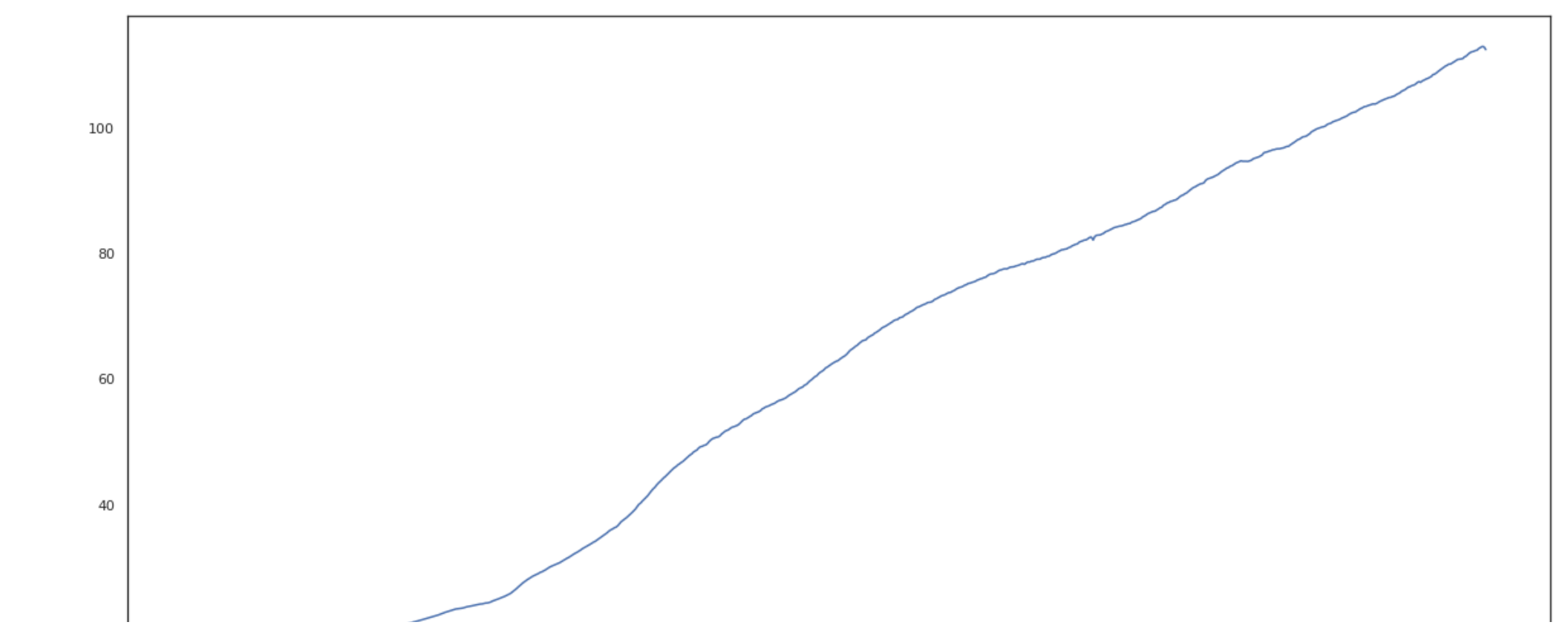
Use Core PCE excluding Food and Energy (per FRB recommendations)

```
filename = cpi_data_dir + 'PCEPILFE.csv'
pcepilfe = pd.read_csv(filename, header=0)
pcepilfe = pcepilfe.set_index(pd.to_datetime(pcepilfe['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
pcepilfe['diff_prev'] = pcepilfe['PCEPILFE'].diff() / pcepilfe['PCEPILFE'].shift(1) * 100
pcepilfe['diff_year'] = pcepilfe['PCEPILFE'].diff(periods=12) / pcepilfe['PCEPILFE'].shift(12) * 100
pcepilfe
```

DATE	PCEPILFE	diff_prev	diff_year
1959-01-01	16.727	NaN	NaN
1959-02-01	16.740	0.077719	NaN
1959-03-01	16.759	0.113501	NaN
1959-04-01	16.801	0.250612	NaN
1959-05-01	16.822	0.124993	NaN
...	...	...	...
2019-12-01	112.550	0.233329	1.568422
2020-01-01	112.725	0.155486	1.689640
2020-02-01	112.886	0.142825	1.796310
2020-03-01	112.834	-0.046064	1.688897
2020-04-01	112.390	-0.393498	1.041067

736 rows × 3 columns

```
fig, ax = plt.subplots()
ax.plot(pcepilfe.index.values, pcepilfe['PCEPILFE'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```



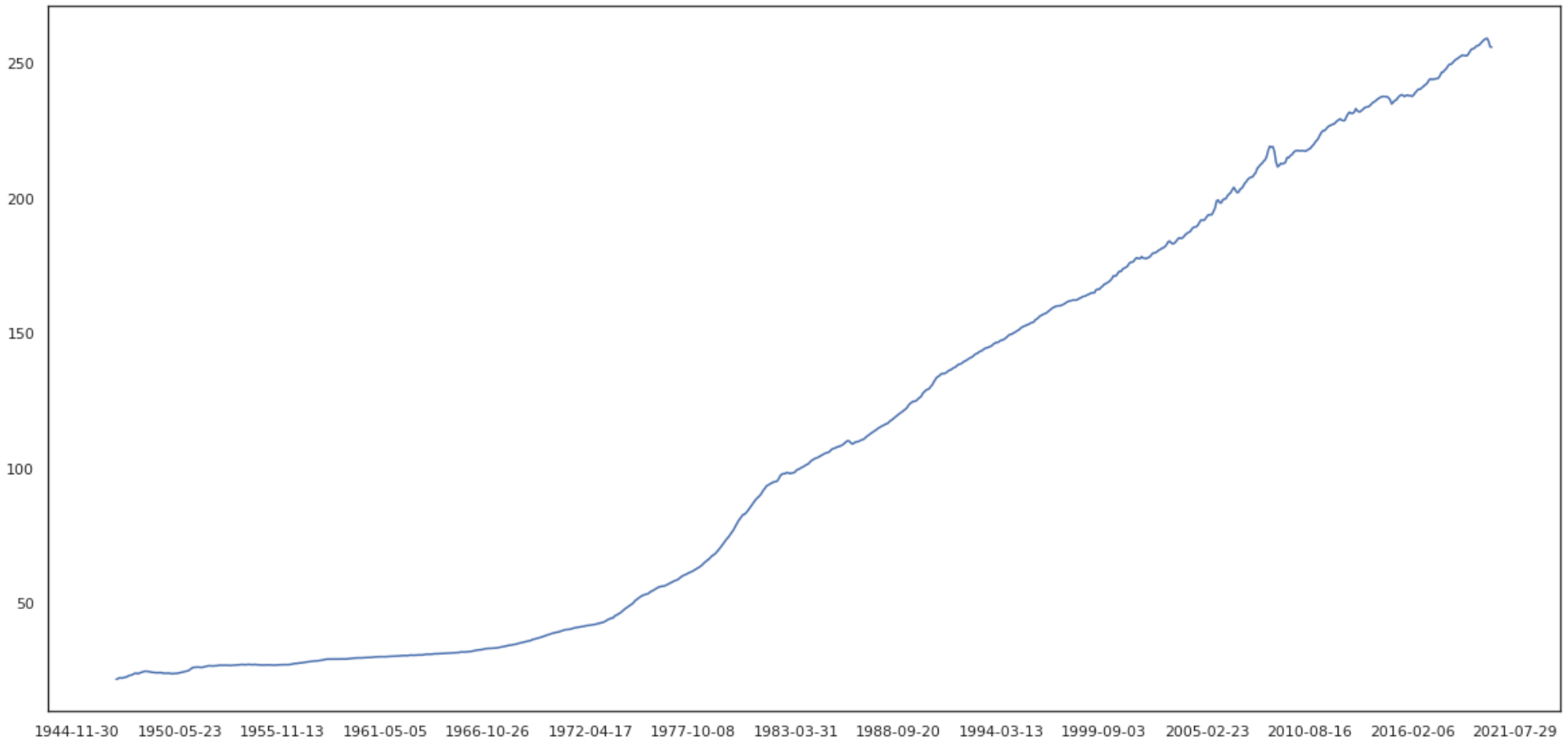
Personal Consumption: CPI

1961-05-05 1966-10-26 1972-04-17 1977-10-08 1983-03-31 1988-09-20 1994-03-13 1999-09-03 2005-02-23 2010-08-16 2016-02-06 2021-07-29

```
filename = cpi_data_dir + 'CPIAUCSL.csv'
cpiaucsl = pd.read_csv(filename, header=0)
cpiaucsl = cpiaucsl.set_index(pd.to_datetime(cpiaucsl['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
cpiaucsl['diff_prev'] = cpiaucsl['CPIAUCSL'].diff() / cpiaucsl['CPIAUCSL'].shift(1) * 100
cpiaucsl['diff_year'] = cpiaucsl['CPIAUCSL'].diff(periods=12) / cpiaucsl['CPIAUCSL'].shift(12) * 100
cpiaucsl
```

DATE	CPIAUCSL	diff_prev	diff_year
1947-01-01	21.480	NaN	NaN
1947-02-01	21.620	0.651769	NaN
1947-03-01	22.000	1.757632	NaN
1947-04-01	22.000	0.000000	NaN

```
fig, ax = plt.subplots()
ax.plot(cpiaucsl.index.values, cpiaucsl['CPIAUCSL'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```



Unemployment

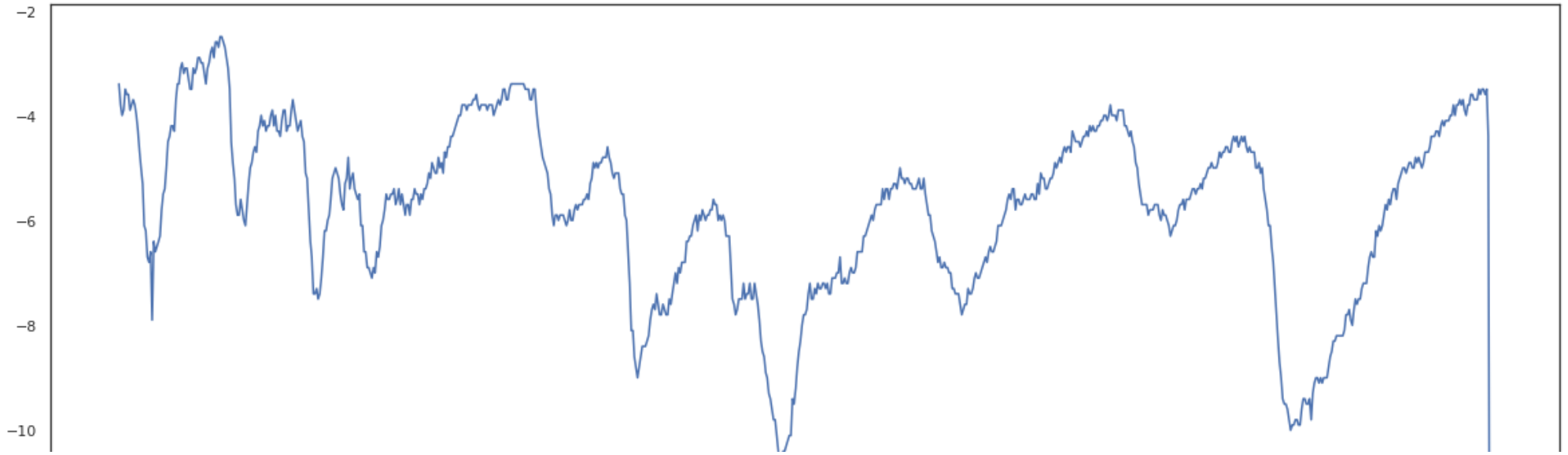
FRB's decision is weighed heavily by unemployment data.

```
filename = employment_data_dir + 'UNRATE.csv'
unrate = pd.read_csv(filename, header=0)
unrate = unrate.set_index(pd.to_datetime(unrate['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
unrate['UNRATE'] = unrate['UNRATE'] * -1
unrate['diff_prev'] = unrate['UNRATE'].diff()
unrate['diff_year'] = unrate['UNRATE'].diff(periods=12)
unrate
```

DATE	UNRATE	diff_prev	diff_year
1948-01-01	-3.4	NaN	NaN
1948-02-01	-3.8	-0.4	NaN
1948-03-01	-4.0	-0.2	NaN
1948-04-01	-3.9	0.1	NaN
1948-05-01	-3.5	0.4	NaN
...	...	...	...
2020-01-01	-3.6	-0.1	0.4
2020-02-01	-3.5	0.1	0.3
2020-03-01	-4.4	-0.9	-0.6
2020-04-01	-14.7	-10.3	-11.1
2020-05-01	-13.3	1.4	-9.7

869 rows × 3 columns

```
fig, ax = plt.subplots()
ax.plot(unrate.index.values, unrate['UNRATE'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```

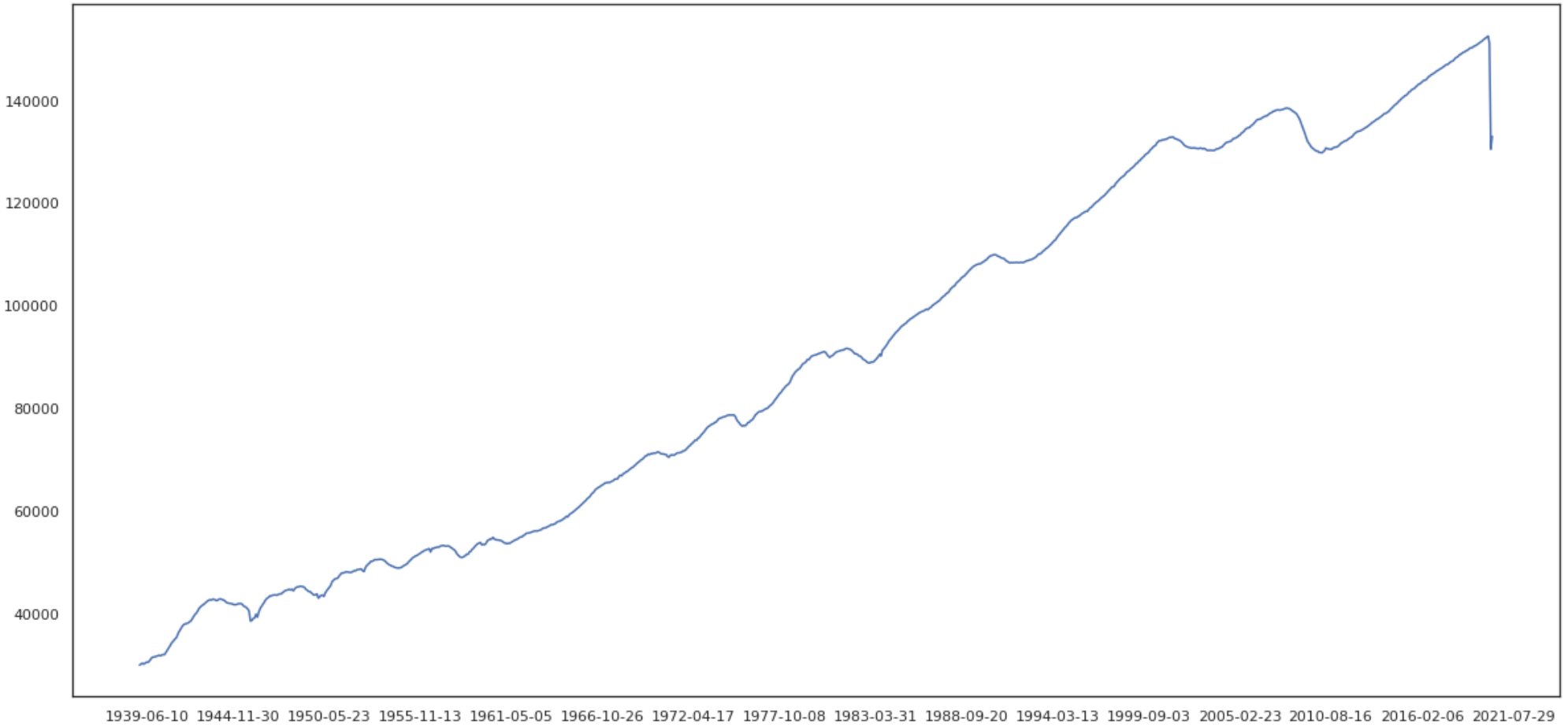


Employment

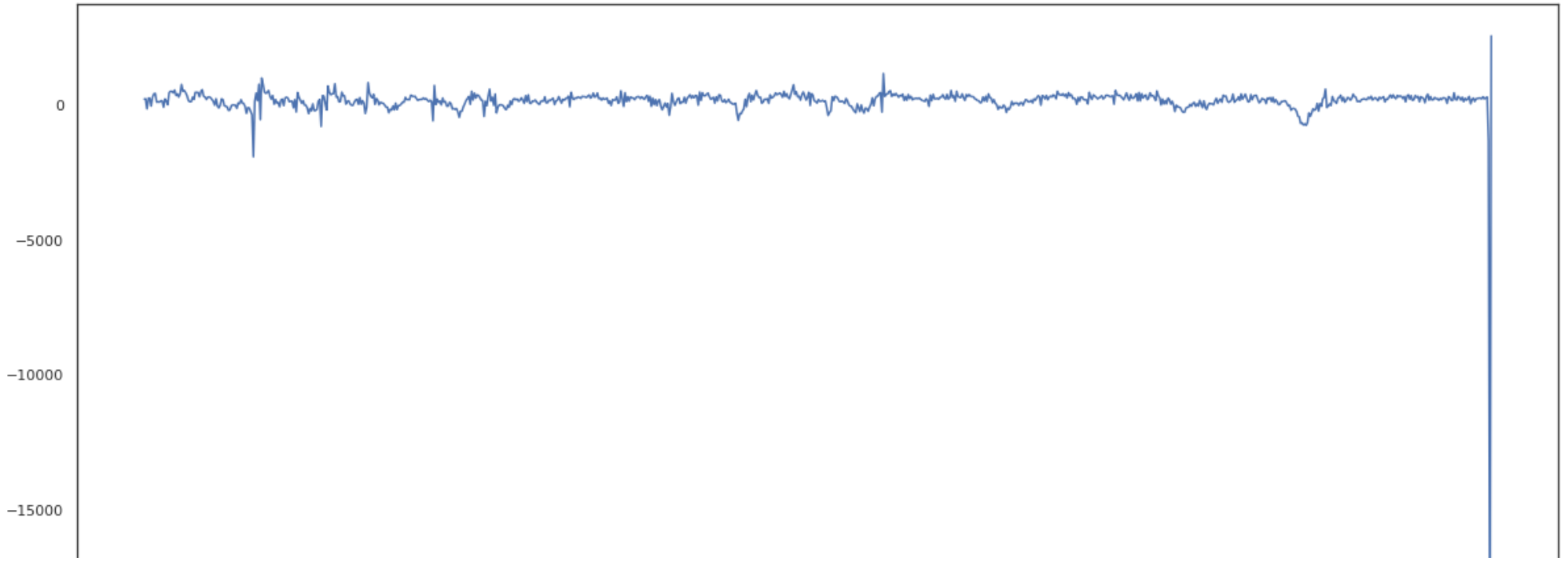
```
filename = employment_data_dir + 'PAYEMS.csv'
payems = pd.read_csv(filename, header=0)
payems = payems.set_index(pd.to_datetime(payems['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
payems['diff_prev'] = payems['PAYEMS'].diff()
payems['diff_year'] = payems['PAYEMS'].diff(periods=12)
payems
```

```
            PAYEMS  diff_prev  diff_year
DATE
```

```
fig, ax = plt.subplots()
ax.plot(payems.index.values, payems['PAYEMS'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```




```
fig, ax = plt.subplots()
ax.plot(payems.index.values, payems['diff_prev'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```



ISM Purchasing Managers Index / Non-manufacturing Index


```
filename = ism_data_dir + 'ISM-MAN_PMI.csv'
ism_pmi = pd.read_csv(filename, header=0)
ism_pmi = ism_pmi.sort_values(by=['Date'], ascending=True)
ism_pmi = ism_pmi.set_index(pd.to_datetime(ism_pmi['Date'], format="%Y-%m-%d")).drop(columns=['Date'])
ism_pmi['diff_prev'] = ism_pmi['PMI'].diff()
ism_pmi['diff_year'] = ism_pmi['PMI'].diff(periods=12)
ism_pmi
```

Date	PMI	diff_prev	diff_year
1948-01-01	51.7	NaN	NaN
1948-02-01	50.2	-1.5	NaN
1948-03-01	43.3	-6.9	NaN

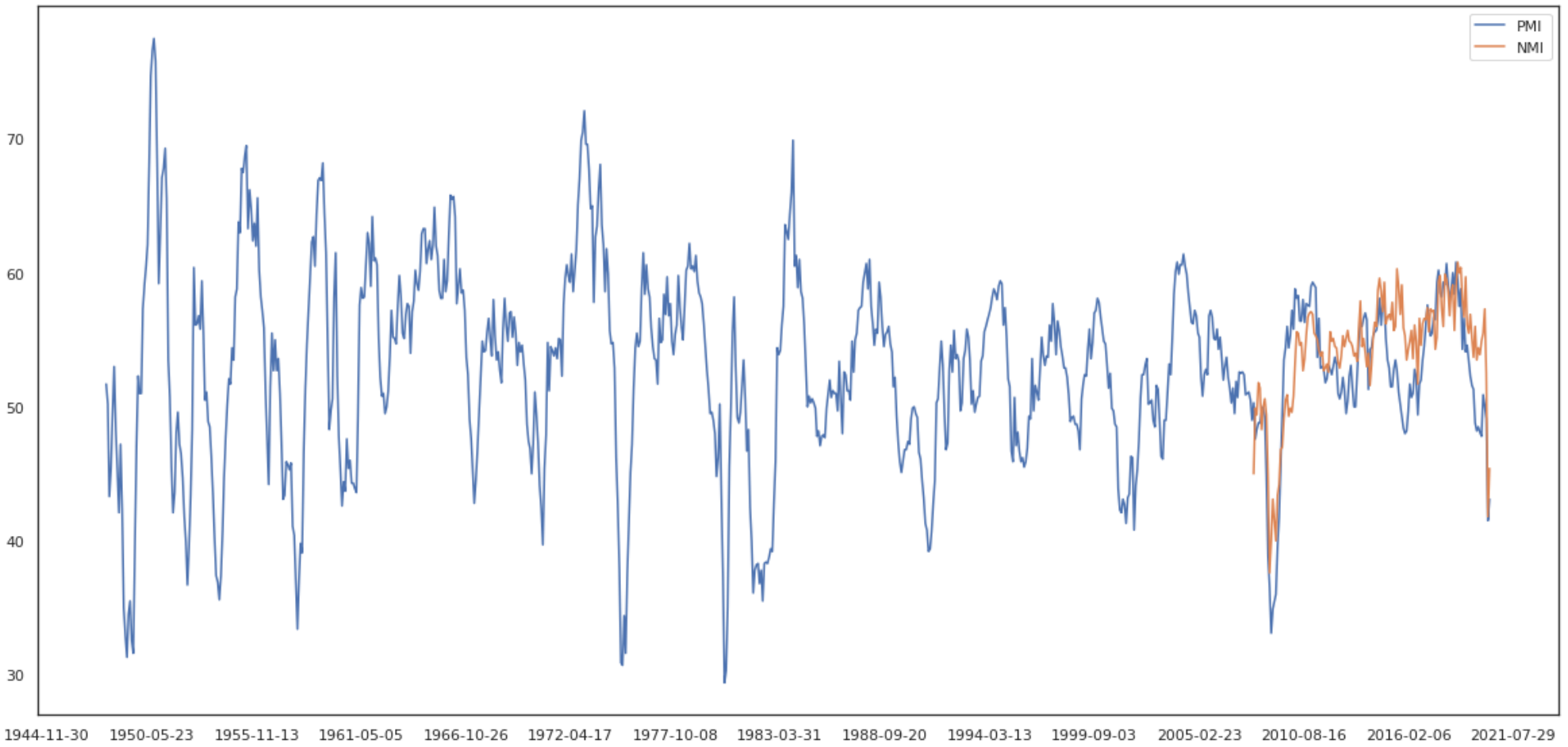
```
# Load ISM NMI
filename = ism_data_dir + 'ISM-NONMAN_NMI.csv'

ism_nmi = pd.read_csv(filename, header=0)
ism_nmi = ism_nmi.sort_values(by=['Date'], ascending=True)
ism_nmi.columns = ['Date', 'NMI']
ism_nmi = ism_nmi.set_index(pd.to_datetime(ism_nmi['Date'], format="%Y-%m-%d")).drop(columns=['Date'])
# Add difference from previous value
ism_nmi['diff_prev'] = ism_nmi['NMI'].diff()
ism_nmi['diff_year'] = ism_nmi['NMI'].diff(periods=12)
ism_nmi
```

Date	NMI	diff_prev	diff_year
2008-01-01	45.0	NaN	NaN
2008-02-01	49.9	4.9	NaN
2008-03-01	49.4	-0.5	NaN
2008-04-01	51.8	2.4	NaN
2008-05-01	51.4	-0.4	NaN
...	...	...	...
2020-01-01	55.5	0.6	-1.2
2020-02-01	57.3	1.8	-2.4
2020-03-01	52.5	-4.8	-3.6
2020-04-01	41.8	-10.7	-13.7
2020-05-01	45.4	3.6	-11.5

149 rows × 3 columns

```
fig, ax = plt.subplots()
ax.plot(ism_pmi.index.values, ism_pmi['PMI'].values)
ax.plot(ism_nmi.index.values, ism_nmi['NMI'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
ax.legend(['PMI', 'NMI'])
plt.show()
```

```
plt.show()
```



Non-manufacturing index (NMI) is available only post 2008.
It cannot cover a lot percentage of the target period, decided not to use it.

Retail Sales

```
filename = sales_data_dir + 'RRSFS.csv'
rrsfs = pd.read_csv(filename, header=0)
rrsfs = rrsfs.set_index(pd.to_datetime(rrsfs['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
rrsfs['diff_prev'] = rrsfs['RRSFS'].diff() / rrsfs['RRSFS'].shift(1) * 100
rrsfs['diff_year'] = rrsfs['RRSFS'].diff(periods=12) / rrsfs['RRSFS'].shift(12) * 100
rrsfs
```

DATE	RRSFS	diff_prev	diff_year
1992-01-01	118651	NaN	NaN
1992-02-01	118480	-0.144120	NaN
1992-03-01	117700	-0.658339	NaN
1992-04-01	118156	0.387426	NaN
1992-05-01	118548	0.331765	NaN
...	...	...	...
2019-12-01	203319	-0.154199	3.245873
2020-01-01	204627	0.643324	2.326291
2020-02-01	203541	-0.530722	2.108479
2020-03-01	187428	-7.916341	-7.092438
2020-04-01	157852	-15.779926	-21.902613

```
fig, ax = plt.subplots()
ax.plot(rrsfs.index.values, rrsfs['RRSFS'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```

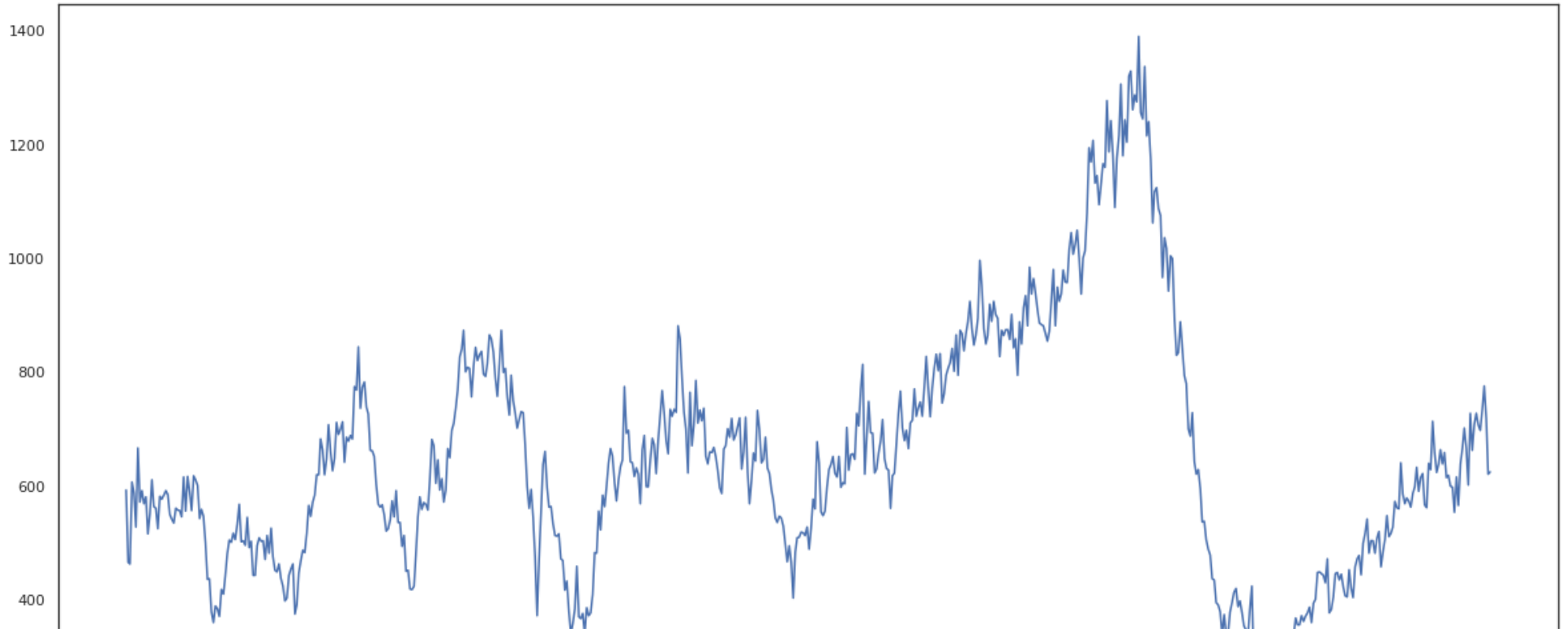
New Home Sales


```
filename = sales_data_dir + 'HSN1F.csv'
hsn1f = pd.read_csv(filename, header=0)
hsn1f = hsn1f.set_index(pd.to_datetime(hsn1f['DATE'], format="%Y-%m-%d")).drop(columns=['DATE'])
hsn1f['diff_prev'] = hsn1f['HSN1F'].diff() / hsn1f['HSN1F'].shift(1) * 100
hsn1f['diff_year'] = hsn1f['HSN1F'].diff(periods=12) / hsn1f['HSN1F'].shift(12) * 100
hsn1f
```

DATE	HSN1F	diff_prev	diff_year
1963-01-01	591.0	NaN	NaN
1963-02-01	464.0	-21.489002	NaN
1963-03-01	461.0	-0.646552	NaN
1963-04-01	605.0	31.236443	NaN
1963-05-01	586.0	-3.140496	NaN
...	...	...	...
2019-12-01	731.0	5.028736	29.609929
2020-01-01	774.0	5.882353	21.507064
2020-02-01	717.0	-7.364341	7.819549
2020-03-01	619.0	-13.668061	-11.571429
2020-04-01	623.0	0.646204	-6.174699

688 rows × 3 columns

```
fig, ax = plt.subplots()
ax.plot(hsn1f.index.values, hsn1f['HSN1F'].values)
ax.xaxis.set_major_locator(ticker.MultipleLocator(2000))
plt.show()
```



Treasury Yield

```
# https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yieldAll

xml_path = treasury_data_dir + 'DailyTreasuryYieldCurveRateData.xml'
xml_data = etree.parse(xml_path)

namespaces = {"base": "http://data.treasury.gov/Feed.svc/",
              "d": "http://schemas.microsoft.com/ado/2007/08/dataservices",
              "m": "http://schemas.microsoft.com/ado/2007/08/dataservices/metadata",
              "x": "http://www.w3.org/2005/Atom"}

df_cols = ["date", "1mo", "2mo", "3mo", "6montn", "1yr", "2yr", "3yr", "5yr", "7yr", "10yr", "20yr", "30yr"]
rows = []

contents = xml_data.xpath('/x:feed/x:entry/x:content', namespaces=namespaces)
for content in contents:
    s_date = content.xpath('./m:properties/d:NEW_DATE', namespaces=namespaces)[0].text[:10]
    s_1mo = content.xpath('./m:properties/d:BC_1MONTH', namespaces=namespaces)[0].text
    s_2mo = content.xpath('./m:properties/d:BC_2MONTH', namespaces=namespaces)[0].text
    s_3mo = content.xpath('./m:properties/d:BC_3MONTH', namespaces=namespaces)[0].text
    s_6mo = content.xpath('./m:properties/d:BC_6MONTH', namespaces=namespaces)[0].text
    s_1yr = content.xpath('./m:properties/d:BC_1YEAR', namespaces=namespaces)[0].text
```

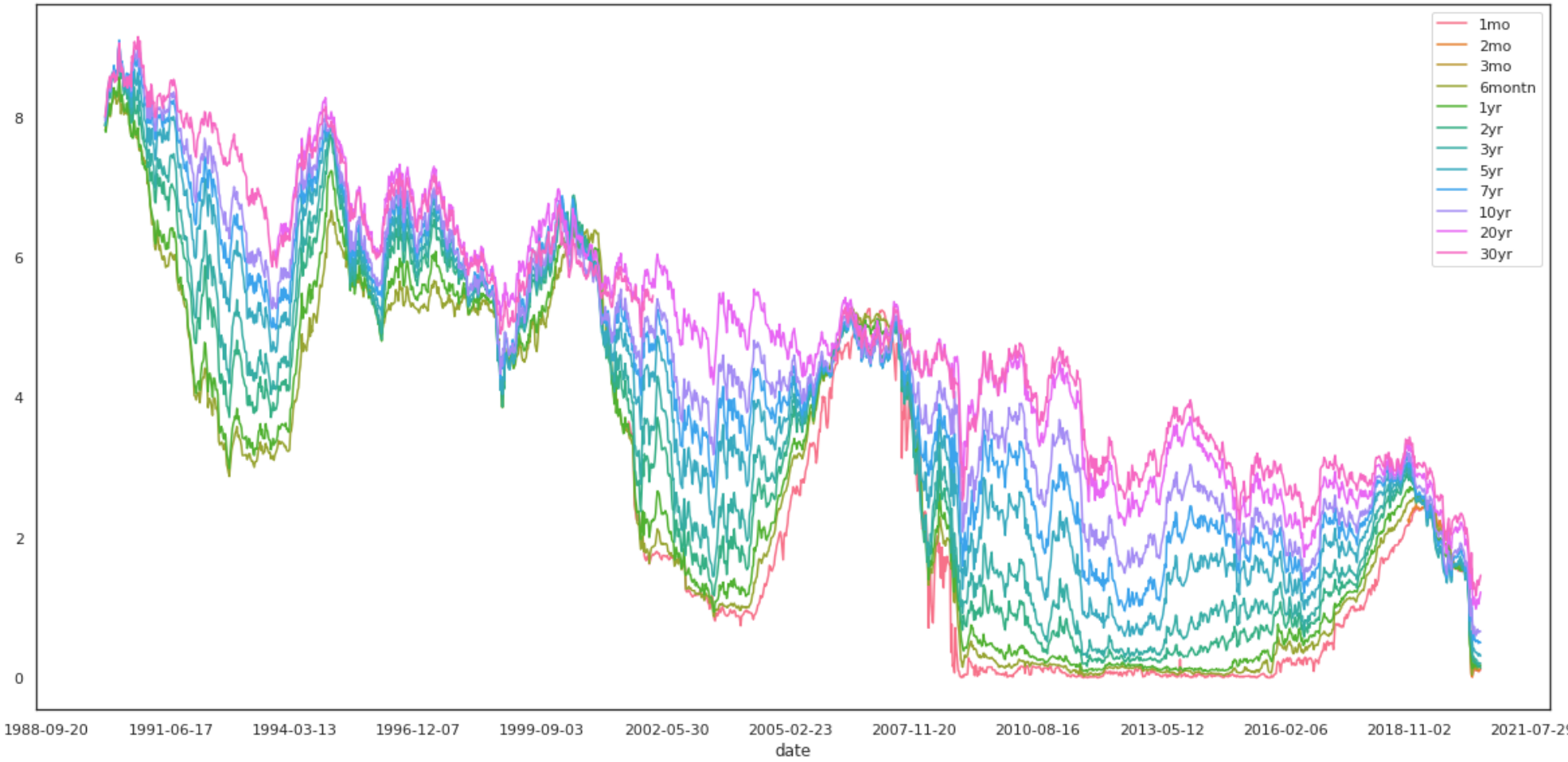
```
    s_2yr = content.xpath('./m:properties/d:BC_2YEAR', namespaces=namespaces)[0].text
    s_3yr = content.xpath('./m:properties/d:BC_3YEAR', namespaces=namespaces)[0].text
    s_5yr = content.xpath('./m:properties/d:BC_5YEAR', namespaces=namespaces)[0].text
    s_7yr = content.xpath('./m:properties/d:BC_7YEAR', namespaces=namespaces)[0].text
    s_10yr = content.xpath('./m:properties/d:BC_10YEAR', namespaces=namespaces)[0].text
    s_20yr = content.xpath('./m:properties/d:BC_20YEAR', namespaces=namespaces)[0].text
    s_30yr = content.xpath('./m:properties/d:BC_30YEAR', namespaces=namespaces)[0].text

    rows.append({"date": dt.datetime.strptime(s_date, '%Y-%m-%d'),
                 "1mo": s_1mo,
                 "2mo": s_2mo,
                 "3montn": s_3mo,
                 "6montn": s_6mo,
                 "1yr": s_1yr,
                 "2yr": s_2yr,
                 "3yr": s_3yr,
                 "5yr": s_5yr,
                 "7yr": s_7yr,
                 "10yr": s_10yr,
                 "20yr": s_20yr,
                 "30yr": s_30yr})

treasury = pd.DataFrame(rows, columns = df_cols).set_index('date').sort_index(ascending=True).astype(float)
treasury
```

date	1mo	2mo	3mo	6montn	1yr	2yr	3yr	5yr	7yr	10yr	20yr	30yr
1990-01-02	NaN	NaN	NaN	7.89	7.81	7.87	7.90	7.87	7.98	7.94	NaN	8.00
1990-01-03	NaN	NaN	NaN	7.94	7.85	7.94	7.96	7.92	8.04	7.99	NaN	8.04
1990-01-04	NaN	NaN	NaN	7.90	7.82	7.92	7.93	7.91	8.02	7.98	NaN	8.04
1990-01-05	NaN	NaN	NaN	7.85	7.79	7.90	7.94	7.92	8.03	7.99	NaN	8.06
1990-01-08	NaN	NaN	NaN	7.88	7.81	7.90	7.95	7.92	8.05	8.02	NaN	8.09
...	...	...	...	...	...	...	...	...	...	...	...	...
2020-06-01	0.12	0.14	NaN	0.18	0.17	0.14	0.20	0.31	0.50	0.66	1.22	1.46
2020-06-02	0.12	0.13	NaN	0.18	0.17	0.17	0.20	0.32	0.52	0.68	1.24	1.48
2020-06-03	0.12	0.14	NaN	0.19	0.17	0.19	0.26	0.38	0.59	0.77	1.32	1.56
2020-06-04	0.13	0.15	NaN	0.18	0.17	0.19	0.26	0.40	0.63	0.82	1.38	1.61
2020-06-05	0.13	0.14	NaN	0.18	0.18	0.22	0.29	0.47	0.71	0.91	1.46	1.68

7615 rows × 12 columns

```
treasury_5 = treasury.iloc[::5, :]
```

```
fig, ax = plt.subplots()
ax = sns.lineplot(data = treasury_5, dashes=False)
ax.xaxis.set_major_locator(ticker.MultipleLocator(1000))
plt.show()
```



Process the data

Add Rate and Decisions

```
# -1: Rate lower
#  0: No change
# +1: Rate hike

rate_list = []
decision_list = []
```

```
rate_diff_list = []

for i in tqdm(range(len(fomc_calendar))):
    not_found = True
    for j in range(len(fedrate_df)):
        if fomc_calendar.index[i] == fedrate_df.index[j]:
            not_found = False
            rate_list.append(float(fedrate_df['Rate'].iloc[j+3]))
            rate_diff_list.append(float(fedrate_df['Rate'].iloc[j+3]) - float(fedrate_df['Rate'].iloc[j-1]))
            if fedrate_df['Rate'].iloc[j-1] == fedrate_df['Rate'].iloc[j+3]:
                decision_list.append(0)
            elif fedrate_df['Rate'].iloc[j-1] < fedrate_df['Rate'].iloc[j+3]:
                decision_list.append(1)
            elif fedrate_df['Rate'].iloc[j-1] > fedrate_df['Rate'].iloc[j+3]:
                decision_list.append(-1)
            break
    if not_found:
        rate_list.append(np.nan)
        decision_list.append(np.nan)
        rate_diff_list.append(np.nan)

fomc_calendar.loc[:,'Rate'] = rate_list
fomc_calendar.loc[:,'RateDiff'] = rate_diff_list
fomc_calendar.loc[:,'RateDecision'] = decision_list
fomc_calendar['RateDecision'] = fomc_calendar['RateDecision'].astype('Int8')

fomc_calendar
```

```
100%                                403/403 [00:51<00:00, 7.86it/s]
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/indexing.py:1596: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self.obj[key] = _infer_fill_value(value)
/usr/local/lib/python3.6/dist-packages/pandas/core/indexing.py:1743: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  isetter(ilocs[0], value)
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
fomc_calendar.loc[fomc_calendar['Rate'].isnull()]
```

date	unscheduled	forecast	confcall	ChairPerson	Rate	RateDiff	RateDecision
2020-06-10	False	True	False	Jerome Powell	NaN	NaN	<NA>
2020-07-29	False	False	False	Jerome Powell	NaN	NaN	<NA>
2020-08-27	False	False	False	Jerome Powell	NaN	NaN	<NA>
2020-09-16	False	True	False	Jerome Powell	NaN	NaN	<NA>
2020-11-05	False	False	False	Jerome Powell	NaN	NaN	<NA>
2020-12-16	False	True	False	Jerome Powell	NaN	NaN	<NA>
2021-01-27	False	False	False	Jerome Powell	NaN	NaN	<NA>
2021-03-17	False	True	False	Jerome Powell	NaN	NaN	<NA>
2021-04-28	False	False	False	Jerome Powell	NaN	NaN	<NA>
2021-06-16	False	True	False	Jerome Powell	NaN	NaN	<NA>
2021-07-28	False	False	False	Jerome Powell	NaN	NaN	<NA>
2021-09-22	False	True	False	Jerome Powell	NaN	NaN	<NA>
2021-11-03	False	False	False	Jerome Powell	NaN	NaN	<NA>
2021-12-15	False	True	False	Jerome Powell	NaN	NaN	<NA>

Add Quantitative Easing as a Lower event

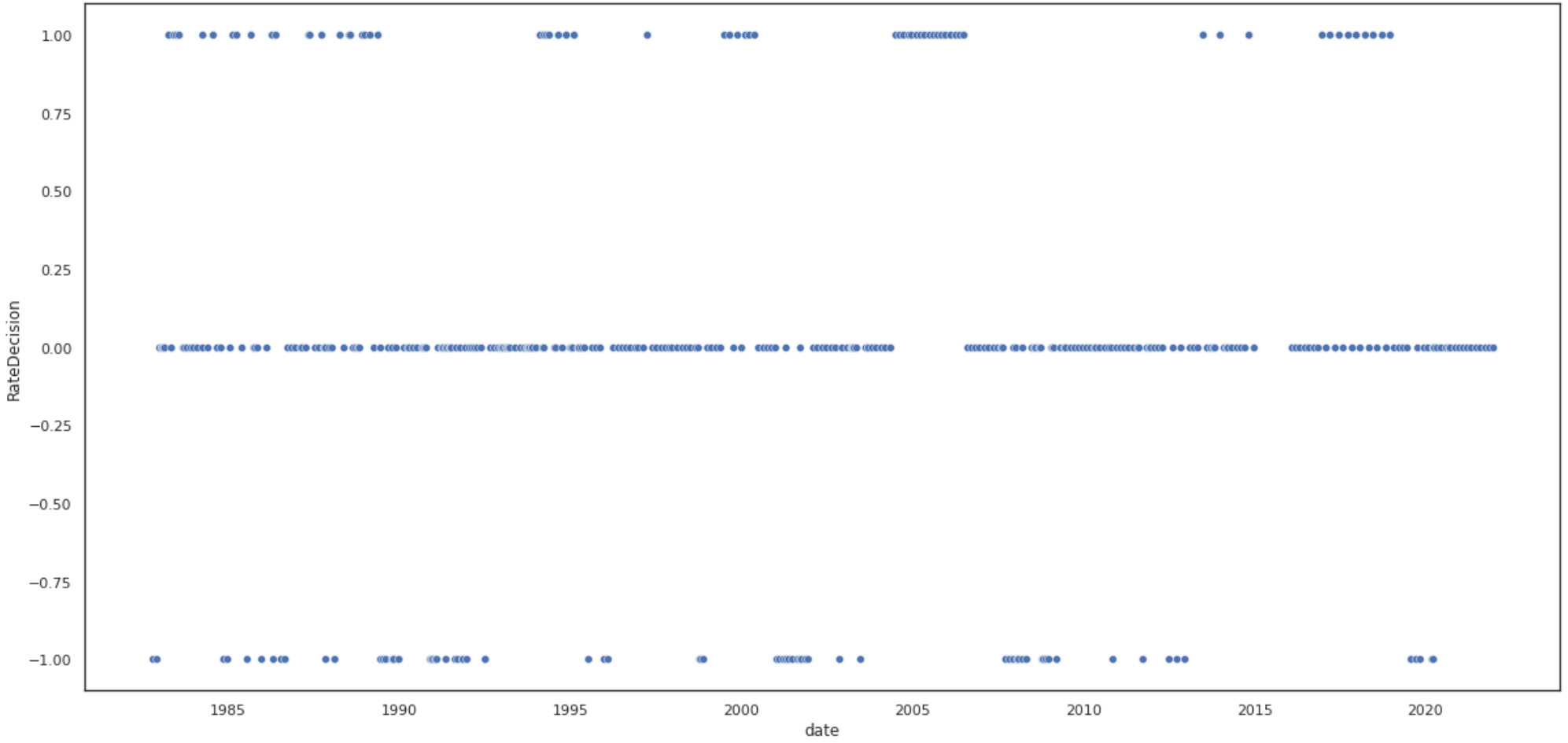
```
def parse_values(x):
  if x == 0:
    return 0
  elif x == 1:
    return 1
  elif x == -1:
    return 1
  else:
    return 0


rec_20081125 = pd.Series([True, False, False, 'Ben Bernanke', 0, -1, -1], index=['unscheduled', 'forecast', 'confcall', 'ChairPerson', 'Rate', 'RateD
if fomc_calendar.loc[fomc_calendar.index == dt.datetime.strptime('2008-11-25', '%Y-%m-%d')].shape[0] == 0:
    fomc_calendar = fomc_calendar.append(rec_20081125)

fomc_calendar.loc[fomc_calendar.index == dt.datetime(2009,3,18), ['RateDecision', 'RateDiff']] = (-1, -0.5) # QE1 Expanded
fomc_calendar.loc[fomc_calendar.index == dt.datetime(2010,11,3), ['RateDecision', 'RateDiff']] = (-1, -0.5) # QE2 Announced
fomc_calendar.loc[fomc_calendar.index == dt.datetime(2011,9,21), ['RateDecision', 'RateDiff']] = (-1, -0.5) # Operation Twist Announced
fomc_calendar.loc[fomc_calendar.index == dt.datetime(2012,6,20), ['RateDecision', 'RateDiff']] = (-1, -0.5) # Operation Twist Extended
fomc_calendar.loc[fomc_calendar.index == dt.datetime(2012,9,13), ['RateDecision', 'RateDiff']] = (-1, -0.5) # QE3 Announced
fomc_calendar.loc[fomc_calendar.index == dt.datetime(2012,12,12), ['RateDecision', 'RateDiff']] = (-1, -0.5) # QE3 Expanded
fomc_calendar.loc[fomc_calendar.index == dt.datetime(2013,6,19), ['RateDecision', 'RateDiff']] = (1, 1) # Tapering Announced
fomc_calendar.loc['2013-12-18', ['RateDecision', 'RateDiff']] = (1, 1) # Tapering Begins
fomc_calendar.loc['2014-10-29', ['RateDecision', 'RateDiff']] = (1, 0.5) # QE3 Terminated
fomc_calendar.loc['2017-06-14', ['RateDecision', 'RateDiff']] = (1, 0.5) # Signaled Balance Sheet Normalization
fomc_calendar.loc['2017-09-20', ['RateDecision', 'RateDiff']] = (1, 0.5) # Stated Balance Sheet Normalization Begins in October
fomc_calendar.sort_index(ascending=True, inplace=True)
fomc_calendar
```

	unscheduled	forecast	confcall	ChairPerson	Rate	RateDiff	RateDecision
date							
1982-12-21	False	False	False	Paul Volcker	8.5	0.0	0

```
fomc_calendar['RateDecision'] = fomc_calendar['RateDecision'].fillna(0)
fomc_calendar['RateChanged'] = fomc_calendar['RateDecision'].apply(lambda x: 0 if x == 0 else 1)
```

```
sns.scatterplot(x=fomc_calendar.index, y=fomc_calendar['RateDecision'].apply(lambda x: float(x)))
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f2bc5839cf8>
```



Add major economic indices

```
def get_available_latest(train_df, index_df, value_col, diff_prev_col, diff_year_col, date_offset):
    '''
    Returns the latest available ecoonmic index for each row of train_df
    INPUTS:
```

```
        train_df: Index must be in datetime format
        idex_df: Index must be in datetime format
        value_col: The column name of the value in index_df
        diff_prev_col: The column name of the difference from previous period in index_df
        diff_year_col: The column name of the difference from the same priod in previous year in index_df
        date_offset: Use relativedelta for the offset when the index is published
    OUTPUTS:
        date_list: List of date matched with train_df.index
        value_list: List of values for the date_list
        diff_list: List of diff values for the date_list
    '''

    date_list, value_list, diff_prev_list, diff_year_list = [], [], [], []

    for i, row_data in tqdm(train_df.iterrows(), total=train_df.shape[0]):
        #print(row_data.name)
        not_available = True
        for j, row_index in index_df.sort_index(ascending=False).iterrows():
            if row_data.name > row_index.name + date_offset:
                #print("   matched: ", row_index.name)
                date_list.append(row_index.name)
                value_list.append(row_index[value_col])
                diff_prev_list.append(row_index[diff_prev_col])
                diff_year_list.append(row_index[diff_year_col])
                not_available = False
                break
        if not_available:
            date_list.append(None)
            value_list.append(None)
            diff_prev_list.append(None)
            diff_year_list.append(None)
    if train_df.shape[0] != len(date_list):
        print("train_df has {} rows but returned {} rows from index_df!".format(train_df.shape[0], len(date_list)))

    return date_list, value_list, diff_prev_list, diff_year_list


def add_market_data(calendar_df, window=1):
  df = calendar_df.copy(deep=True)
  df.dropna(subset=['Rate'], inplace=True)
  print("Processing GDP...")
  df['GDP_date'], df['GDP_value'], df['GDP_diff_prev'], df['GDP_diff_year'] \
  = get_available_latest(df, gdpc1.rolling(window).mean(), 'GDPC1', 'diff_prev', 'diff_year', relativedelta(months=+4, days=-2))
  print("Processing Potential GDP...")
  df['GDPPOT_date'], df['GDPPOT_value'], df['GDPPOT_diff_prev'], df['GDPPOT_diff_year'] \
  = get_available_latest(df, gdppot.rolling(window).mean(), 'GDPPOT', 'diff_prev', 'diff_year', relativedelta(months=+4, days=-2))
  print("Processing PCE...")
  df['PCE_date'], df['PCE_value'], df['PCE_diff_prev'], df['PCE_diff_year'] \
  = get_available_latest(df, pcepilfe.rolling(window).mean(), 'PCEPILFE', 'diff_prev', 'diff_year', relativedelta(months=+2, days=-1))
  print("Processing CPI...")
  df['CPI_date'], df['CPI_value'], df['CPI_diff_prev'], df['CPI_diff_year'] \
```

```
  = get_available_latest(df, cpiaucsl.rolling(window).mean(), 'CPIAUCSL', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+9))
  print("Processing Unemployemnt...")
  df['Unemp_date'], df['Unemp_value'], df['Unemp_diff_prev'], df['Unemp_diff_year'] \
  = get_available_latest(df, unrate.rolling(window).mean(), 'UNRATE', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+2))
  print("Processing Employment...")
  df['Employ_date'], df['Employ_value'], df['Employ_diff_prev'], df['Employ_diff_year'] \
  = get_available_latest(df, payems.rolling(window).mean(), 'PAYEMS', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+2))
  print("Processing ISM PMI...")
  df['PMI_date'], df['PMI_value'], df['PMI_diff_prev'], df['PMI_diff_year'] \
  = get_available_latest(df, ism_pmi.rolling(window).mean(), 'PMI', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+2))
  print("Processing ISM NMI...")
  df['NMI_date'], df['NMI_value'], df['NMI_diff_prev'], df['NMI_diff_year'] \
  = get_available_latest(df, ism_nmi.rolling(window).mean(), 'NMI', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+2))
  print("Processing Retail Sales...")
  df['Rsales_date'], df['Rsales_value'], df['Rsales_diff_prev'], df['Rsales_diff_year'] \
  = get_available_latest(df, rrsfs.rolling(window).mean(), 'RRSFS', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+2))
  print("Processing New Home Sales...")
  df['Hsales_date'], df['Hsales_value'], df['Hsales_diff_prev'], df['Hsales_diff_year'] \
  = get_available_latest(df, hsn1f.rolling(window).mean(), 'HSN1F', 'diff_prev', 'diff_year', relativedelta(months=+1, days=+2))
  return df


nontext_data = add_market_data(fomc_calendar)
nontext_data
```

```
Processing GDP...
100%  390/390 [00:06<00:00, 55.79it/s]

Processing Potential GDP...
100%  390/390 [00:04<00:00, 93.65it/s]

Processing PCE...
100%  390/390 [00:13<00:00, 29.23it/s]

Processing CPI...
100%  390/390 [00:21<00:00, 17.82it/s]

Processing Unemployemnt...
100%  390/390 [00:14<00:00, 27.70it/s]

Processing Employment...
100%  390/390 [00:31<00:00, 12.25it/s]

Processing ISM PMI...
100%  390/390 [00:23<00:00, 16.31it/s]

Processing ISM NMI...
100%  390/390 [00:04<00:00, 94.89it/s]

Processing Retail Sales...
100%  390/390 [00:12<00:00, 31.73it/s]

Processing New Home Sales...
100%  390/390 [00:28<00:00, 13.87it/s]
```

date	unscheduled	forecast	confcall	ChairPerson	Rate	RateDiff	RateDecision	RateChanged	GDP_date	GDP_value	GDP_diff_prev	GDP_diff_year	GDPPOT_
1982-10-05	False	False	False	Paul Volcker	9.5	-0.5	-1	1	1982-04-01	6825.876	0.456197	-1.010549	1982-
1982-11-16	False	False	False	Paul Volcker	9.0	-0.5	-1	1	1982-07-01	6799.781	-0.382295	-2.555898	1982-

```
nontext_ma2 = add_market_data(fomc_calendar, 2)
nontext_ma3 = add_market_data(fomc_calendar, 3)
nontext_ma6 = add_market_data(fomc_calendar, 6)
nontext_ma12 = add_market_data(fomc_calendar, 12)
```

```
Processing GDP...
100%                                                390/390 [00:06<00:00, 57.35it/s]

Processing Potential GDP...
100%                                                390/390 [00:04<00:00, 96.92it/s]

Processing PCE...
100%                                                390/390 [00:13<00:00, 28.74it/s]

Processing CPI...
100%                                                390/390 [00:21<00:00, 17.84it/s]

Processing Unemployemnt...
100%                                                390/390 [00:14<00:00, 27.62it/s]

Processing Employment...
100%                                                390/390 [00:32<00:00, 12.18it/s]

Processing ISM PMI...
100%                                                390/390 [00:24<00:00, 16.07it/s]

Processing ISM NMI...
100%                                                390/390 [00:04<00:00, 95.76it/s]

Processing Retail Sales...
100%                                                390/390 [00:12<00:00, 30.91it/s]

Processing New Home Sales...
100%                                                390/390 [00:28<00:00, 13.67it/s]

Processing GDP...
100%                                                390/390 [00:06<00:00, 57.20it/s]

Processing Potential GDP...
100%                                                390/390 [00:04<00:00, 96.55it/s]

Processing PCE...
100%                                                390/390 [00:14<00:00, 27.66it/s]

Processing CPI...
100%                                                390/390 [00:22<00:00, 17.62it/s]

Processing Unemployemnt...
```

```
100%                                                390/390 [00:14<00:00, 26.76it/s]

Processing Employment...
100%                                                390/390 [00:32<00:00, 11.90it/s]

Processing ISM PMI...
100%                                                390/390 [00:25<00:00, 15.52it/s]

Processing ISM NMI...
100%                                                390/390 [00:04<00:00, 96.37it/s]

Processing Retail Sales...
100%                                                390/390 [00:13<00:00, 28.69it/s]

Processing New Home Sales...
100%                                                390/390 [00:28<00:00, 13.48it/s]

Processing GDP...
100%                                                390/390 [00:06<00:00, 58.52it/s]

Processing Potential GDP...
100%                                                390/390 [00:03<00:00, 98.55it/s]

Processing PCE...
100%                                                390/390 [00:14<00:00, 26.25it/s]

Processing CPI...
100%                                                390/390 [00:22<00:00, 17.14it/s]

Processing Unemployemnt...
100%                                                390/390 [00:15<00:00, 25.64it/s]

Processing Employment...
100%                                                390/390 [00:07<00:00, 51.21it/s]

Processing ISM PMI...
100%                                                390/390 [00:33<00:00, 11.73it/s]

Processing ISM NMI...
100%                                                390/390 [00:04<00:00, 97.30it/s]

Processing Retail Sales...
100%                                                390/390 [00:21<00:00, 17.96it/s]
```

```
Processing New Home Sales...
100%                                                390/390 [00:14<00:00, 26.13it/s]

Processing GDP...
100%                                                390/390 [00:06<00:00, 58.75it/s]

Processing Potential GDP...
100%                                                390/390 [00:03<00:00, 99.06it/s]

Processing PCE...
100%                                                390/390 [00:18<00:00, 21.51it/s]

Processing CPI...
100%                                                390/390 [00:10<00:00, 38.16it/s]

Processing Unemployemnt...
100%                                                390/390 [00:19<00:00, 20.41it/s]

Processing Employment...
100%                                                390/390 [00:11<00:00, 33.87it/s]

Processing ISM PMI...
100%                                                390/390 [00:49<00:00, 7.89it/s]

Processing ISM NMI...
100%                                                390/390 [00:04<00:00, 95.60it/s]

Processing Retail Sales...
100%                                                390/390 [00:37<00:00, 10.32it/s]

Processing New Home Sales...
100%                                                390/390 [00:30<00:00, 12.62it/s]
```

Add Taylor Rule

https://www.federalreserve.gov/monetarypolicy/policy-rules-and-how-policymakers-use-them.htm

```
taylor = fedrate_df.copy(deep=True)
_, taylor['Y'],_,_ = get_available_latest(taylor, gdpc1, 'GDPC1', 'diff_prev', 'diff_year', relativedelta(months=+4, days=-2))
_, taylor['Yp'],_,_ = get_available_latest(taylor, gdppot, 'GDPPOT', 'diff_prev', 'diff_year', relativedelta(months=+4, days=-2))
taylor['Y-Yp'] = (np.log(taylor['Y']*10**9) - np.log(taylor['Yp']*10**9)) * 100
_, _,_, taylor['Pi'] = get_available_latest(taylor, pcepilfe, 'PCEPILFE', 'diff_prev', 'diff_year', relativedelta(months=+2, days=-1))
taylor['Pi*'] = 2
taylor['Pi-Pi*'] = taylor['Pi'] - taylor['Pi*']
```

```
taylor['r'] = 2
```

```
100%                                                13765/13765 [03:43<00:00, 61.50it/s]
```

```
100%                                                13765/13765 [02:15<00:00, 101.91it/s]
```

```
100%                                                13765/13765 [04:01<00:00, 56.91it/s]
```

```
taylor['Taylor'] = taylor['r'] + taylor['Pi'] + 0.5 * taylor['Pi-Pi*'] + 0.5 * taylor['Y-Yp']
taylor['Balanced'] = (taylor['r'] + taylor['Pi'] + 0.5 * taylor['Pi-Pi*'] + taylor['Y-Yp']).map(lambda x: 0 if x < 0 else x)
taylor['Inertia'] = 0.85 * taylor['Rate'] - 0.15 * taylor['Balanced']
taylor = taylor.drop(columns = ['Y', 'Yp', 'Y-Yp', 'Pi', 'Pi*', 'Pi-Pi*', 'r', 'diff'])
```

```
fig, ax = plt.subplots()
ax = sns.lineplot(data=taylor, dashes=False, lw=1)
plt.grid(True)
plt.show()
```


```
taylor['Taylor-Rate'] = taylor['Taylor'] - taylor['Rate']
taylor['Balanced-Rate'] = taylor['Balanced'] - taylor['Rate']
taylor['Inertia-Rate'] = taylor['Inertia'] - taylor['Rate']
taylor['Taylor_diff'] = taylor['Taylor'].diff(1)
taylor['Balanced_diff'] = taylor['Balanced'].diff(1)
taylor['Inertia_diff'] = taylor['Inertia'].diff(1)
taylor
```

Date	Rate	Taylor	Balanced	Inertia	Taylor-Rate	Balanced-Rate	Inertia-Rate	Taylor_diff	Balanced_diff	Inertia_diff
1982-09-27	10.25	8.054621	5.219243	7.929613	-2.195379	-5.030757	-2.320387	NaN	NaN	NaN
1982-09-28	10.25	8.054621	5.219243	7.929613	-2.195379	-5.030757	-2.320387	0.000000	0.000000	0.000000
1982-09-29	10.25	8.054621	5.219243	7.929613	-2.195379	-5.030757	-2.320387	0.000000	0.000000	0.000000
1982-09-30	10.25	8.054621	5.219243	7.929613	-2.195379	-5.030757	-2.320387	0.000000	0.000000	0.000000
1982-10-01	10.00	7.718209	4.882832	7.767575	-2.281791	-5.117168	-2.232425	-0.336412	-0.336412	-0.162038
...	...	...	...	...	...	...	...	...	...	...
2020-05-30	0.00	2.949439	2.365532	-0.354830	2.949439	2.365532	-0.354830	0.000000	0.000000	0.000000
2020-05-31	0.00	2.949439	2.365532	-0.354830	2.949439	2.365532	-0.354830	0.000000	0.000000	0.000000
2020-06-01	0.00	1.977694	1.393788	-0.209068	1.977694	1.393788	-0.209068	-0.971744	-0.971744	0.145762
2020-06-02	0.00	1.977694	1.393788	-0.209068	1.977694	1.393788	-0.209068	0.000000	0.000000	0.000000
2020-06-03	0.00	1.977694	1.393788	-0.209068	1.977694	1.393788	-0.209068	0.000000	0.000000	0.000000

13765 rows × 10 columns

```
def add_taylor(df, window=1):
    taylor_ma = taylor.rolling(window).mean()
    df['Taylor'] = df.index.map(lambda x: taylor_ma.loc[taylor_ma.index == x + relativedelta(days=-1), 'Taylor'].values[0])
    df['Balanced'] = df.index.map(lambda x: taylor_ma.loc[taylor_ma.index == x + relativedelta(days=-1), 'Balanced'].values[0])
    df['Inertia'] = df.index.map(lambda x: taylor_ma.loc[taylor_ma.index == x + relativedelta(days=-1), 'Inertia'].values[0])
    df['Taylor-Rate'] = df.index.map(lambda x: taylor_ma.loc[taylor_ma.index == x + relativedelta(days=-1), 'Taylor-Rate'].values[0])
    df['Balanced-Rate'] = df.index.map(lambda x: taylor_ma.loc[taylor_ma.index == x + relativedelta(days=-1), 'Balanced-Rate'].values[0])
    df['Inertia-Rate'] = df.index.map(lambda x: taylor_ma.loc[taylor_ma.index == x + relativedelta(days=-1), 'Inertia-Rate'].values[0])
    df['Taylor_diff'] = df['Taylor'].diff(1)
    df['Balanced_diff'] = df['Balanced'].diff(1)
    df['Inertia_diff'] = df['Inertia'].diff(1)


add_taylor(nontext_data)
add_taylor(nontext_ma2_60)
```

```
add_taylor(nontext_ma3, 90)
add_taylor(nontext_ma6, 180)
add_taylor(nontext_ma12, 360)


fomc_calendar.index.get_level_values(0).values
```

```
array(['1982-10-05T00:00:00.000000000', '1982-11-16T00:00:00.000000000',
       '1982-12-21T00:00:00.000000000', '1983-01-14T00:00:00.000000000',
       '1983-01-21T00:00:00.000000000', '1983-01-28T00:00:00.000000000',
       '1983-02-09T00:00:00.000000000', '1983-03-29T00:00:00.000000000',
       '1983-04-29T00:00:00.000000000', '1983-05-24T00:00:00.000000000',
       '1983-06-23T00:00:00.000000000', '1983-07-13T00:00:00.000000000',
       '1983-08-23T00:00:00.000000000', '1983-09-08T00:00:00.000000000',
       '1983-10-04T00:00:00.000000000', '1983-11-15T00:00:00.000000000',
       '1983-12-20T00:00:00.000000000', '1984-01-31T00:00:00.000000000',
       '1984-03-20T00:00:00.000000000', '1984-03-27T00:00:00.000000000',
       '1984-05-22T00:00:00.000000000', '1984-07-17T00:00:00.000000000',
       '1984-08-21T00:00:00.000000000', '1984-10-02T00:00:00.000000000',
       '1984-11-07T00:00:00.000000000', '1984-12-18T00:00:00.000000000',
       '1985-01-18T00:00:00.000000000', '1985-02-13T00:00:00.000000000',
       '1985-03-26T00:00:00.000000000', '1985-05-21T00:00:00.000000000',
       '1985-07-10T00:00:00.000000000', '1985-08-20T00:00:00.000000000',
       '1985-09-23T00:00:00.000000000', '1985-10-01T00:00:00.000000000',
       '1985-11-05T00:00:00.000000000', '1985-12-17T00:00:00.000000000',
       '1986-02-12T00:00:00.000000000', '1986-04-01T00:00:00.000000000',
       '1986-04-21T00:00:00.000000000', '1986-05-20T00:00:00.000000000',
       '1986-07-09T00:00:00.000000000', '1986-08-19T00:00:00.000000000',
       '1986-09-23T00:00:00.000000000', '1986-11-05T00:00:00.000000000',
       '1986-12-16T00:00:00.000000000', '1987-02-11T00:00:00.000000000',
       '1987-02-23T00:00:00.000000000', '1987-03-31T00:00:00.000000000',
       '1987-04-29T00:00:00.000000000', '1987-05-19T00:00:00.000000000',
       '1987-07-07T00:00:00.000000000', '1987-08-18T00:00:00.000000000',
       '1987-09-22T00:00:00.000000000', '1987-10-19T00:00:00.000000000',
       '1987-10-20T00:00:00.000000000', '1987-10-30T00:00:00.000000000',
       '1987-11-03T00:00:00.000000000', '1987-12-16T00:00:00.000000000',
       '1988-01-05T00:00:00.000000000', '1988-02-10T00:00:00.000000000',
       '1988-03-29T00:00:00.000000000', '1988-05-17T00:00:00.000000000',
       '1988-06-30T00:00:00.000000000', '1988-07-19T00:00:00.000000000',
       '1988-08-16T00:00:00.000000000', '1988-09-20T00:00:00.000000000',
       '1988-10-17T00:00:00.000000000', '1988-11-01T00:00:00.000000000',
       '1988-11-22T00:00:00.000000000', '1988-12-14T00:00:00.000000000',
       '1989-02-08T00:00:00.000000000', '1989-03-28T00:00:00.000000000',
       '1989-05-16T00:00:00.000000000', '1989-05-31T00:00:00.000000000',
       '1989-06-05T00:00:00.000000000', '1989-07-06T00:00:00.000000000',
       '1989-07-26T00:00:00.000000000', '1989-08-22T00:00:00.000000000',
       '1989-10-03T00:00:00.000000000', '1989-10-16T00:00:00.000000000',
       '1989-10-17T00:00:00.000000000', '1989-10-18T00:00:00.000000000',
       '1989-11-14T00:00:00.000000000', '1989-12-19T00:00:00.000000000',
       '1990-02-07T00:00:00.000000000', '1990-03-27T00:00:00.000000000',
       '1990-04-11T00:00:00.000000000', '1990-05-15T00:00:00.000000000',
       '1990-07-03T00:00:00.000000000', '1990-08-21T00:00:00.000000000',
       '1990-09-07T00:00:00.000000000', '1990-09-17T00:00:00.000000000',
       '1990-10-02T00:00:00.000000000', '1990-11-13T00:00:00.000000000',
       '1990-12-07T00:00:00.000000000', '1990-12-18T00:00:00.000000000',
```

```
            '1991-01-09T00:00:00.000000000', '1991-02-01T00:00:00.000000000',
            '1991-02-06T00:00:00.000000000', '1991-03-26T00:00:00.000000000',
            '1991-04-12T00:00:00.000000000', '1991-04-30T00:00:00.000000000',
            '1991-05-01T00:00:00.000000000', '1991-05-14T00:00:00.000000000',
            '1991-06-10T00:00:00.000000000', '1991-06-24T00:00:00.000000000',
            '1991-07-03T00:00:00.000000000', '1991-08-05T00:00:00.000000000',
            '1991-08-20T00:00:00.000000000', '1991-09-13T00:00:00.000000000',
            '1991-10-01T00:00:00.000000000', '1991-10-30T00:00:00.000000000',
            '1991-11-05T00:00:00.000000000', '1991-12-02T00:00:00.000000000',
            '1991-12-17T00:00:00.000000000', '1992-01-09T00:00:00.000000000',
            '1992-02-05T00:00:00.000000000', '1992-03-11T00:00:00.000000000',
```

```
fomc_calendar.loc['2020-06-10', 'Rate'] = 0
fomc_calendar.loc['2020-07-29', 'Rate'] = 0
fomc_calendar.loc['2020-06-10', 'RateDiff'] = 0
fomc_calendar.loc['2020-07-29', 'RateDiff'] = 0
```

Save the train data

```
if IN_COLAB:
  def save_data(df, file_name, dir_name=preprocessed_dir, index_csv=True):
    if not os.path.exists(dir_name):
      os.mkdir(dir_name)
    # Save results to a picke file
    file = open(dir_name + file_name + '.pickle', 'wb')
    pickle.dump(df, file)
    file.close()
    print('Successfully saved {}.pickle. in {}'.format(file_name, dir_name + file_name + '.pickle'))
    # Save results to a csv file
    df.to_csv(dir_name + file_name + '.csv', index=True)
    print('Successfully saved {}.csv. in {}'.format(file_name, dir_name + file_name + '.csv'))

else:
  def save_data(df, file_name, dir_name=preprocessed_dir):
    # Save results to a .picke file
    file = open(dir_name + file_name + '.pickle', 'wb')
    pickle.dump(df, file)
    file.close()
    print('Successfully saved {}.pickle. in {}'.format(file_name, dir_name + file_name + '.pickle'))
    # Save results to a .csv file
    df.to_csv(dir_name + file_name + '.csv', index=True)
    print('Successfully saved {}.csv. in {}'.format(file_name, dir_name + file_name + '.csv'))


# Save data
save_data(nontext_data, 'nontext_data')
save_data(nontext_ma2, 'nontext_ma2')
save_data(nontext_ma3, 'nontext_ma3')
save_data(nontext_ma6, 'nontext_ma6')
```

```
save_data(nontext_ma12, 'nontext_ma12')
save_data(treasury, 'treasury')
save_data(fomc_calendar, 'fomc_calendar')
```

```
Successfully saved nontext_data.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_data.pickle
Successfully saved nontext_data.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_data.csv
Successfully saved nontext_ma2.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma2.pickle
Successfully saved nontext_ma2.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma2.csv
Successfully saved nontext_ma3.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma3.pickle
Successfully saved nontext_ma3.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma3.csv
Successfully saved nontext_ma6.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma6.pickle
Successfully saved nontext_ma6.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma6.csv
Successfully saved nontext_ma12.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma12.pickle
Successfully saved nontext_ma12.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/nontext_ma12.csv
Successfully saved treasury.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/treasury.pickle
Successfully saved treasury.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/treasury.csv
Successfully saved fomc_calendar.pickle. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/fomc_calendar.pickle
Successfully saved fomc_calendar.csv. in /content/drive/My Drive/Colab Notebooks/proj2/src/data/preprocessed/fomc_calendar.csv
```