

# CISB62 Deep Learning

Course: CISB 62

Professor: Angel Hernandez

Student: Jack Chen

Topic: TimeSeries - ANN, LSTM, Bidirectional LSTM, Hyperparameters Tuning

1. Parsing - alpha\_vantage, beautifulsoup; ML - sklearn, keras, tensorflow
2. Data cleaning, EDA, Preprocessing, Model featuring
3. Time Series: Machine Learning, Deep Learning (ANN, LSTM, Bidirectional LSTM)
4. Save transformer to pickle, Model checkpoint
5. Conclusion
6. References

## Libraries, Functions, Load/Cleaning Data

### Load Libraries

```
In [ ]: # Parsing Part
import requests
from bs4 import BeautifulSoup
# Alpha Vantage API - stock data
from alpha_vantage.timeseries import TimeSeries
from alpha_vantage.fundamentaldata import FundamentalData
from alpha_vantage.cryptocurrencies import CryptoCurrencies
from alpha_vantage.techindicators import TechIndicators

# Data
import numpy as np
import pandas as pd

# Visualization
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
sns.set_style("whitegrid")

# Deep Learning
import tensorflow
import keras.layers

# Data Preprocessing
from sklearn.preprocessing import StandardScaler, MinMaxScaler
from sklearn.model_selection import train_test_split

# Model Featurizing
from keras.layers import Input, Flatten, Dense, Activation, LeakyReLU, Bidirectional,
```

```

from tensorflow.keras.optimizers import SGD
# Hyper parameters
from sklearn.model_selection import GridSearchCV
from keras.wrappers.scikit_learn import KerasClassifier, KerasRegressor

# Models
from xgboost import XGBRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.linear_model import Ridge, LinearRegression
from keras import Sequential, Model

# Analyze Results
from sklearn.metrics import roc_curve, plot_roc_curve, r2_score, mean_absolute_error,
from sklearn import metrics

# Misc
# filter warnings
from keras.callbacks import ModelCheckpoint, LearningRateScheduler, History
import pickle

import datetime as dt
from datetime import datetime

import warnings
warnings.filterwarnings("ignore")

```

## Functions

In [ ]:

```

# Function to clean balance sheet df
def convMonth(x):
    if x == 'MAR':
        x = 3
    elif x == 'DEC':
        x = 12
    elif x == 'JUN':
        x = 6
    elif x == 'SEP':
        x = 9
    return x

```

In [ ]:

```

# Function - ML - run machine Learning model and print out MSE
def runML(model, feature, target, ftest, ttest):
    model.fit(feature, target)
    t_predict = model.predict(ftest)
    print(model)
    print('MAE score:', mean_absolute_error(ttest, t_predict))
    print('MSE score:', mean_squared_error(ttest, t_predict))
    print('')

```

In [ ]:

```

# Convert to sequence
# function for TimeSeries to seq models
def convSeq(feature, target, seq):
    Xs, ys = [], []
    # from 0 to (len - seq)
    for i in range(len(feature) - seq):
        # from i to (i + seq)

```

```
v = feature.iloc[i:(i+seq)]
Xs.append(v)

# target of (i+seq)
ys.append(target.iloc[i+seq])
return np.array(Xs), np.array(ys)
```

In [ ]: # Convert sequence dimensions

```
def convDim(feature, target):
    targetArray = np.array(target)
    targetNew = targetArray.reshape(-1,1)
    featureArray = np.array(feature)
    featureNew = featureArray.reshape(featureArray.shape[0], featureArray.shape[1], 1)
    return featureNew, targetNew
```

In [ ]: # didnt work...

```
# x, neurons
def hyperLSTM(x, units=32, activation='relu', optimizer='adam'):
    ls = Sequential()
    ls.add(LSTM(units=32, input_dim=5, activation=activation, return_sequences=True, input_shape=(x[1], units)))
    ls.add(LSTM(units=32/2, activation=activation, input_shape=(x[1], units)))
    ls.add(Dense(units=3, activation = activation))
    ls.add(Dense(units=1, activation = activation))
    ls.compile(optimizer=optimizer, loss='mse', metrics=['mse', 'mae'])
    return ls
```

## AlphaVantage API

In [ ]: # Variable - store Alpha Vantage API key

```
# path = r'C:\Users\Gumo\Desktop\Git\Notebook\keys\alphaVantage.txt'
# with open(path, mode='r') as w:
#     key = (w.readline())
```

In [ ]: # URL Method

```
# def alpha(function, symbol):
#     url = 'https://www.alphavantage.co/query?function=' + function + '&symbol=' + symbol +
#     response = requests.get(url)

# Function AlphaVantage
def alpha(symbol, function, period=None, typ = None, tim=None):

    # Funciton - TimeSeries
    if function == 't':
        # Instance - TimeSeries Instance
        ts = TimeSeries(key = key, output_format='pandas')
        if period == 'd':
            data = ts.get_daily_adjusted(symbol, outputsize=outputsize)[0]
        elif period == 'w':
            data = ts.get_weekly_adjusted(symbol)[0]
        elif period == 'm':
            data = ts.get_monthly_adjusted(symbol)[0]

    # Funciton - FundamentalData
    elif function == 'f':
        # Instance - FundamentalData Instance
        fd = FundamentalData(key, output_format='pandas')
        if period == 'q':
```

```

if typ == 'i':
    data = fd.get_income_statement_quarterly(symbol)[0]
    data.index = data.iloc[:,0]
    data=data.iloc[:,2:]
elif typ == 'b':
    data = fd.get_balance_sheet_quarterly(symbol)[0]
    data.index = data.iloc[:,0]
    data=data.iloc[:,2:]
elif typ=='c':
    data = fd.get_cash_flow_quarterly(symbol)[0]
    data.index = data.iloc[:,0]
    data=data.iloc[:,2:]
elif period =='a':
    if typ == 'i':
        data = fd.get_income_statement_annual(symbol)[0]
        data.index = data.iloc[:,0]
        data=data.iloc[:,2:]
    elif typ == 'b':
        data = fd.get_balance_sheet_annual(symbol)[0]
        data.index = data.iloc[:,0]
        data=data.iloc[:,2:]
    elif typ=='c':
        data = fd.get_cash_flow_annual(symbol)[0]
        data.index = data.iloc[:,0]
        data=data.iloc[:,2:]

# Funciton - TechnicalIndicator
elif function =='ti':
    ti = TechIndicators(key,output_format='pandas')

    # reassign period into TI format
    if period == 'm':
        period = 'monthly'
    elif period =='w':
        period = 'weekly'
    elif period == 'd':
        period ='daily'

    if typ == 'rsi':
        data=ti.get_rsi(symbol,interval=period,time_period=tim,series_type='close')
    elif typ =='so':
        data = ti.get_stoch(symbol,interval=period)[0]

# Funciton - CC
elif function == 'c':
    # Instance - Crypto
    cc = CryptoCurrencies(key, output_format='pandas')
    pass
return data

```

```

In [ ]: # Variable Size
outputsize = 'compact'

# Variable Stock
symbol = 'cvx'

# Variable Function - t, f, c, ti (timeseries, financialdata, crypto, technical indicator)
function = 'ti'

```

```
# Variable Period
# TimeSeries: d,w,m,i (daily, weekly, monthly, interval(mins))
# Fundamental: q,a (quarterly,annually)
# Technical: d,w,m, (interval(mins))
period = 'm'

# Variable - Type
# Fundamental: i,b,c
# Technical: so,rsi
typ = 'so'

# Variable - Time
tim = 60

info = alpha(symbol,function,period=period,typ = typ,tim=tim)
info.head()
```

```
In [ ]: # save to Local stock data  
# info.to_csv('data/' + symbol.upper() + 'stockPrice.csv')
```

In [ ]:

## BeautifulSoup

## Scrape Inflation

```
In [ ]: # Define a variable for the url of the site  
site = "https://www.usinflationcalculator.com/inflation/current-inflation-rates/#:~:te
```

```
In [ ]: # Making a get request and assign the result to a variable response
response = requests.get(site)
```

```
#Check that the response was processed correctly  
response.status_code
```

Out[1]: 200

```
In [ ]: # Extracting the HTML  
#assign a variable html to response content.  
html = response.content  
  
# Checking that the reply is indeed an HTML  
html[:200]
```

```
In [ ]: #Convert HTML to a BeautifulSoup object, using the default parser of html  
#Create a BeautifulSoup object and store it in a variable named soup.  
soup = BeautifulSoup(html, "html.parser")
```

```
In [ ]: # The soup variable (BeautifulSoup object) we defined earlier can be seen as represent  
soup
```

```
Out[ ]: <!DOCTYPE html>

<!--[if IE 7]>
<html class="ie ie7" dir="ltr" lang="en-US"
      prefix="og: https://ogp.me/ns#" >
<![endif]-->
<!--[if IE 8]>
<html class="ie ie8" dir="ltr" lang="en-US"
      prefix="og: https://ogp.me/ns#" >
<![endif]-->
<!--[if !(IE 7) | !(IE 8) ]><!--
<html dir="ltr" lang="en-US" prefix="og: https://ogp.me/ns#">
<!--<![endif]-->
<head>
<!-- Global site tag (gtag.js) - Google Analytics -->
<script async="" src="https://www.googletagmanager.com/gtag/js?id=UA-2181571-7"></script>
<script>
  window.dataLayer = window.dataLayer || [];
  function gtag(){dataLayer.push(arguments);}
  gtag('js', new Date());

  gtag('config', 'UA-2181571-7');
</script>
<meta charset="utf-8"/>
<meta content="width=device-width" name="viewport"/>
<link href="http://gmpg.org/xfn/11" rel="profile"/>
<link href="https://www.usinflationcalculator.com/xmlrpc.php" rel="pingback"/>
<!--[if lt IE 9]>
    <script src="https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen/js/html5.js"></script>
    <![endif]-->
<!-- All in One SEO 4.2.0 -->
<title>Current US Inflation Rates: 2000-2022 | US Inflation Calculator</title>
<meta content="The annual inflation rate for the United States is 8.3% for the 12 months ended April 2022 after rising 8.5% previously, according to U.S. Labor Department data published May 11. The next inflation update is scheduled for release on June 10 at 8:30 a.m. ET. It will offer the rate of inflation over the 12" name="description">
<meta content="max-image-preview:large" name="robots">
<link href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/" rel="canonical">
<meta content="en_US" property="og:locale"/>
<meta content="US Inflation Calculator |" property="og:site_name"/>
<meta content="article" property="og:type"/>
<meta content="Current US Inflation Rates: 2000-2022 | US Inflation Calculator" property="og:title"/>
<meta content="The annual inflation rate for the United States is 8.3% for the 12 months ended April 2022 after rising 8.5% previously, according to U.S. Labor Department data published May 11. The next inflation update is scheduled for release on June 10 at 8:30 a.m. ET. It will offer the rate of inflation over the 12" property="og:description"/>
<meta content="https://www.usinflationcalculator.com/inflation/current-inflation-rates/" property="og:url"/>
<meta content="2008-07-23T03:07:58+00:00" property="article:published_time"/>
<meta content="2022-05-11T13:01:22+00:00" property="article:modified_time"/>
<meta content="summary" name="twitter:card"/>
<meta content="Current US Inflation Rates: 2000-2022 | US Inflation Calculator" name="twitter:title"/>
<meta content="The annual inflation rate for the United States is 8.3% for the 12 months ended April 2022 after rising 8.5% previously, according to U.S. Labor Department data published May 11. The next inflation update is scheduled for release on June 10 at 8:30 a.m. ET. It will offer the rate of inflation over the 12" name="twitter:description"/>
```

data published May 11. The next inflation update is scheduled for release on June 10 at 8:30 a.m. ET. It will offer the rate of inflation over the 12" name="twitter:description"/>

```
<meta content="nositelinkssearchbox" name="google"/>
<script class="aioseo-schema" type="application/ld+json">
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</script>

<link href="//secure.gravatar.com" rel="dns-prefetch">
<link href="//www.usinflationcalculator.com" rel="dns-prefetch"/>
<link href="//fonts.googleapis.com" rel="dns-prefetch"/>
<link href="//s.w.org" rel="dns-prefetch"/>
<link href="//v0.wordpress.com" rel="dns-prefetch"/>
<link href="//jetpack.wordpress.com" rel="dns-prefetch"/>
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```

```

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<link href="https://www.usinflationcalculator.com/comments/feed/" rel="alternate" title="US Inflation Calculator » Comments Feed" type="application/rss+xml"/>
<script>
window._wpemojiSettings = {"baseUrl":"https://s.w.org/images/core/emoji/13.1.0/72x72/","ext":".png","svgUrl":"https://s.w.org/images/core/emoji/13.1.0/svg/","svgExt":".svg","source":{"concatemoji":"https://www.usinflationcalculator.com/wp-includes/js/wp-emoji-release.min.js?ver=5.9.3"}};
/*! This file is auto-generated */
!function(e,a,t){var n,r,o,i=a.createElement("canvas"),p=i.getContext&&i.getContext("2d");function s(e,t){var a=String.fromCharCode;p.clearRect(0,0,i.width,i.height),p.fillText(a.apply(this,e),0,0);e=i.toDataURL();return p.clearRect(0,0,i.width,i.height),p.fillText(a.apply(this,t),0,0),e==i.toDataURL()}function c(e){var t=a.createElement("script");t.src=e,t.defer=t.type="text/javascript",a.getElementsByTagName("head")[0].appendChild(t)}for(o=Array("flag","emoji"),t.supports={everything:!0,everythingExceptFlag:!0},r=0;r<o.length;r++)t.supports[o[r]]=function(e){if(!p||!p.fillText) return!1;switch(p.textBaseline="top",p.font="600 32px Arial",e){case"flag":return s([127987,65039,8205,9895,65039],[127987,65039,8203,9895,65039])?!1:!s([55356,56826,55356,56819],[55356,56826,8203,55356,56819])&&!s([55356,57332,56128,56423,56128,56418,56128,56421,56128,56430,56128,56423,56128,56447],[55356,57332,8203,56128,56423,8203,56128,56418,8203,56128,56421,8203,56128,56430,8203,56128,56423,8203,56128,56447]);case"emoji":return!s([10084,65039,8205,55357,56613],[10084,65039,8203,55357,56613])}return!1}(o[r]),t.supports.everything=t.supports.everything&&t.supports[o[r]],"flag"!=o[r]&&(t.supports.everythingExceptFlag=t.supports.everythingExceptFlag&&t.supports[o[r]]);t.supports.everythingExceptFlag=t.supports.everythingExceptFlag&&!t.supports.flag,t.DOMReady=!1,t.readyCallback=function(){t.DOMReady=!0},t.supports.everything||(n=function(){t.readyCallback()},a.addEventListener?(a.addEventListener("DOMContentLoaded",n,!1),e.addEventListener("load",n,!1)):(e.attachEvent("onload",n),a.attachEvent("onreadystatechange",function(){("complete"==a.readyState&&t.readyCallback())}),n=t.source||{}).concatemoji?c(n.concatemoji):n.wpemoji&&n.twemoji&&(c(n.twemoji),c(n.wpemoji)))}(window,document,window._wpemojiSettings);
</script>
<style>
img.wp-smiley,
img.emoji {
    display: inline !important;
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    box-shadow: none !important;
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    width: 1em !important;
    margin: 0 0.07em !important;
    vertical-align: -0.1em !important;
    background: none !important;
    padding: 0 !important;
}
</style>
<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/modules/theme-tools/compat/twentyfourteen.css?ver=10.9" id="twentyfourteen-jetpack-css" media="all" rel="stylesheet"/>
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</style>
<style id="wp-block-library-theme-inline-css">
.wp-block-audio figcaption{color:#555;font-size:13px;text-align:center}.is-dark-theme .wp-block-audio figcaption{color:hsla(0,0%,100%,.65)}.wp-block-code>code{font-family:

```

```
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```

</style>

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```

```
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```

```
<style id="global-styles-inline-css">
```

body{--wp--preset--color--black: #1a4e88;--wp--preset--color--cyan-bluish-gray: #abb8c3;--wp--preset--color--white: #fff;--wp--preset--color--pale-pink: #f78da7;--wp--preset--color--vivid-red: #cf2e2e;--wp--preset--color--luminous-vivid-orange: #ff6900;--wp--preset--color--luminous-vivid-amber: #fcb900;--wp--preset--color--light-green-cyan: #7bdcb5;--wp--preset--color--vivid-green-cyan: #00d084;--wp--preset--color--pale-cyan-blue: #8ed1fc;--wp--preset--color--vivid-cyan-blue: #0693e3;--wp--preset--color--vivid-purple: #9b51e0;--wp--preset--color--green: #2c6db7;--wp--preset--color--dark-gray: #2b2b2b;--wp--preset--color--medium-gray: #767676;--wp--preset--color--light-gray: #f5f5f5;--wp--preset--gradient--vivid-cyan-blue-to-vivid-purple: linear-gradient(135deg,rgba(6,147,227,1) 0%,rgb(155,81,224) 100%);--wp--preset--gradient--light-green-cyan-to-vivid-green-cyan: linear-gradient(135deg,rgb(122,220,180) 0%,rgb(0,208,130) 100%);--wp--preset--gradient--luminous-vivid-amber-to-luminous-vivid-orange: linear-gradient(135deg,rgba(252,185,0,1) 0%,rgba(255,105,0,1) 100%);--wp--preset--gradient--luminous-vivid-orange-to-vivid-red: linear-gradient(135deg,rgba(255,105,0,1) 0%,rgb(207,46,46) 100%);--wp--preset--gradient--very-light-gray-to-cyan-bluish-gray: linear-gradient(135deg,rgb(238,238,238) 0%,rgb(169,184,195) 100%);--wp--preset--gradient--cool-to-warm-spectrum: linear-gradient(135deg,rgb(74,234,220) 0%,rgb(151,120,209) 20%,rgb(207,42,186) 40%,rgb(238,44,130) 60%,rgb(251,105,98) 80%,rgb(254,248,76) 100%);--wp--preset--gradient--blush-light-purple: linear-gradient(135deg,rgb(255,206,236) 0%,rgb(152,150,240) 100%);--wp--preset--gradient--blush-bordeaux: linear-gradient(135deg,rgb(254,205,165) 0%,rgb(254,45,45) 50%,rgb(107,0,62) 100%);--wp--preset--gradient--luminous-dusk: linear-gradient(135deg,rgb(255,203,112) 0%,rgb(199,81,192) 50%,rgb(65,88,208) 100%);--wp--preset--gradient--pale-ocean: linear-gradient(135deg,rgb(255,245,203) 0%,rgb(182,227,212) 50%,rgb(51,167,181) 100%);--wp--preset--gradient--electric-grass: linear-gradient(135deg,rgb(202,248,128) 0%,rgb(113,206,126) 100%);--wp--preset--gradient--midnight: linear-gradient(135deg,rgb(2,3,129) 0%,rgb(40,116,252) 100%);--wp--pre

```
set--duotone--dark-grayscale: url('#wp-duotone-dark-grayscale');--wp--preset--duotone--grayscale: url('#wp-duotone-grayscale');--wp--preset--duotone--purple-yellow: url('#wp-duotone-purple-yellow');--wp--preset--duotone--blue-red: url('#wp-duotone-blue-red');--wp--preset--duotone--midnight: url('#wp-duotone-midnight');--wp--preset--duotone--magenta-yellow: url('#wp-duotone-magenta-yellow');--wp--preset--duotone--purple-green: url('#wp-duotone-purple-green');--wp--preset--duotone--blue-orange: url('#wp-duotone-blue-orange');--wp--preset--font-size--small: 13px;--wp--preset--font-size--medium: 20px;--wp--preset--font-size--large: 36px;--wp--preset--font-size--x-large: 42px;}.has-black-color{color: var(--wp--preset--color--black) !important;}.has-cyan-blush-gray-color{color: var(--wp--preset--color--cyan-blush-gray) !important;}.has-white-color{color: var(--wp--preset--color--white) !important;}.has-pale-pink-color{color: var(--wp--preset--color--pale-pink) !important;}.has-vivid-red-color{color: var(--wp--preset--color--vivid-red) !important;}.has-luminous-vivid-orange-color{color: var(--wp--preset--color--luminous-vivid-orange) !important;}.has-luminous-vivid-amber-color{color: var(--wp--preset--color--luminous-vivid-amber) !important;}.has-light-green-cyan-color{color: var(--wp--preset--color--light-green-cyan) !important;}.has-vivid-green-cyan-color{color: var(--wp--preset--color--vivid-green-cyan) !important;}.has-pale-cyan-blue-color{color: var(--wp--preset--color--pale-cyan-blue) !important;}.has-vivid-cyan-blue-color{color: var(--wp--preset--color--vivid-cyan-blue) !important;}.has-vivid-purple-color{color: var(--wp--preset--color--vivid-purple) !important;}.has-black-background-color{background-color: var(--wp--preset--color--black) !important;}.has-cyan-blush-gray-background-color{background-color: var(--wp--preset--color--cyan-blush-gray) !important;}.has-white-background-color{background-color: var(--wp--preset--color--white) !important;}.has-pale-pink-background-color{background-color: var(--wp--preset--color--pale-pink) !important;}.has-vivid-red-background-color{background-color: var(--wp--preset--color--vivid-red) !important;}.has-luminous-vivid-orange-background-color{background-color: var(--wp--preset--color--luminous-vivid-orange) !important;}.has-luminous-vivid-amber-background-color{background-color: var(--wp--preset--color--luminous-vivid-amber) !important;}.has-light-green-cyan-background-color{background-color: var(--wp--preset--color--light-green-cyan) !important;}.has-vivid-green-cyan-background-color{background-color: var(--wp--preset--color--vivid-green-cyan) !important;}.has-pale-cyan-blue-background-color{background-color: var(--wp--preset--color--pale-cyan-blue) !important;}.has-vivid-cyan-blue-background-color{background-color: var(--wp--preset--color--vivid-cyan-blue) !important;}.has-vivid-purple-background-color{background-color: var(--wp--preset--color--vivid-purple) !important;}.has-black-border-color{border-color: var(--wp--preset--color--black) !important;}.has-cyan-blush-gray-border-color{border-color: var(--wp--preset--color--cyan-blush-gray) !important;}.has-white-border-color{border-color: var(--wp--preset--color--white) !important;}.has-pale-pink-border-color{border-color: var(--wp--preset--color--pale-pink) !important;}.has-vivid-red-border-color{border-color: var(--wp--preset--color--vivid-red) !important;}.has-luminous-vivid-orange-border-color{border-color: var(--wp--preset--color--luminous-vivid-orange) !important;}.has-luminous-vivid-amber-border-color{border-color: var(--wp--preset--color--luminous-vivid-amber) !important;}.has-light-green-cyan-border-color{border-color: var(--wp--preset--color--light-green-cyan) !important;}.has-vivid-green-cyan-border-color{border-color: var(--wp--preset--color--vivid-green-cyan) !important;}.has-pale-cyan-blue-border-color{border-color: var(--wp--preset--color--pale-cyan-blue) !important;}.has-vivid-cyan-blue-border-color{border-color: var(--wp--preset--color--vivid-cyan-blue) !important;}.has-vivid-purple-border-color{border-color: var(--wp--preset--color--vivid-purple) !important;}.has-vivid-cyan-blue-to-vivid-purple-gradient-background{background: var(--wp--preset--gradient--vivid-cyan-blue-to-vivid-purple) !important;}.has-light-green-cyan-to-vivid-green-cyan-gradient-background{background: var(--wp--preset--gradient--light-green-cyan-to-vivid-green-cyan) !important;}.has-luminous-vivid-amber-to-luminous-vivid-orange-gradient-background{background: var(--wp--preset--gradient--luminous-vivid-amber-to-luminous-vivid-orange) !important;}.has-luminous-vivid-orange-to-vivid-red-gradient-background{background: var(--wp--preset--gradient--luminous-vivid-orange-to-vivid-red) !important;}.has-very-light-gray-to-cyan-blush-gray-gradient-background{background: var(--wp--preset--gradient--very-light-gray-to-cyan-blush-gray) !important;}.has-cool-to-warm-spectrum-gradient-background{background: var(--wp--preset--gradient--cool-to-warm-spectrum) !important;}.has-blush-light-purple-gradient-background{background: var(--
```

```

wp--preset--gradient--blush-light-purple) !important;}.has-blush-bordeaux-gradient-ba
ckground{background: var(--wp--preset--gradient--blush-bordeaux) !important;}.has-lum
inous-dusk-gradient-background{background: var(--wp--preset--gradient--luminous-dusk)
!important;}.has-pale-ocean-gradient-background{background: var(--wp--preset--gradien
t--pale-ocean) !important;}.has-electric-grass-gradient-background{background: var(
--wp--preset--gradient--electric-grass) !important;}.has-midnight-gradient-background{b
ackground: var(--wp--preset--gradient--midnight) !important;}.has-small-font-size{fon
t-size: var(--wp--preset--font-size--small) !important;}.has-medium-font-size{font-si
ze: var(--wp--preset--font-size--medium) !important;}.has-large-font-size{font-size:
var(--wp--preset--font-size--large) !important;}.has-x-large-font-size{font-size: var
(--wp--preset--font-size--x-large) !important;}
</style>
<link href="https://fonts.googleapis.com/css?family=Lato%3A300%2C400%2C700%2C900%2C30
0italic%2C400italic%2C700italic&subset=latin%2Clatin-ext&display=fallback" id
="twentyfourteen-lato-css" media="all" rel="stylesheet"/>
<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/_inc/gen
ericons/genericons.css?ver=3.1" id="genericons-css" media="all" rel="style
sheet"/>
<link href="https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen-ch
ild/style.css?ver=20190507" id="twentyfourteen-style-css" media="all" rel="styleshee
t"/>
<link href="https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen/cs
s(blocks.css?ver=20190102" id="twentyfourteen-block-style-css" media="all" rel="style
sheet"/>
<!--[if lt IE 9]>
<link rel='stylesheet' id='twentyfourteen-ie-css' href='https://www.usinflationcalcu
lator.com/wp-content/themes/twentyfourteen/css/ie.css?ver=20140701' media='all' />
<![endif]-->
<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/_inc/soc
ial-logos/social-logos.min.css?ver=10.9" id="social-logos-css" media="all" rel="style
sheet"/>
<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/css/jetp
ack.css?ver=10.9" id="jetpack_css-css" media="all" rel="stylesheet"/>
<script id="jquery-core-js" src="https://www.usinflationcalculator.com/wp-includes/j
s/jquery/jquery.min.js?ver=3.6.0"></script>
<script id="jquery-migrate-js" src="https://www.usinflationcalculator.com/wp-includ
es/js/jquery/jquery-migrate.min.js?ver=3.3.2"></script>
<link href="https://www.usinflationcalculator.com/wp-json/" rel="https://api.w.org/"/
><link href="https://www.usinflationcalculator.com/wp-json/wp/v2/pages/75" rel="alter
nate" type="application/json"/><link href="https://www.usinflationcalculator.com/xmlr
pc.php?rsd" rel="EditURI" title="RSD" type="application/rsd+xml"/>
<link href="https://www.usinflationcalculator.com/wp-includes/wlwmanifest.xml" rel="w
lwmanifest" type="application/wlwmanifest+xml"/>
<link href="https://wp.me/PoZpd-1d" rel="shortlink"/>
<link href="https://www.usinflationcalculator.com/wp-json/oembed/1.0/embed?url=https%
3A%2F%2Fwww.usinflationcalculator.com%2Finflation%2Fcurrent-inflation-rates%2F" rel
="alternate" type="application/json+oembed"/>
<link href="https://www.usinflationcalculator.com/wp-json/oembed/1.0/embed?url=https%
3A%2F%2Fwww.usinflationcalculator.com%2Finflation%2Fcurrent-inflation-rates%2F&fo
rmat=xml" rel="alternate" type="text/xml+oembed"/>
<style id="fourteen-colors" type="text/css"> /* Custom Contrast Color */
    .site:before,
    #secondary,
    .site-header,
    .site-footer,
    .menu-toggle,
    .featured-content,
    .featured-content .entry-header,
    .slider-direction-nav a,
    .ie8 .featured-content,

```

```
.ie8 .site:before,  
.has-black-background-color {  
    background-color: #1a4e88;  
}  
  
.has-black-color {  
    color: #1a4e88;  
}  
  
.grid .featured-content .entry-header,  
.ie8 .grid .featured-content .entry-header {  
    border-color: #1a4e88;  
}  
  
.slider-control-paging a:before {  
    background-color: rgba(255,255,255,.33);  
}  
  
.hentry .mejs-mediaelement,  
.widget .mejs-mediaelement,  
.hentry .mejs-container .mejs-controls,  
.widget .mejs-container .mejs-controls {  
    background: #1a4e88;  
}  
  
/* Player controls need separation from the contrast background */  
.primary-sidebar .mejs-controls,  
.site-footer .mejs-controls {  
    border: 1px solid;  
}  
  
.content-sidebar .widget_twentyfourteen_ephemera .widget-title  
e:before {  
    background: #1a4e88;  
}  
  
.paging-navigation,  
.content-sidebar .widget .widget-title {  
    border-top-color: #1a4e88;  
}  
  
.content-sidebar .widget .widget-title,  
.content-sidebar .widget .widget-title a,  
.paging-navigation,  
.paging-navigation a:hover,  
.paging-navigation a {  
    color: #1a4e88;  
}  
  
/* Override the site title color option with an over-qualified  
d selector, as the option is hidden. */  
h1.site-title a {  
    color: #fff;  
}  
  
.menu-toggle:active,  
.menu-toggle:focus,  
.menu-toggle:hover {  
    background-color: #5e92cc;  
}
```

```
/* Custom accent color. */
button,
.button,
.contributor-posts-link,
input[type="button"],
input[type="reset"],
input[type="submit"],
.search-toggle,
.hentry .mejs-controls .mejs-time-rail .mejs-time-current,
.widget .mejs-controls .mejs-time-rail .mejs-time-current,
.hentry .mejs-overlay:hover .mejs-overlay-button,
.widget .mejs-overlay:hover .mejs-overlay-button,
.widget button,
.widget .button,
.widget input[type="button"],
.widget input[type="reset"],
.widget input[type="submit"],
.widget_calendar tbody a,
.content-sidebar .widget input[type="button"],
.content-sidebar .widget input[type="reset"],
.content-sidebar .widget input[type="submit"],
.slider-control-paging .slider-active:before,
.slider-control-paging .slider-active:hover:before,
.slider-direction-nav a:hover,
.ie8 .primary-navigation ul ul,
.ie8 .secondary-navigation ul ul,
.ie8 .primary-navigation li:hover > a,
.ie8 .primary-navigation li.focus > a,
.ie8 .secondary-navigation li:hover > a,
.ie8 .secondary-navigation li.focus > a,
.wp-block-file .wp-block-file__button,
.wp-block-button__link,
.has-green-background-color {
    background-color: #2c6db7;
}

.site-navigation a:hover,
.is-style-outline .wp-block-button__link:not(.has-text-color),
.has-green-color {
    color: #2c6db7;
}

::-moz-selection {
    background: #2c6db7;
}

::selection {
    background: #2c6db7;
}

.paging-navigation .page-numbers.current {
    border-color: #2c6db7;
}

@media screen and (min-width: 782px) {
    .primary-navigation li:hover > a,
    .primary-navigation li.focus > a,
    .primary-navigation ul ul {
        background-color: #2c6db7;
}
```

```
}

@media screen and (min-width: 1008px) {
    .secondary-navigation li:hover > a,
    .secondary-navigation li.focus > a,
    .secondary-navigation ul ul {
        background-color: #2c6db7;
    }
}

.contributor-posts-link,
button,
.button,
input[type="button"],
input[type="reset"],
input[type="submit"],
.search-toggle:before,
.hentry .mejs-overlay:hover .mejs-overlay-button,
.widget .mejs-overlay:hover .mejs-overlay-button,
.widget button,
.widget .button,
.widget input[type="button"],
.widget input[type="reset"],
.widget input[type="submit"],
.widget_calendar tbody a,
.widget_calendar tbody a:hover,
.site-footer .widget_calendar tbody a,
.content-sidebar .widget input[type="button"],
.content-sidebar .widget input[type="reset"],
.content-sidebar .widget input[type="submit"],
button:hover,
button:focus,
.button:hover,
.button:focus,
.widget a.button:hover,
.widget a.button:focus,
.widget a.button:active,
.content-sidebar .widget a.button,
.content-sidebar .widget a.button:hover,
.content-sidebar .widget a.button:focus,
.content-sidebar .widget a.button:active,
.contributor-posts-link:hover,
.contributor-posts-link:active,
input[type="button"]:hover,
input[type="button"]:focus,
input[type="reset"]:hover,
input[type="reset"]:focus,
input[type="submit"]:hover,
input[type="submit"]:focus,
.slider-direction-nav a:hover:before {
    color: #fff;
}

@media screen and (min-width: 782px) {
    .primary-navigation ul ul a,
    .primary-navigation li:hover > a,
    .primary-navigation li.focus > a,
    .primary-navigation ul ul {
        color: #fff;
    }
}
```

```
}
```

```
@media screen and (min-width: 1008px) {  
    .secondary-navigation ul ul a,  
    .secondary-navigation li:hover > a,  
    .secondary-navigation li.focus > a,  
    .secondary-navigation ul ul {  
        color: #fff;  
    }  
}
```

```
/* Generated variants of custom accent color. */  
a,  
.content-sidebar .widget a {  
    color: #2c6db7;  
}
```

```
.contributor-posts-link:hover,  
.button:hover,  
.button:focus,  
.slider-control-paging a:hover:before,  
.search-toggle:hover,  
.search-toggle.active,  
.search-box,  
.widget_calendar tbody a:hover,  
button:hover,  
button:focus,  
input[type="button"]:hover,  
input[type="button"]:focus,  
input[type="reset"]:hover,  
input[type="reset"]:focus,  
input[type="submit"]:hover,  
input[type="submit"]:focus,  
.widget button:hover,  
.widget .button:hover,  
.widget button:focus,  
.widget .button:focus,  
.widget input[type="button"]:hover,  
.widget input[type="button"]:focus,  
.widget input[type="reset"]:hover,  
.widget input[type="reset"]:focus,  
.widget input[type="submit"]:hover,  
.widget input[type="submit"]:focus,  
.content-sidebar .widget input[type="button"]:hover,  
.content-sidebar .widget input[type="button"]:focus,  
.content-sidebar .widget input[type="reset"]:hover,  
.content-sidebar .widget input[type="reset"]:focus,  
.content-sidebar .widget input[type="submit"]:hover,  
.content-sidebar .widget input[type="submit"]:focus,  
.ie8 .primary-navigation ul ul a:hover,  
.ie8 .primary-navigation ul ul li.focus > a,  
.ie8 .secondary-navigation ul ul a:hover,  
.ie8 .secondary-navigation ul ul li.focus > a,  
.wp-block-file .wp-block-file_button:hover,  
.wp-block-file .wp-block-file_button:focus,  
.wp-block-button_link:not(.has-text-color):hover,  
.wp-block-button_link:not(.has-text-color):focus,  
.is-style-outline .wp-block-button_link:not(.has-text-color):hover,  
.is-style-outline .wp-block-button_link:not(.has-text-color):focus {  
    background-color: #498ad4;
```

```
}

.featured-content a:hover,
.featured-content .entry-title a:hover,
.widget a:hover,
.widget-title a:hover,
.widget_twentyfourteen_ephemera .entry-meta a:hover,
.hentry .mejs-controls .mejs-button button:hover,
.widget .mejs-controls .mejs-button button:hover,
.site-info a:hover,
.featured-content a:hover,
.wp-block-latest-comments_comment-meta a:hover,
.wp-block-latest-comments_comment-meta a:focus {
    color: #498ad4;
}

a:active,
a:hover,
.entry-title a:hover,
.entry-meta a:hover,
.cat-links a:hover,
.entry-content .edit-link a:hover,
.post-navigation a:hover,
.image-navigation a:hover,
.comment-author a:hover,
.comment-list .pingback a:hover,
.comment-list .trackback a:hover,
.comment-metadata a:hover,
.comment-reply-title small a:hover,
.content-sidebar .widget a:hover,
.content-sidebar .widget .widget-title a:hover,
.content-sidebar .widget_twentyfourteen_ephemera .entry-meta a:hover
{
    color: #498ad4;
}

.page-links a:hover,
.paging-navigation a:hover {
    border-color: #498ad4;
}

.entry-meta .tag-links a:hover:before {
    border-right-color: #498ad4;
}

.page-links a:hover,
.entry-meta .tag-links a:hover {
    background-color: #498ad4;
}

@media screen and (min-width: 782px) {
    .primary-navigation ul ul a:hover,
    .primary-navigation ul ul li.focus > a {
        background-color: #498ad4;
    }
}

@media screen and (min-width: 1008px) {
    .secondary-navigation ul ul a:hover,
    .secondary-navigation ul ul li.focus > a {
```

```

background-color: #498ad4;
}
}

button:active,
.button:active,
.contributor-posts-link:active,
input[type="button"]:active,
input[type="reset"]:active,
input[type="submit"]:active,
.widget input[type="button"]:active,
.widget input[type="reset"]:active,
.widget input[type="submit"]:active,
.content-sidebar .widget input[type="button"]:active,
.content-sidebar .widget input[type="reset"]:active,
.content-sidebar .widget input[type="submit"]:active,
.wp-block-file .wp-block-file__button:active,
.wp-block-button__link:active {
    background-color: #5d9ee8;
}

.site-navigation .current_page_item > a,
.site-navigation .current_page_ancestor > a,
.site-navigation .current-menu-item > a,
.site-navigation .current-menu-ancestor > a {
    color: #5d9ee8;
}

/* Higher contrast Accent Color against contrast color */
.site-navigation .current_page_item > a,
.site-navigation .current_page_ancestor > a,
.site-navigation .current-menu-item > a,
.site-navigation .current-menu-ancestor > a,
.site-navigation a:hover,
.featured-content a:hover,
.featured-content .entry-title a:hover,
.widget a:hover,
.widget-title a:hover,
.widget_twentyfourteen_ephemera .entry-meta a:hover,
.hentry .mejs-controls .mejs-button button:hover,
.widget .mejs-controls .mejs-button button:hover,
.site-info a:hover,
.featured-content a:hover {
    color: #64a5ef;
}

.hentry .mejs-controls .mejs-time-rail .mejs-time-current,
.widget .mejs-controls .mejs-time-rail .mejs-time-current,
.slider-control-paging a:hover:before,
.slider-control-paging .slider-active:before,
.slider-control-paging .slider-active:hover:before {
    background-color: #64a5ef;
}

</style> <style>@media screen and (min-width: 783px){.primary-navigation{float: left; margin-left: 20px;}a { transition: all .5s ease; }}</style>
<style>.site {margin: 0 auto; max-width: 1260px; width: 100%;}.site-header{max-width: 1260px; }

        @media screen and (min-width: 1110px) {.archive-header,.comments-area,a,.image-navigation,.page-header,.page-content,.post-navigation,.site-content .entry-header,
```

```
.site-content .entry-content,.site-content .entry-summary,.site-content footer.entry-meta{padding-left: 55px;}</style>
<style>
    .site-content .entry-header,.site-content .entry-content,.site-content .entry-summary,.site-content .entry-meta,.page-content
        {max-width: 600px;}.comments-area{max-width: 600px;}.post-navigation,
    .image-navigation{max-width: 600px;}</style>
<style>.content-area{padding-top: 30px;}.content-sidebar{padding-top: 30px;}
    @media screen and (min-width: 846px) {.content-area,.content-sidebar
{padding-top: 30px;}}</style>
<style>.hentry{max-width: 1260px;}
    img.size-full,img.size-large,.wp-post-image,.post-thumbnail img,.site-content .post-thumbnail img{max-height: 572px;}
</style>
<style>
    .slider .featured-content .hentry{max-height: 500px;}.slider .feature
d-content{max-width: 1600px;
    margin: 0px auto;}.slider .featured-content .post-thumbnail img{max-w
idth: 1600px;width: 100%;}
    .slider .featured-content .post-thumbnail{background:none;}.slider .f
eatured-content a.post-thumbnail:hover{background-color:transparent;}
</style>
<style>.featured-content{background:none;}</style>
<style>.featured-content{display:none; visibility: hidden;}</style>
<meta content="The annual inflation rate for the United States is 8.3% for the 12 mon
ths ended April 2022 after rising 8.5% previously, according to U.S. Labor Department
data published May 11. ..." name="description"/>
<style type="text/css">img#wpstats{display:none}</style>
<style id="twentyfourteen-header-css" type="text/css">
    .site-title,
    .site-description {
        clip: rect(1px 1px 1px 1px); /* IE7 */
        clip: rect(1px, 1px, 1px, 1px);
        position: absolute;
    }
</style>
<style id="custom-background-css">
body.custom-background { background-color: #f7f7f7; }
</style>
<link href="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-32x32.jpg" rel="icon" sizes="32x32"/>
<link href="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-192x192.jpg" rel="icon" sizes="192x192"/>
<link href="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-180x180.jpg" rel="apple-touch-icon"/>
<meta content="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-270x270.jpg" name="msapplication-TileImage"/>
<script async="" data-ad-client="ca-pub-6084777151829107" src="https://pagead2.google
syndication.com/pagead/js/adsbygoogle.js"></script>
</link></link></meta></head>
<body class="page-template-default page page-id-75 page-child parent-pageid-19 custom
-background wp-embed-responsive header-image singular">
<div class="hfeed site" id="page">
<div id="site-header">
<a href="https://www.usinflationcalculator.com/" rel="home">

</a>
</div>
<header class="site-header" id="masthead" role="banner">
```

```
<div class="header-main">
<h1 class="site-title"><a href="https://www.usinflationcalculator.com/" rel="home">US
Inflation Calculator</a></h1>
<div class="search-toggle">
<a class="screen-reader-text" href="#search-container">Search</a>
</div>
<nav class="site-navigation primary-navigation" id="primary-navigation" role="navigation">
<h1 class="menu-toggle">Primary Menu</h1>
<a class="screen-reader-text skip-link" href="#content">Skip to content</a>
<div class="menu-mainmen-container"><ul class="nav-menu" id="menu-mainmen"><li class
="menu-item menu-item-type-custom menu-item-object-custom menu-item-home menu-item-13
43" id="menu-item-1343"><a href="http://www.usinflationcalculator.com/">US Inflation
Home</a></li>
<li class="menu-item menu-item-type-custom menu-item-object-custom current-menu-ances
tor current-menu-parent menu-item-has-children menu-item-1344" id="menu-item-1344"><a
href="http://www.usinflationcalculator.com/inflation/">Inflation and Prices</a>
<ul class="sub-menu">
<li class="menu-item menu-item-type-post_type menu-item-object-page current-menu-item
page_item page-item-75 current_page_item menu-item-1349" id="menu-item-1349"><a aria-
current="page" href="https://www.usinflationcalculator.com/inflation/current-inflatio
n-rates/">Current US Inflation Rates: 2000-2022</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1348" i
d="menu-item-1348"><a href="https://www.usinflationcalculator.com/inflation/historica
l-inflation-rates/">Historical Inflation Rates: 1914-2022</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1352" i
d="menu-item-1352"><a href="https://www.usinflationcalculator.com/inflation/consumer-
price-index-and-annual-percent-changes-from-1913-to-2008/">Consumer Price Index Data
from 1913 to 2022</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1351" i
d="menu-item-1351"><a href="https://www.usinflationcalculator.com/inflation/consumer-
price-index-release-schedule/">Consumer Price Index - Release Schedule (2018-2022)</a
></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1353" i
d="menu-item-1353"><a href="https://www.usinflationcalculator.com/inflation/inflation
-vs-consumer-price-index-cpi-how-they-are-different/">Inflation vs. Consumer Price In
dex (CPI), How They Are Different</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15703"
id="menu-item-15703"><a href="https://www.usinflationcalculator.com/inflation/united-
states-core-inflation-rates/">Core Inflation Rates (1957-2022)</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-22750"
id="menu-item-22750"><a href="https://www.usinflationcalculator.com/inflation/average
-prices-for-selected-grocery-store-items-2015-present/">Grocery Store Food Prices (20
15-Present)</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-22769"
id="menu-item-22769"><a href="https://www.usinflationcalculator.com/inflation/energy-
prices-gasoline-electricity-and-fuel-oil-2015-present/">Energy Prices: Gasoline, Elec
tricity and Fuel Oil (2015-Present)</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1350" i
d="menu-item-1350"><a href="https://www.usinflationcalculator.com/inflation/annual-av
erages-for-rate-of-inflation/">Annual Averages for Rates of Inflation</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1739" i
d="menu-item-1739"><a href="https://www.usinflationcalculator.com/monthly-us-inflatio
n-rates-1913-present/">Monthly US Inflation Rates: 1913-Present</a></li>
</ul>
</li>
<li class="menu-item menu-item-type-custom menu-item-object-custom menu-item-has-chil
dren menu-item-15728" id="menu-item-15728"><a href="#">Energy, Food & Health Care
Inflation</a>
<ul class="sub-menu">
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<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15726" id="menu-item-15726"><a href="https://www.usinflationcalculator.com/inflation/gasoline-inflation-in-the-united-states/">Gasoline Inflation (1968-2022)</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15714" id="menu-item-15714"><a href="https://www.usinflationcalculator.com/inflation/food-inflation-in-the-united-states/">Food Inflation (1968-2022)</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-20964" id="menu-item-20964"><a href="https://www.usinflationcalculator.com/inflation/health-care-inflation-in-the-united-states/">Health Care Inflation in the United States (1948-2022)</a></li>
</ul>
</li>
<li class="menu-item menu-item-type-custom menu-item-object-custom menu-item-has-children menu-item-20992" id="menu-item-20992"><a href="#">Items Adjusted for Inflation</a>
<ul class="sub-menu">
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15779" id="menu-item-15779"><a href="https://www.usinflationcalculator.com/gasoline-prices-adjusted-for-inflation/">Gasoline Prices Adjusted for Inflation</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-20990" id="menu-item-20990"><a href="https://www.usinflationcalculator.com/inflation/electricity-prices-adjusted-for-inflation/">Electricity Prices By Year And Adjusted For Inflation</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-20977" id="menu-item-20977"><a href="https://www.usinflationcalculator.com/inflation/milk-prices-adjusted-for-inflation/">Milk Prices By Year And Adjusted For Inflation</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-21034" id="menu-item-21034"><a href="https://www.usinflationcalculator.com/inflation/coffee-prices-by-year-and-adjust-for-inflation/">Coffee Prices By Year And Adjusted For Inflation</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-21043" id="menu-item-21043"><a href="https://www.usinflationcalculator.com/inflation/bacon-prices-by-year-and-adjusted-for-inflation/">Bacon Prices By Year And Adjusted For Inflation</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-20997" id="menu-item-20997"><a href="https://www.usinflationcalculator.com/inflation/egg-prices-adjusted-for-inflation/">Egg Prices By Year And Adjusted For Inflation</a></li>
</ul>
</li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1345" id="menu-item-1345"><a href="https://www.usinflationcalculator.com/frequently-asked-questions-faqs/">Inflation FAQ's</a></li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1346" id="menu-item-1346"><a href="https://www.usinflationcalculator.com/about/">About</a></li>
</ul></div> </nav>
</div>
<div class="search-box-wrapper hide" id="search-container">
<div class="search-box">
<form action="https://www.usinflationcalculator.com/" class="search-form" method="get" role="search">
<label>
<span class="screen-reader-text">Search for:</span>
<input class="search-field" name="s" placeholder="Search ..." type="search" value="" />
</label>
<input class="search-submit" type="submit" value="Search"/>
</form> </div>
</div>
</header><!-- #masthead -->
<div class="site-main" id="main">
```

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<div class="main-content" id="main-content">
<div class="content-area" id="primary">
<div class="site-content" id="content" role="main">
<article class="post-75 page type-page status-publish hentry" id="post-75">
<header class="entry-header"><h1 class="entry-title">Current US Inflation Rates: 2000-2022</h1></header><!-- .entry-header -->
<div class="entry-content">
<p>The annual inflation rate for the United States is 8.3% for the 12 months ended April 2022 after rising 8.5% previously, according to U.S. Labor Department data published May 11. The next inflation update is scheduled for release on June 10 at 8:30 a.m. ET. It will offer the rate of inflation over the 12 months ended May 2022.</p>
<p>The chart and table below display <strong>annual US inflation rates</strong> for calendar years from 2000 and 2012 to 2022. (For prior years, see <a href="https://www.usinflationcalculator.com/inflation/historical-inflation-rates/" title="Historical US Inflation Rates">historical inflation rates</a>.) If you would like to calculate accumulated rates between two different dates, use the <a href="https://www.usinflationcalculator.com/" title="US Inflation Calculator">US Inflation Calculator</a>.</p>
<div style="margin-left:-50px"><iframe frameborder="0" height="450" scrolling="yes" seamless="" src="https://www.usinflationcalculator.com/charts/inflation/inflation-chart.html" width="580"></iframe></div>
<p>*The latest inflation data (12-month based) is always displayed in the chart's final column.</p>
<p><strong>Table: Annual Inflation Rates by Month and Year</strong></p>
<p>Since figures below are 12-month periods, look to the December column to find inflation rates by calendar year. For example, the rate of inflation in 2021 was 7.0%.</p>
<p>The last column, "Ave," shows the average inflation rate for each year <a href="https://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/" title="Consumer Price Index Data">using CPI data</a>, which was 4.7% in 2021. They are published by the BLS but are rarely discussed in news media, taking a back seat to a calendar year's actual rate of inflation.</p>
<div style="overflow-x:auto;">
<table cellpadding="0" cellspacing="0" width="110%">
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<td align="right" height="17"><strong>Year</strong></td>
<td align="right"><strong>Jan</strong></td>
<td align="right"><strong>Feb</strong></td>
<td align="right"><strong>Mar</strong></td>
<td align="right"><strong>Apr</strong></td>
<td align="right"><strong>May</strong></td>
<td align="right"><strong>Jun</strong></td>
<td align="right"><strong>Jul</strong></td>
<td align="right"><strong>Aug</strong></td>
<td align="right"><strong>Sep</strong></td>
<td align="right"><strong>Oct</strong></td>
<td align="right"><strong>Nov</strong></td>
<td align="right"><strong>Dec</strong></td>
<td align="right"><strong>Ave</strong></td>
</tr>
<tr>
<td align="right" height="17"><strong>2022</strong></td>
<td align="right">7.5</td>
<td align="right">7.9</td>
<td align="right">8.5</td>
<td align="right">8.3</td>
<td align="right"><em>Avail.<br/>June<br/>10</em></td>
<td align="right"></td>
<td align="right"></td>
```

```
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</tr>
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<td align="right">5.4</td>
<td align="right">5.4</td>
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<td align="right">6.8</td>
<td align="right">7.0</td>
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<td align="right">0.1</td>
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<td align="right">1.0</td>
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<td align="right">1.8</td>
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<td align="right">2.3</td>
<td align="right">1.8</td>
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```

```
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<td align="right">-1.4</td>
<td align="right">-2.1</td>
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<td align="right">4.9</td>
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<td align="right">2.7</td>
<td align="right">2.4</td>
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```
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<td align="right">2.8</td>
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```

```
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</table>
```

```
</div>
<p> </p>
<p><strong>Calculating Annual Inflation Rates</strong></p>
<p>Annual rates of inflation are calculated using 12-month selections of the <a href = "http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/" title="Consumer Price Index Data from 1913 to Present">Consumer Price Index</a> which is <a href="https://www.usinflationcalculator.com/inflation/consumer-price-index-release-schedule/" title="Consumer Price Index Release Schedule">published monthly</a> by the Labor Department's Bureau of Labor Statistics (<a href="http://www.bls.gov/cpi/" title="Bureau of Labor Statistics (BLS) - Consumer Price Index">BLS</a>). </p>
<p>For example, to calculate the inflation rate for January 2017, subtract the January 2016 CPI of "236.916" from the January 2017 CPI of "242.839." The result is "5.923." Divide this number by the January 2016 CPI and then multiply by 100 and add a % sign.</p>
<p>The result is January's annual inflation rate of 2.5%.</p>
<div class="sharedaddy sd-sharing-enabled"><div class="robots-nocontent sd-block sd-social sd-social-icon-text sd-sharing"><h3 class="sd-title">Share this:</h3><div class="sd-content"><ul><li class="share-facebook"><a class="share-facebook sd-button share-icon" data-shared="sharing-facebook-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?share=facebook" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on Facebook"><span>Facebook</span></a></li><li class="share-twitter"><a class="share-twitter sd-button share-icon" data-shared="sharing-twitter-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?share=twitter" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on Twitter"><span>Twitter</span></a></li><li class="share-reddit"><a class="share-reddit sd-button share-icon" data-shared="" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?share=reddit" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on Reddit"><span>Reddit</span></a></li><li><a class="sharing-anchor sd-button share-more" href="#"><span>More</span></a></li><li class="share-end"></li></ul><div class="sharing-hidden"><div class="inner" style="display: none;"><ul><li class="share-print"><a class="share-print sd-button share-icon" data-shared="" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/#print" rel="nofollow noopener noreferrer" target="_blank" title="Click to print"><span>Print</span></a></li><li class="share-email"><a class="share-email sd-button share-icon" data-shared="" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?share=email" rel="nofollow noopener noreferrer" target="_blank" title="Click to email this to a friend"><span>Email</span></a></li><li class="share-end"></li><li class="share-end"></li></ul></div></div></div></div><!-- .entry-content -->
</article><!-- #post-75 -->
</div><!-- #content -->
</div><!-- #primary -->
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    border-bottom-width: 1px;
    border-left-width: 1px;
    border-top-style: solid;
    border-right-style: solid;
    border-bottom-style: solid;
    border-left-style: solid;
}
.style1 {font-size: xx-small}
-->
</style>
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```
<div align="center">
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enter" style="margin-bottom:2px; border-bottom:none"><a href="https://www.usinflation
calculator.com/" title="US Inflation Calculator">Try Inflation Calculator!</a></h3>
<p ;="" align="center" style="margin-bottom:2px; border-bottom:none"> </p></td></tr>
</table>
</div></div>
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er-bottom-style: solid; border-left-style: solid; } hr { border-top:1px dotted #000;
width:85%; align="center"; margin-bottom:7px; margin-top:7px; /*Rest of stuff here*/
} .style1 {font-size: xx-small} --><br /></style>
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tor.com/inflation/current-inflation-rates/" title="Current US Inflation Rates">Inflat
ion Rate</a> <u>8.3%</u></h3>
</td>
</tr>
<tr>
<td>
<hr/>
</td>
</tr>
<tr>
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<hr/>
</td>
</tr>
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<h3 align="center" style="margin-bottom: 0px; margin-top: 0px; padding-top: 2px;">Con
sumer Price Index (CPI) 289.109</h3>
</td>
</tr>
<tr>
<td>
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</td>
</tr>
<tr>
<td>
<p align="center" class="style1">Released on May 11 for April 2022.<br/>
<a href="http://www.usinflationcalculator.com/inflation/consumer-price-index-release-
schedule/" title="Consumer Price Index Release Schedule">Next release</a> on June 10
for May 2022.</p>
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</table>
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!-- USInflationCalc300x600 -->
<ins class="adsbygoogle" data-ad-client="ca-pub-0374335159561115" data-ad-format="aut
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<script>
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```
(adsbygoogle = window.adsbygoogle || []).push({});</script></div></div></aside><aside class="widget widget_recent_entries" id="recent-posts-2"><h1 class="widget-title">US Inflation Reports (Monthly CPI)</h1><nav aria-label="US Inflation Reports (Monthly CPI)"><ul><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-remains-near-40-year-highs-as-april-cpi-tops-expectations/100022650/">U.S. Inflation Remains Near 40-Year Highs as April CPI Tops Expectations</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-highest-since-1981-as-cpi-hits-8-5-in-march/100022605/">U.S. Inflation Highest Since 1981 as CPI Hits 8.5% in March</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-at-7-9-highest-since-1982-as-prices-surge-for-gas-food-and-shelter/100022175/">U.S. Inflation at 7.9% Highest Since 1982 as Prices Surge for Gas, Food and Shelter</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-rate-at-7-5-hits-40-year-high/100021757/">U.S. Inflation Rate at 7.5% Hits 40-Year High</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-rises-7-in-2021-marking-highest-rate-since-1982/100021708/">U.S. Inflation Rises 7% in 2021, Marking Highest Rate Since 1982</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-rate-of-inflation-soars-to-39-year-high-as-consumer-prices-jump-in-november/100021666/">U.S. Rate of Inflation Soars to 39-Year High as Consumer Prices Jump in November</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-rate-of-inflation-highest-since-1990/100021620/">U.S. Rate of Inflation Highest Since 1990</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-resumes-quicker-pace-in-september/100021573/">U.S. Inflation Resumes Quicker Pace in September</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-cools-slightly-consumer-price-gains-ease-in-august/100021451/">Annual U.S. Inflation Cools Slightly; Consumer Price Gains Ease in August</a></li><li><a href="https://www.usinflationcalculator.com/inflation/u-s-consumer-price-gains-slow-in-july-annual-inflation-remains-near-13-year-high/100021394/">U.S. Consumer Price Gains Slow in July; Annual Inflation Remains Near 13-Year High</a></li><li><a href="https://www.usinflationcalculator.com/inflation/annual-inflation-and-consumer-prices-in-june-rise-most-since-2008/100021352/">Annual Inflation and Consumer Prices in June Rise Most Since 2008</a></li><li>
```

```
<a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-hottest-annual  
ly-since-august-2008-consumer-prices-in-may-rise-strongly/100021287/">U.S. Inflation  
Hottest Annually Since August 2008; Consumer Prices in May Rise Strongly</a>  
</li>  
<li>  
<a href="https://www.usinflationcalculator.com/inflation/inflation-marks-quickest-pac  
e-since-2008-consumer-prices-surge-in-april/100021243/">Inflation Marks Quickest Pace  
Since 2008; Consumer Prices Surge in April</a>  
</li>  
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s://www.usinflationcalculator.com/" class="search-form" method="get" role="search">  
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<span class="screen-reader-text">Search for:</span>  
<input class="search-field" name="s" placeholder="Search ..." type="search" value="" />  
</label>  
<input class="search-submit" type="submit" value="Search"/>  
</form></aside><aside class="widget widget_top-posts" id="top-posts-2"><h1 class="wid  
get-title">Popular US Inflation Pages</h1><ul><li><a aria-current="page" class="bump  
-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/inflation/curre  
nt-inflation-rates/">Current US Inflation Rates: 2000-2022</a></li><li><a class="bump  
-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/inflation/hist  
orical-inflation-rates/">Historical Inflation Rates: 1914-2022</a></li><li><a class  
="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/gasoline  
-prices-adjusted-for-inflation/">Gasoline Prices Adjusted for Inflation</a></li><li>  
<a class="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/i  
nflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/">Consumer  
Price Index Data from 1913 to 2022</a></li><li><a class="bump-view" data-bump-view="t  
p" href="https://www.usinflationcalculator.com/inflation/consumer-price-index-release  
-schedule/">Consumer Price Index - Release Schedule (2021-2022)</a></li></ul></aside>  
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</aside><aside class="widget widget_block" id="block-5"><p><strong>**NEW**</strong></p>  
<ul>  
<li><a href="https://www.usinflationcalculator.com/inflation/inflation-in-the-los-ang  
eles-long-beach-anaheim-metropolitan-area/" title="Inflation in the Los Angeles-Long  
Beach-Anaheim Metropolitan Area">Los Angeles Area Inflation Data and Calculator</a>  
</li><br/>  
<li><a href="https://www.usinflationcalculator.com/inflation/inflation-in-new-york-ne  
wark-and-jersey-city-metropolitan-area/" title="Inflation in New York, Newark and Jer  
sey City Metropolitan Area">New York-Newark-Jersey City Area Inflation Data and Calcu  
lator</a></li>  
</ul></aside></div><!-- #content-sidebar -->  
</div><!-- #main-content -->  
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us" src="https://pagead2.googlesyndication.com/pagead/js/adsbygoogle.js?client=ca-pub  
-0374335159561115"></script>  
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72341" style="display:inline-block;width:160px;height:600px"></ins>  
<script>  
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</script></aside><aside class="widget widget_block" id="block-4"><p><strong>RESOURCE  
LINKS</strong></p>  
<ul>  
<li><a href="http://www.bls.gov/cpi/" title="http://www.bls.gov/cpi/">Bureau of Labor  
Statistics</a></li>
```

```

<li><a href="https://percentcalculators.com/" title="Percentage Calculators">Percent Calculators</a></li>
<li><a href="https://www.federalreserve.gov/monetarypolicy.htm" title="Federal Reserve Monetary Policy">Reserve Monetary Policy</a></li>
</ul></aside><aside class="widget widget_block" id="block-3"><script async="" crossorigin="anonymous" src="https://pagead2.googlesyndication.com/pagead/js/adsbygoogle.js?client=ca-pub-0374335159561115"></script>
<!-- USInflat2 -->
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<script>
    (adsbygoogle = window.adsbygoogle || []).push({});
</script></aside> </div><!-- #primary-sidebar -->
</div><!-- #secondary -->
</div><!-- #main -->
<footer class="site-footer" id="colophon" role="contentinfo">
<div class="site-info">
<p align="center">US <a href="http://www.usinflationcalculator.com/" title="Inflation Calculator">INFLATION CALCULATOR</a> · COPYRIGHT © 2008-2022 COINNEWS MEDIA GROUP LLC (<a href="http://www.coinnews.net/" title="Coin News">COIN NEWS</a>) · ALL RIGHTS RESERVED</p>
<p> </p>
</div><!-- .site-info -->
</footer><!-- #colophon -->
</div><!-- #page -->
<script type="text/javascript">
    window.WPCOM_sharing_counts = {"https:\/\/www.usinflationcalculator.com\/inflation\/current-inflation-rates\/":75};
</script>
<div id="sharing_email" style="display: none;">
<form action="/inflation/current-inflation-rates/" method="post">
<label for="target_email">Send to Email Address</label>
<input id="target_email" name="target_email" type="email" value="" />
<label for="source_name">Your Name</label>
<input id="source_name" name="source_name" type="text" value="" />
<label for="source_email">Your Email Address</label>
<input id="source_email" name="source_email" type="email" value="" />
<input autocomplete="off" class="input" id="jetpack-source_f_name" name="source_f_name" size="25" title="This field is for validation and should not be changed" type="text" value="" />

<input class="sharing_send" type="submit" value="Send Email"/>
<a class="sharing_cancel" href="#cancel" rel="nofollow" role="button">Cancel</a>
<div class="errors errors-1" style="display: none;">
    Post was not sent - check your email addresses!
</div>
<div class="errors errors-2" style="display: none;">
    Email check failed, please try again
</div>
<div class="errors errors-3" style="display: none;">
    Sorry, your blog cannot share posts by email.
</div>
</img></form>
</div>
<script id="twentyfourteen-script-js" src="https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen/js/functions.js?ver=20171218"></script>
<script id="sharing-js-js-extra">
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</script>
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<script id="sharing-js-js-after">
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    ( function () {
        function matches( el, sel ) {
            return !! (
                el.matches && el.matches( sel ) ||
                el.msMatchesSelector && el.msMatchesSelector( sel )
            );
        }
        document.body.addEventListener( 'click', function ( event ) {
            if ( ! event.target ) {
                return;
            }
            var el;
            if ( matches( event.target, 'a.share-facebook' ) ) {
                el = event.target;
            } else if ( event.target.parentNode && matches( event.target.parentNode, 'a.share-facebook' ) ) {
                el = event.target.parentNode;
            }
            if ( el ) {
                event.preventDefault();
                // If there's another sharing window open, close it.
                if ( typeof windowOpen !== 'undefined' )
                    windowOpen.close();
                windowOpen = window.open( el.getAttribute( 'href' ), 'wpcomfacebook', 'menubar=1,resizable=1,width=600,height=400' );
                return false;
            }
        } );
    } )();
var windowOpen;
    ( function () {
        function matches( el, sel ) {
            return !! (
                el.matches && el.matches( sel ) ||
                el.msMatchesSelector && el.msMatchesSelector( sel )
            );
        }
        document.body.addEventListener( 'click', function ( event ) {
            if ( ! event.target ) {
                return;
            }
        }
    )
}

```

```
        index

        var el;
        if ( matches( event.target, 'a.share-twitter' )
) ) {
            el = event.target;
        } else if ( event.target.parentNode && matches(
event.target.parentNode, 'a.share-twitter' ) ) {
            el = event.target.parentNode;
        }

        if ( el ) {
            event.preventDefault();

            // If there's another sharing window
            open, close it.

            if ( typeof windowOpen !== 'undefined'
d' ) {
                windowOpen.close();
            }
            windowOpen = window.open( el.getAttribute(
'href' ), 'wpcomtwitter', 'menubar=1,resizable=1,width=600,height=350' );
            return false;
        }
    } );
} )();
</script>
<script defer="" src="https://stats.wp.com/e-202222.js"></script>
<script>
    _stq = window._stq || [];
    _stq.push([ 'view', {v:'ext',j:'1:10.9',blog:'5955919',post:'75',tz:'-4',sr
v:'www.usinflationcalculator.com'} ]);
    _stq.push([ 'clickTrackerInit', '5955919', '75' ]);
</script>
</body>
</html>
```

```
In [ ]: #using prettify() method to turn a Beautiful Soup parse tree into a nicely formatted L  
#with a separate line for each tag and each string:  
print(soup.prettify())
```

```
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<!--[if IE 7]>
<html class="ie ie7" dir="ltr" lang="en-US"
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<![endif]-->
<!--[if IE 8]>
<html class="ie ie8" dir="ltr" lang="en-US"
      prefix="og: https://ogp.me/ns#" >
<![endif]-->
<!--[if !(IE 7) | !(IE 8) ]><!-->
<html dir="ltr" lang="en-US" prefix="og: https://ogp.me/ns#">
<!--<![endif]-->
<head>
    <!-- Global site tag (gtag.js) - Google Analytics -->
    <script async="" src="https://www.googletagmanager.com/gtag/js?id=UA-2181571-7">
    </script>
    <script>
        window.dataLayer = window.dataLayer || [];
        function gtag(){dataLayer.push(arguments);}
        gtag('js', new Date());

        gtag('config', 'UA-2181571-7');
    </script>
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        Current US Inflation Rates: 2000-2022 | US Inflation Calculator
    </title>
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<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/_inc/genericons/genericons/genericons.css?ver=3.1" id="genericons-css" media="all" rel="stylesheet"/>
<link href="https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen-child/style.css?ver=20190507" id="twentyfourteen-style-css" media="all" rel="stylesheet"/>
<link href="https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen/css(blocks.css?ver=20190102" id="twentyfourteen-block-style-css" media="all" rel="stylesheet"/>
<!--[if lt IE 9]>
<link rel='stylesheet' id='twentyfourteen-ie-css' href='https://www.usinflationcalculator.com/wp-content/themes/twentyfourteen/css/ie.css?ver=20140701' media='all' />
<![endif]-->
<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/_inc/social-logos/social-logos.min.css?ver=10.9" id="social-logos-css" media="all" rel="stylesheet"/>
<link href="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/css/jetpack.css?ver=10.9" id="jetpack_css-css" media="all" rel="stylesheet"/>
<script id="jquery-core-js" src="https://www.usinflationcalculator.com/wp-includes/js/jquery/jquery.min.js?ver=3.6.0">
</script>
<script id="jquery-migrate-js" src="https://www.usinflationcalculator.com/wp-includes/js/jquery/jquery-migrate.min.js?ver=3.3.2">
</script>
<link href="https://www.usinflationcalculator.com/wp-json/" rel="https://api.wordpress.org/"/>
<link href="https://www.usinflationcalculator.com/wp-json/wp/v2/pages/75" rel="alternate" type="application/json"/>
<link href="https://www.usinflationcalculator.com/xmlrpc.php?rsd" rel="EditURI" title="RSID" type="application/rsd+xml"/>
<link href="https://www.usinflationcalculator.com/wp-includes/wlwmanifest.xml" rel="wlwmanifest" type="application/wlwmanifest+xml"/>
<link href="https://wp.me/PoZpd-1d" rel="shortlink"/>
<link href="https://www.usinflationcalculator.com/wp-json/oembed/1.0/embed?url=https%3A%2F%2Fwww.usinflationcalculator.com%2Finflation%2Fcurrent-inflation-rates%2F" rel="alternate" type="application/json+oembed"/>
<link href="https://www.usinflationcalculator.com/wp-json/oembed/1.0/embed?url=https%3A%2F%2Fwww.usinflationcalculator.com%2Finflation%2Fcurrent-inflation-rates%2F&format=xml" rel="alternate" type="text/xml+oembed"/>
<style id="fourteen-colors" type="text/css">
/* Custom Contrast Color */

```

```
.site:before,  
#secondary,  
.site-header,  
.site-footer,  
.menu-toggle,  
.featured-content,  
.featured-content .entry-header,  
.slider-direction-nav a,  
.ie8 .featured-content,  
.ie8 .site:before,  
.has-black-background-color {  
    background-color: #1a4e88;  
}  
  
.has-black-color {  
    color: #1a4e88;  
}  
  
.grid .featured-content .entry-header,  
.ie8 .grid .featured-content .entry-header {  
    border-color: #1a4e88;  
}  
  
.slider-control-paging a:before {  
    background-color: rgba(255,255,255,.33);  
}  
  
.hentry .mejs-mediaelement,  
.widget .mejs-mediaelement,  
.hentry .mejs-container .mejs-controls,  
.widget .mejs-container .mejs-controls {  
    background: #1a4e88;  
}  
  
/* Player controls need separation from the contrast background */  
.primary-sidebar .mejs-controls,  
.site-footer .mejs-controls {  
    border: 1px solid;  
}  
  
e:before {  
    background: #1a4e88;  
}  
  
.content-sidebar .widget_twentyfourteen_ephemera .widget-title,  
.paging-navigation,  
.content-sidebar .widget .widget-title {  
    border-top-color: #1a4e88;  
}  
  
.content-sidebar .widget .widget-title,  
.content-sidebar .widget .widget-title a,  
.paging-navigation,  
.paging-navigation a:hover,  
.paging-navigation a {  
    color: #1a4e88;  
}  
  
/* Override the site title color option with an over-qualified selector, as the option is hidden. */
```

```
h1.site-title a {
    color: #fff;
}

.menu-toggle:active,
.menu-toggle:focus,
.menu-toggle:hover {
    background-color: #5e92cc;
}
/* Custom accent color. */
button,
.button,
.contributor-posts-link,
input[type="button"],
input[type="reset"],
input[type="submit"],
.search-toggle,
.hentry .mejs-controls .mejs-time-rail .mejs-time-current,
.widget .mejs-controls .mejs-time-rail .mejs-time-current,
.hentry .mejs-overlay:hover .mejs-overlay-button,
.widget .mejs-overlay:hover .mejs-overlay-button,
.widget button,
.widget .button,
.widget input[type="button"],
.widget input[type="reset"],
.widget input[type="submit"],
.widget_calendar tbody a,
.content-sidebar .widget input[type="button"],
.content-sidebar .widget input[type="reset"],
.content-sidebar .widget input[type="submit"],
.slider-control-paging .slider-active:before,
.slider-control-paging .slider-active:hover:before,
.slider-direction-nav a:hover,
.ie8 .primary-navigation ul ul,
.ie8 .secondary-navigation ul ul,
.ie8 .primary-navigation li:hover > a,
.ie8 .primary-navigation li.focus > a,
.ie8 .secondary-navigation li:hover > a,
.ie8 .secondary-navigation li.focus > a,
.wp-block-file .wp-block-file__button,
.wp-block-button__link,
.has-green-background-color {
    background-color: #2c6db7;
}

.site-navigation a:hover,
.is-style-outline .wp-block-button__link:not(.has-text-color),
.has-green-color {
    color: #2c6db7;
}

::-moz-selection {
    background: #2c6db7;
}

::selection {
    background: #2c6db7;
}

.paging-navigation .page-numbers.current {
```

```
border-color: #2c6db7;
}

@media screen and (min-width: 782px) {
    .primary-navigation li:hover > a,
    .primary-navigation li.focus > a,
    .primary-navigation ul ul {
        background-color: #2c6db7;
    }
}

@media screen and (min-width: 1008px) {
    .secondary-navigation li:hover > a,
    .secondary-navigation li.focus > a,
    .secondary-navigation ul ul {
        background-color: #2c6db7;
    }
}

.contributor-posts-link,
button,
.button,
input[type="button"],
input[type="reset"],
input[type="submit"],
.search-toggle:before,
.hentry .mejs-overlay:hover .mejs-overlay-button,
.widget .mejs-overlay:hover .mejs-overlay-button,
.widget button,
.widget .button,
.widget input[type="button"],
.widget input[type="reset"],
.widget input[type="submit"],
.widget_calendar tbody a,
.widget_calendar tbody a:hover,
.site-footer .widget_calendar tbody a,
.content-sidebar .widget input[type="button"],
.content-sidebar .widget input[type="reset"],
.content-sidebar .widget input[type="submit"],
button:hover,
button:focus,
.button:hover,
.button:focus,
.widget a.button:hover,
.widget a.button:focus,
.widget a.button:active,
.content-sidebar .widget a.button,
.content-sidebar .widget a.button:hover,
.content-sidebar .widget a.button:focus,
.content-sidebar .widget a.button:active,
.contributor-posts-link:hover,
.contributor-posts-link:active,
input[type="button"]:hover,
input[type="button"]:focus,
input[type="reset"]:hover,
input[type="reset"]:focus,
input[type="submit"]:hover,
input[type="submit"]:focus,
.slider-direction-nav a:hover:before {
    color: #fff;
```

```
}

@media screen and (min-width: 782px) {
    .primary-navigation ul ul a,
    .primary-navigation li:hover > a,
    .primary-navigation li.focus > a,
    .primary-navigation ul ul {
        color: #fff;
    }
}

@media screen and (min-width: 1008px) {
    .secondary-navigation ul ul a,
    .secondary-navigation li:hover > a,
    .secondary-navigation li.focus > a,
    .secondary-navigation ul ul {
        color: #fff;
    }
}

/* Generated variants of custom accent color. */
a,
.content-sidebar .widget a {
    color: #2c6db7;
}

.contributor-posts-link:hover,
.button:hover,
.button:focus,
.slider-control-paging a:hover:before,
.search-toggle:hover,
.search-toggle.active,
.search-box,
.widget_calendar tbody a:hover,
button:hover,
button:focus,
input[type="button"]:hover,
input[type="button"]:focus,
input[type="reset"]:hover,
input[type="reset"]:focus,
input[type="submit"]:hover,
input[type="submit"]:focus,
.widget button:hover,
.widget .button:hover,
.widget button:focus,
.widget .button:focus,
.widget input[type="button"]:hover,
.widget input[type="button"]:focus,
.widget input[type="reset"]:hover,
.widget input[type="reset"]:focus,
.widget input[type="submit"]:hover,
.widget input[type="submit"]:focus,
.content-sidebar .widget input[type="button"]:hover,
.content-sidebar .widget input[type="button"]:focus,
.content-sidebar .widget input[type="reset"]:hover,
.content-sidebar .widget input[type="reset"]:focus,
.content-sidebar .widget input[type="submit"]:hover,
.content-sidebar .widget input[type="submit"]:focus,
.ie8 .primary-navigation ul ul a:hover,
.ie8 .primary-navigation ul ul li.focus > a,
```

```
.ie8 .secondary-navigation ul ul a:hover,  
.ie8 .secondary-navigation ul ul li.focus > a,  
.wp-block-file .wp-block-file__button:hover,  
.wp-block-file .wp-block-file__button:focus,  
.wp-block-button__link:not(.has-text-color):hover,  
.wp-block-button__link:not(.has-text-color):focus,  
.is-style-outline .wp-block-button__link:not(.has-text-color):hover,  
.is-style-outline .wp-block-button__link:not(.has-text-color):focus {  
    background-color: #498ad4;  
}  
  
.featured-content a:hover,  
.featured-content .entry-title a:hover,  
.widget a:hover,  
.widget-title a:hover,  
.widget_twentyfourteen_ephemera .entry-meta a:hover,  
.hentry .mejs-controls .mejs-button button:hover,  
.widget .mejs-controls .mejs-button button:hover,  
.site-info a:hover,  
.featured-content a:hover,  
.wp-block-latest-comments_comment-meta a:hover,  
.wp-block-latest-comments_comment-meta a:focus {  
    color: #498ad4;  
}  
  
a:active,  
a:hover,  
.entry-title a:hover,  
.entry-meta a:hover,  
.cat-links a:hover,  
.entry-content .edit-link a:hover,  
.post-navigation a:hover,  
.image-navigation a:hover,  
.comment-author a:hover,  
.comment-list .pingback a:hover,  
.comment-list .trackback a:hover,  
.comment-metadata a:hover,  
.comment-reply-title small a:hover,  
.content-sidebar .widget a:hover,  
.content-sidebar .widget .widget-title a:hover,  
.content-sidebar .widget_twentyfourteen_ephemera .entry-meta a:hover  
{  
    color: #498ad4;  
}  
  
.page-links a:hover,  
.paging-navigation a:hover {  
    border-color: #498ad4;  
}  
  
.entry-meta .tag-links a:hover:before {  
    border-right-color: #498ad4;  
}  
  
.page-links a:hover,  
.entry-meta .tag-links a:hover {  
    background-color: #498ad4;  
}  
  
@media screen and (min-width: 782px) {
```

```
.primary-navigation ul ul a:hover,  
.primary-navigation ul ul li.focus > a {  
    background-color: #498ad4;  
}  
}  
  
@media screen and (min-width: 1008px) {  
    .secondary-navigation ul ul a:hover,  
    .secondary-navigation ul ul li.focus > a {  
        background-color: #498ad4;  
}  
}  
  
button:active,  
.button:active,  
.contributor-posts-link:active,  
input[type="button"]:active,  
input[type="reset"]:active,  
input[type="submit"]:active,  
.widget input[type="button"]:active,  
.widget input[type="reset"]:active,  
.widget input[type="submit"]:active,  
.content-sidebar .widget input[type="button"]:active,  
.content-sidebar .widget input[type="reset"]:active,  
.content-sidebar .widget input[type="submit"]:active,  
.wp-block-file .wp-block-file__button:active,  
.wp-block-button__link:active {  
    background-color: #5d9ee8;  
}  
  
.site-navigation .current_page_item > a,  
.site-navigation .current_page_ancestor > a,  
.site-navigation .current-menu-item > a,  
.site-navigation .current-menu-ancestor > a {  
    color: #5d9ee8;  
}  
  
/* Higher contrast Accent Color against contrast color */  
.site-navigation .current_page_item > a,  
.site-navigation .current_page_ancestor > a,  
.site-navigation .current-menu-item > a,  
.site-navigation .current-menu-ancestor > a,  
.site-navigation a:hover,  
.featured-content a:hover,  
.featured-content .entry-title a:hover,  
.widget a:hover,  
.widget-title a:hover,  
.widget_twentyfourteen_ephemera .entry-meta a:hover,  
.hentry .mejs-controls .mejs-button button:hover,  
.widget .mejs-controls .mejs-button button:hover,  
.site-info a:hover,  
.featured-content a:hover {  
    color: #64a5ef;  
}  
  
.hentry .mejs-controls .mejs-time-rail .mejs-time-current,  
.widget .mejs-controls .mejs-time-rail .mejs-time-current,  
.slider-control-paging a:hover:before,  
.slider-control-paging .slider-active:before,  
.slider-control-paging .slider-active:hover:before {
```

```
background-color: #64a5ef;
}
</style>
<style>
    @media screen and (min-width: 783px){.primary-navigation{float: left; margin-left: 20px;}a { transition: all .5s ease; }}
    </style>
    <style>
        .site {margin: 0 auto; max-width: 1260px; width: 100%;}.site-header{max-width: 1260px;}
            @media screen and (min-width: 1110px) {.archive-header,.comments-area,.image-navigation,.page-header,.page-content,.post-navigation,.site-content .entry-header,.site-content .entry-content,.site-content .entry-summary,.site-content footer.entry-meta{padding-left: 55px;}}
            </style>
            <style>
                .site-content .entry-header,.site-content .entry-content,.site-content .entry-summary,.site-content .entry-meta,.page-content
                    {max-width: 600px;}.comments-area{max-width: 600px;}.post-navigation,.image-navigation{max-width: 600px;}
                </style>
                <style>
                    .content-area{padding-top: 30px;}.content-sidebar{padding-top: 30px;}
                    @media screen and (min-width: 846px) {.content-area,.content-sidebar
{padding-top: 30px;}}
                </style>
                <style>
                    .hentry{max-width: 1260px;}
                    img.size-full,img.size-large,.wp-post-image,.post-thumbnail img,.site-content .post-thumbnail img{max-height: 572px;}
                </style>
                <style>
                    .slider .featured-content .hentry{max-height: 500px;}.slider .featured-content
{max-width: 1600px;
margin: 0px auto;}.slider .featured-content .post-thumbnail img{max-width: 1600px; width: 100%;}
                    .slider .featured-content .post-thumbnail{background:none;}.slider .featured-content a.post-thumbnail:hover{background-color:transparent;}
                </style>
                <style>
                    .featured-content{background:none; }
                </style>
                <style>
                    .featured-content{display:none; visibility: hidden; }
                </style>
<meta content="The annual inflation rate for the United States is 8.3% for the 12 months ended April 2022 after rising 8.5% previously, according to U.S. Labor Department data published May 11. ..." name="description"/>
<style type="text/css">
    img#wpstats{display:none}
</style>
<style id="twentyfourteen-header-css" type="text/css">
    .site-title,
        .site-description {
            clip: rect(1px 1px 1px 1px); /* IE7 */
            clip: rect(1px, 1px, 1px, 1px);
            position: absolute;
        }
</style>
```

```
<style id="custom-background-css">
    body.custom-background { background-color: #f7f7f7; }
</style>
<link href="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-32x32.jpg" rel="icon" sizes="32x32"/>
<link href="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-192x192.jpg" rel="icon" sizes="192x192"/>
<link href="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-180x180.jpg" rel="apple-touch-icon"/>
<meta content="https://www.usinflationcalculator.com/wp-content/uploads/2021/12/cropped-usinflation-fav-270x270.jpg" name="msapplication-TileImage"/>
<script async="" data-ad-client="ca-pub-6084777151829107" src="https://pagead2.googlesyndication.com/pagead/js/adsbygoogle.js">
</script>
</link>
</link>
</meta>
</meta>
</head>
<body class="page-template-default page page-id-75 page-child parent-pageid-19 custom-background wp-embed-responsive header-image singular">
<div class="hfeed site" id="page">
<div id="site-header">
<a href="https://www.usinflationcalculator.com/" rel="home">

</a>
</div>
<header class="site-header" id="masthead" role="banner">
<div class="header-main">
<h1 class="site-title">
<a href="https://www.usinflationcalculator.com/" rel="home">
    US Inflation Calculator
</a>
</h1>
<div class="search-toggle">
<a class="screen-reader-text" href="#search-container">
    Search
</a>
</div>
<nav class="site-navigation primary-navigation" id="primary-navigation" role="navigation">
<h1 class="menu-toggle">
    Primary Menu
</h1>
<a class="screen-reader-text skip-link" href="#content">
    Skip to content
</a>
<div class="menu-mainmen-container">
<ul class="nav-menu" id="menu-mainmen">
<li class="menu-item menu-item-type-custom menu-item-object-custom menu-item-home menu-item-1343" id="menu-item-1343">
<a href="http://www.usinflationcalculator.com/">
    US Inflation Home
</a>
</li>
<li class="menu-item menu-item-type-custom menu-item-object-custom current-menu-ancestor current-menu-parent menu-item-has-children menu-item-1344" id="menu-item-1344">
<a href="http://www.usinflationcalculator.com/inflation/">
```

```
Inflation and Prices
</a>
<ul class="sub-menu">
    <li class="menu-item menu-item-type-post_type menu-item-object-page current-menu-item page_item page-item-75 current_page_item menu-item-1349" id="menu-item-1349">
        <a aria-current="page" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/">
            Current US Inflation Rates: 2000-2022
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1348" id="menu-item-1348">
        <a href="https://www.usinflationcalculator.com/inflation/historical-inflation-rates/">
            Historical Inflation Rates: 1914-2022
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1352" id="menu-item-1352">
        <a href="https://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/">
            Consumer Price Index Data from 1913 to 2022
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1351" id="menu-item-1351">
        <a href="https://www.usinflationcalculator.com/inflation/consumer-price-index-release-schedule/">
            Consumer Price Index - Release Schedule (2018-2022)
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1353" id="menu-item-1353">
        <a href="https://www.usinflationcalculator.com/inflation/inflation-vs-consumer-price-index-cpi-how-they-are-different/">
            Inflation vs. Consumer Price Index (CPI), How They Are Different
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15703" id="menu-item-15703">
        <a href="https://www.usinflationcalculator.com/inflation/united-states-core-inflation-rates/">
            Core Inflation Rates (1957-2022)
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-22750" id="menu-item-22750">
        <a href="https://www.usinflationcalculator.com/inflation/average-prices-for-selected-grocery-store-items-2015-present/">
            Grocery Store Food Prices (2015-Present)
        </a>
    </li>
    <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-22769" id="menu-item-22769">
        <a href="https://www.usinflationcalculator.com/inflation/energy-prices-gasoline-electricity-and-fuel-oil-2015-present/">
            Energy Prices: Gasoline, Electricity and Fuel Oil (2015-Present)
        </a>
    </li>
```

```
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1350" id="menu-item-1350">
    <a href="https://www.usinflationcalculator.com/inflation/annual-averages-for-rate-of-inflation/">
        Annual Averages for Rates of Inflation
    </a>
</li>
<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1739" id="menu-item-1739">
    <a href="https://www.usinflationcalculator.com/monthly-us-inflation-rates-1913-present/">
        Monthly US Inflation Rates: 1913-Present
    </a>
</li>
</ul>
</li>
<li class="menu-item menu-item-type-custom menu-item-object-custom menu-item-has-children menu-item-15728" id="menu-item-15728">
    <a href="#">
        Energy, Food & Health Care Inflation
    </a>
    <ul class="sub-menu">
        <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15726" id="menu-item-15726">
            <a href="https://www.usinflationcalculator.com/inflation/gasoline-inflation-in-the-united-states/">
                Gasoline Inflation (1968-2022)
            </a>
        </li>
        <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15714" id="menu-item-15714">
            <a href="https://www.usinflationcalculator.com/inflation/food-inflation-in-the-united-states/">
                Food Inflation (1968-2022)
            </a>
        </li>
        <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-20964" id="menu-item-20964">
            <a href="https://www.usinflationcalculator.com/inflation/health-care-inflation-in-the-united-states/">
                Health Care Inflation in the United States (1948-2022)
            </a>
        </li>
    </ul>
</li>
<li class="menu-item menu-item-type-custom menu-item-object-custom menu-item-has-children menu-item-20992" id="menu-item-20992">
    <a href="#">
        Items Adjusted for Inflation
    </a>
    <ul class="sub-menu">
        <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-15779" id="menu-item-15779">
            <a href="https://www.usinflationcalculator.com/gasoline-prices-adjusted-for-inflation/">
                Gasoline Prices Adjusted for Inflation
            </a>
        </li>
        <li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-20990" id="menu-item-20990">
```

```
<a href="https://www.usinflationcalculator.com/inflation/electricity-price  
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    Electricity Prices By Year And Adjusted For Inflation  
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    <a href="https://www.usinflationcalculator.com/inflation/milk-prices-adjusted-for-inflation/">  
        Milk Prices By Year And Adjusted For Inflation  
</a>  
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<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-21034" id="menu-item-21034">  
    <a href="https://www.usinflationcalculator.com/inflation/coffee-prices-by-year-and-adjust-for-inflation/">  
        Coffee Prices By Year And Adjusted For Inflation  
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    <a href="https://www.usinflationcalculator.com/inflation/bacon-prices-by-year-and-adjusted-for-inflation/">  
        Bacon Prices By Year And Adjusted For Inflation  
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        Egg Prices By Year And Adjusted For Inflation  
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<li class="menu-item menu-item-type-post_type menu-item-object-page menu-item-1345" id="menu-item-1345">  
    <a href="https://www.usinflationcalculator.com/frequently-asked-questions-faqs/">  
        Inflation FAQ's  
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    <a href="https://www.usinflationcalculator.com/about/">  
        About  
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                    Search for:  
                </span>
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<div class="content-area" id="primary">
<div class="site-content" id="content" role="main">
<article class="post-75 page type-page status-publish hentry" id="post-75">
<header class="entry-header">
<h1 class="entry-title">
    Current US Inflation Rates: 2000-2022
</h1>
</header>
<!-- .entry-header -->
<div class="entry-content">
<p>
    The annual inflation rate for the United States is 8.3% for the 12 months ended April 2022 after rising 8.5% previously, according to U.S. Labor Department data published May 11. The next inflation update is scheduled for release on June 10 at 8:30 a.m. ET. It will offer the rate of inflation over the 12 months ended May 2022.
</p>
<p>
    The chart and table below display
<strong>
    annual US inflation rates
</strong>
    for calendar years from 2000 and 2012 to 2022. (For prior years, see
    <a href="https://www.usinflationcalculator.com/inflation/historical-inflation-rates/" title="Historical US Inflation Rates">
        historical inflation rates
    </a>
    .) If you would like to calculate accumulated rates between two different dates, use the
    <a href="https://www.usinflationcalculator.com/" title="US Inflation Calculator">
        US Inflation Calculator
    </a>
    .
</p>
<div style="margin-left:-50px">
    <iframe frameborder="0" height="450" scrolling="yes" seamless="" src="https://www.usinflationcalculator.com/charts/inflation/inflation-chart.html" width="580">
        </iframe>
    </div>
<p>
    *The latest inflation data (12-month based) is always displayed in the chart's final column.
</p>
<p>
<strong>
    Table: Annual Inflation Rates by Month and Year
</strong>
</p>
<p>
```

Since figures below are 12-month periods, look to the December column to find inflation rates by calendar year. For example, the rate of inflation in 2021 was 7.0%.

</p>

<p>

The last column, "Ave," shows the average inflation rate for each year

<a href="https://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/" title="Consumer Price Index Data">

using CPI data

</a>

, which was 4.7% in 2021. They are published by the BLS but are rarely discussed in news media, taking a back seat to a calendar year's actual rate of inflation.

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  2.7
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```

```
2.7
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<p>
</p>
<p>
  <strong>
    Calculating Annual Inflation Rates
  </strong>
</p>
<p>
  Annual rates of inflation are calculated using 12-month selections of the
  <a href="http://www.usinflationcalculator.com/inflation/consumer-price-inde
x-and-annual-percent-changes-from-1913-to-2008/" title="Consumer Price Index Data fro
m 1913 to Present">
    Consumer Price Index
  </a>
  which is
  <a href="https://www.usinflationcalculator.com/inflation/consumer-price-ind
ex-release-schedule/" title="Consumer Price Index Release Schedule">
    published monthly
  </a>
  by the Labor Department's Bureau of Labor Statistics (
  <a href="http://www.bls.gov/cpi/" title="Bureau of Labor Statistics (BLS) -
Consumer Price Index">
    BLS
  </a>
  .
</p>
<p>
  For example, to calculate the inflation rate for January 2017, subtract th
e January 2016 CPI of "236.916" from the January 2017 CPI of "242.839." The result is
"5.923." Divide this number by the January 2016 CPI and then multiply by 100 and add
a % sign.
</p>
<p>
  The result is January's annual inflation rate of 2.5%.
</p>
<div class="sharedaddy sd-sharing-enabled">
  <div class="robots-nocontent sd-block sd-social sd-social-icon-text sd-shar
ing">
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      Share this:
    </h3>
    <div class="sd-content">
      <ul>
        <li class="share-facebook">
          <a class="share-facebook sd-button share-icon" data-shared="sharing-fac
ebook-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rat
es/?share=facebook" rel="nofollow noopener noreferrer" target="_blank" title="Click t
o share on Facebook">
            <span>
              Facebook
            </span>
            </a>
          </li>
        <li class="share-twitter">
          <a class="share-twitter sd-button share-icon" data-shared="sharing-twi
tter-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rat
es/?share=twitter" rel="nofollow noopener noreferrer" target="_blank" title="Click t
o share on Twitter">
            <span>
              Twitter
            </span>
            </a>
          </li>
        <li class="share-linkedin">
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edin-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rat
es/?share=linkedin" rel="nofollow noopener noreferrer" target="_blank" title="Click t
o share on LinkedIn">
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              LinkedIn
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ninterest-75" href="https://www.usinflationcalculator.com/inflation/current-inflatio
n-rates/?share=pinterest" rel="nofollow noopener noreferrer" target="_blank" title="Clic
k to share on Pinterest">
            <span>
              Pinterest
            </span>
            </a>
          </li>
        <li class="share-email">
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 href="mailto:mailto:usinflationcalculator.com?subject=Inflation+Calculator+Email+Share
" rel="nofollow noopener noreferrer" target="_blank" title="Click to share via Email">
            <span>
              Email
            </span>
            </a>
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int" rel="nofollow noopener noreferrer" target="_blank" title="Click to print this page">
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              Print
            </span>
            </a>
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py" rel="nofollow noopener noreferrer" target="_blank" title="Click to copy this link">
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            </span>
            </a>
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t-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?sh
are=reddit" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on Re
ddit">
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            </span>
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app-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?sh
are=whatsapp" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on W
hatsapp">
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ram-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?sh
are=telegram" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on Te
legram">
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              Telegram
            </span>
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enger-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/?sh
are=messenger" rel="nofollow noopener noreferrer" target="_blank" title="Click to share on M
essenger">
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              Embed
            </span>
            </a>
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        <li class="share-link">
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              Link
            </span>
            </a>
          </li>
        <li class="share-link-copied">
          <span>
            Link copied!
          </span>
        </li>
      </ul>
    </div>
  </div>
</div>
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ter-75" href="https://www.usinflationcalculator.com/inflation/current-inflation-rate  
s/?share=twitter" rel="nofollow noopener noreferrer" target="_blank" title="Click to  
share on Twitter">  
    <span>  
        Twitter  
    </span>  
    </a>  
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s://www.usinflationcalculator.com/inflation/current-inflation-rates/?share=reddit" re  
l="nofollow noopener noreferrer" target="_blank" title="Click to share on Reddit">  
            <span>  
                Reddit  
            </span>  
            </a>  
        </li>  
        <li>  
            <a class="sharing-anchor sd-button share-more" href="#">  
                <span>  
                    More  
                </span>  
                </a>  
            </li>  
            <li class="share-end">  
            </li>  
        </ul>  
        <div class="sharing-hidden">  
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s://www.usinflationcalculator.com/inflation/current-inflation-rates/#print" rel="nofo  
llow noopener noreferrer" target="_blank" title="Click to print">  
                            <span>  
                                Print  
                            </span>  
                            </a>  
                        </li>  
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s://www.usinflationcalculator.com/inflation/current-inflation-rates/?share=email" rel  
="nofollow noopener noreferrer" target="_blank" title="Click to email this to a frien  
d">  
                                <span>  
                                    Email  
                                </span>  
                                </a>  
                            </li>  
                            <li class="share-end">  
                            </li>  
                            <li class="share-end">  
                            </li>  
                </ul>  
            </div>  
        </div>  
    </div>  
</div>
```

```
</div>
<!-- .entry-content -->
</article>
<!-- #post-75 -->
</div>
<!-- #content -->
</div>
<!-- #primary -->
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y">
    <aside class="widget widget_text" id="text-176465771">
        <div class="textwidget">
            <style type="text/css">
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                .smallBox5{
                    border-right-width: 1px;
                    border-top-width: 1px;
                    border-bottom-width: 1px;
                    border-left-width: 1px;
                    border-top-style: solid;
                    border-right-style: solid;
                    border-bottom-style: solid;
                    border-left-style: solid;
                }
                .style1 {font-size: xx-small}
                -->
            </style>
            <div align="center">
                <table ;="" class="smallBox5" width="180px">
                    <tr>
                        <td valign="middle">
                            <h3 ;="" align="center" style="margin-bottom:2px; border-bottom:none">
                                <a href="https://www.usinflationcalculator.com/" title="US Inflation Cal
culator">
                                    Try Inflation Calculator!
                                </a>
                            </h3>
                            <p ;="" align="center" style="margin-bottom:2px; border-bottom:none">
                                </p>
                            </td>
                        </tr>
                    </table>
                </div>
            </div>
        </aside>
        <aside class="widget widget_text" id="text-176031101">
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om-width: 1px; border-left-width: 1px; border-top-style: solid; border-right-style: s
olid; border-bottom-style: solid; border-left-style: solid; } hr { border-top:1px dot
ed #000; width:85%; align="center"; margin-bottom:7px; margin-top:7px; /*Rest of stu
ff here*/ } .style1 {font-size: xx-small} --><br />
                </style>
                <div align="center">
                    <table class="smallBox5" width="230px">
                        <tbody>
                            <tr>
                                <td>
                                    <h3 align="center" style="margin-bottom: 0px;">
```

```
<a href="http://www.usinflationcalculator.com/inflation/current-inflation-rates/" title="Current US Inflation Rates">
    Inflation Rate
</a>
<u>
    8.3%
</u>
</h3>
</td>
</tr>
<tr>
<td>
    <hr/>
</td>
</tr>
<tr>
<td>
    <h3 align="center" style="margin-bottom: 0px; margin-top: 0px; padding-top: 2px;">
        Consumer Price Index (CPI) 289.109
    </h3>
</td>
</tr>
<tr>
<td>
    <hr/>
</td>
</tr>
<tr>
<td>
    <p align="center" class="style1">
        Released on May 11 for April 2022.
        <br/>
        <a href="http://www.usinflationcalculator.com/inflation/consumer-price-index-release-schedule/" title="Consumer Price Index Release Schedule">
            Next release
        </a>
        on June 10 for May 2022.
    </p>
</td>
</tr>
</tbody>
</table>
</div>
</div>
</aside>
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        </script>
        <!-- USInflationCalc300x600 -->
        <ins class="adsbygoogle" data-ad-client="ca-pub-0374335159561115" data-ad-format="auto" data-ad-slot="9115547791" style="display:block">
            </ins>
            <script>
                (adsbygoogle = window.adsbygoogle || []).push({});
            </script>
        </div>
```

```
</div>
</aside>
<aside class="widget widget_recent_entries" id="recent-posts-2">
<h1 class="widget-title">
    US Inflation Reports (Monthly CPI)
</h1>
<nav aria-label="US Inflation Reports (Monthly CPI)">
    <ul>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-remains-near-40-year-highs-as-april-cpi-tops-expectations/100022650/">
                U.S. Inflation Remains Near 40-Year Highs as April CPI Tops Expectations
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-highest-since-1981-as-cpi-hits-8-5-in-march/100022605/">
                U.S. Inflation Highest Since 1981 as CPI Hits 8.5% in March
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-at-7-9-highest-since-1982-as-prices-surge-for-gas-food-and-shelter/100022175/">
                U.S. Inflation at 7.9% Highest Since 1982 as Prices Surge for Gas, Food and Shelter
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-rate-at-7-5-hits-40-year-high/100021757/">
                U.S. Inflation Rate at 7.5% Hits 40-Year High
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-rises-7-in-2021-marking-highest-rate-since-1982/100021708/">
                U.S. Inflation Rises 7% in 2021, Marking Highest Rate Since 1982
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-rate-of-inflation-soars-to-39-year-high-as-consumer-prices-jump-in-november/100021666/">
                U.S. Rate of Inflation Soars to 39-Year High as Consumer Prices Jump in November
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-rate-of-inflation-highest-since-1990/100021620/">
                U.S. Rate of Inflation Highest Since 1990
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-resumes-quicker-pace-in-september/100021573/">
                U.S. Inflation Resumes Quicker Pace in September
            </a>
        </li>
        <li>
            <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-cool">

```

s-slightly-consumer-price-gains-ease-in-august/100021451/">  
Annual U.S. Inflation Cools Slightly; Consumer Price Gains Ease in August  
</a>  
</li>  
<li>  
  <a href="https://www.usinflationcalculator.com/inflation/u-s-consumer-price-gains-slow-in-july-annual-inflation-remains-near-13-year-high/100021394/">  
    U.S. Consumer Price Gains Slow in July; Annual Inflation Remains Near 13-Year High  
  </a>  
</li>  
<li>  
  <a href="https://www.usinflationcalculator.com/inflation/annual-inflation-and-consumer-prices-in-june-rise-most-since-2008/100021352/">  
    Annual Inflation and Consumer Prices in June Rise Most Since 2008  
  </a>  
</li>  
<li>  
  <a href="https://www.usinflationcalculator.com/inflation/u-s-inflation-hottest-annually-since-august-2008-consumer-prices-in-may-rise-strongly/100021287/">  
    U.S. Inflation Hottest Annually Since August 2008; Consumer Prices in May Rise Strongly  
  </a>  
</li>  
<li>  
  <a href="https://www.usinflationcalculator.com/inflation/inflation-marks-quickest-pace-since-2008-consumer-prices-surge-in-april/100021243/">  
    Inflation Marks Quickest Pace Since 2008; Consumer Prices Surge in April  
  </a>  
</li>  
</ul>  
</nav>  
</aside>  
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    <label>  
      <span class="screen-reader-text">  
        Search for:  
      </span>  
      <input class="search-field" name="s" placeholder="Search ..." type="search" value="" />  
    </label>  
    <input class="search-submit" type="submit" value="Search"/>  
  </form>  
</aside>  
<aside class="widget widget\_top-posts" id="top-posts-2">  
  <h1 class="widget-title">  
    Popular US Inflation Pages  
  </h1>  
  <ul>  
    <li>  
      <a aria-current="page" class="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/inflation/current-inflation-rates/">  
        Current US Inflation Rates: 2000-2022  
      </a>  
    </li>  
    <li>  
      <a class="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/inflation/historical-inflation-rates/">  
    </li>

```
    Historical Inflation Rates: 1914-2022
    </a>
</li>
<li>
    <a class="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/gasoline-prices-adjusted-for-inflation/">
        Gasoline Prices Adjusted for Inflation
    </a>
</li>
<li>
    <a class="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/">
        Consumer Price Index Data from 1913 to 2022
    </a>
</li>
<li>
    <a class="bump-view" data-bump-view="tp" href="https://www.usinflationcalculator.com/inflation/consumer-price-index-release-schedule/">
        Consumer Price Index - Release Schedule (2021-2022)
    </a>
</li>
</ul>
</aside>
<aside class="widget widget_block" id="block-7">
<hr class="wp-block-separator is-style-wide"/>
</aside>
<aside class="widget widget_block" id="block-5">
<p>
    <strong>
        **NEW**
    </strong>
</p>
<ul>
    <li>
        <a href="https://www.usinflationcalculator.com/inflation/inflation-in-the-los-angeles-long-beach-anaheim-metropolitan-area/" title="Inflation in the Los Angeles-Long Beach-Anaheim Metropolitan Area">
            Los Angeles Area Inflation Data and Calculator
        </a>
    </li>
    <br/>
    <li>
        <a href="https://www.usinflationcalculator.com/inflation/inflation-in-new-york-newark-and-jersey-city-metropolitan-area/" title="Inflation in New York, Newark and Jersey City Metropolitan Area">
            New York-Newark-Jersey City Area Inflation Data and Calculator
        </a>
    </li>
</ul>
</aside>
</div>
<!-- #content-sidebar -->
</div>
<!-- #main-content -->
<div id="secondary">
    <div class="primary-sidebar widget-area" id="primary-sidebar" role="complementary">
        <aside class="widget widget_block" id="block-2">
            <script async="" crossorigin="anonymous" src="https://pagead2.googlesyndication.com/pagead/js/adsbygoogle.js?client=ca-pub-2849770000114053" data-bbox="175 850 925 955"></script>
        </aside>
    </div>
</div>
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```
n.com/pagead/js/adsbygoogle.js?client=ca-pub-0374335159561115">
    </script>
    <!-- 160x600, created 7/16/08 -->
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        </ins>
        <script>
            (adsbygoogle = window.adsbygoogle || []).push({});
        </script>
    </aside>
<aside class="widget widget_block" id="block-4">
    <p>
        <strong>
            RESOURCE LINKS
        </strong>
    </p>
    <ul>
        <li>
            <a href="http://www.bls.gov/cpi/" title="http://www.bls.gov/cpi/">
                Bureau of Labor Statistics
            </a>
        </li>
        <li>
            <a href="https://percentcalculators.com/" title="Percentage Calculators">
                Percent Calculators
            </a>
        </li>
        <li>
            <a href="https://www.federalreserve.gov/monetarypolicy.htm" title="Federal Reserve Monetary Policy">
                Reserve Monetary Policy
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        </li>
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        </ins>
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        </script>
    </aside>
</div>
<!-- #primary-sidebar -->
</div>
<!-- #secondary -->
</div>
<!-- #main -->
<footer class="site-footer" id="colophon" role="contentinfo">
    <div class="site-info">
        <p align="center">
            US
            <a href="http://www.usinflationcalculator.com/" title="Inflation Calculator">
                INFLATION CALCULATOR
            </a>
        </p>
    </div>
</footer>
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```
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</a>
) • ALL RIGHTS RESERVED
</p>
</p>
</div>
<!-- .site-info -->
</footer>
<!-- #colophon -->
</div>
<!-- #page -->
<script type="text/javascript">
window.WPCOM_sharing_counts = {"https://www.usinflationcalculator.com/inflation
/current-inflation-rates/":75};
</script>
<div id="sharing_email" style="display: none;">
<form action="/inflation/current-inflation-rates/" method="post">
<label for="target_email">
Send to Email Address
</label>
<input id="target_email" name="target_email" type="email" value="" />
<label for="source_name">
Your Name
</label>
<input id="source_name" name="source_name" type="text" value="" />
<label for="source_email">
Your Email Address
</label>
<input id="source_email" name="source_email" type="email" value="" />
<input autocomplete="off" class="input" id="jetpack-source_f_name" name="source_f
_name" size="25" title="This field is for validation and should not be changed" type
="text" value="" />

<input class="sharing_send" type="submit" value="Send Email"/>
<a class="sharing_cancel" href="#cancel" rel="nofollow" role="button">
Cancel
</a>
<div class="errors errors-1" style="display: none;">
Post was not sent - check your email addresses!
</div>
<div class="errors errors-2" style="display: none;">
Email check failed, please try again
</div>
<div class="errors errors-3" style="display: none;">
Sorry, your blog cannot share posts by email.
</div>
</img>
</form>
</div>
<script id="twentyfourteen-script-js" src="https://www.usinflationcalculator.com/wp
-content/themes/twentyfourteen/js/functions.js?ver=20171218">
</script>
<script id="sharing-js-js-extra">
var sharing_js_options = {"lang":"en","counts":"1","is_stats_active":"1"};
</script>
```

```

<script id="sharing-js-js" src="https://www.usinflationcalculator.com/wp-content/plugins/jetpack/_inc/build/sharedaddy/sharing.min.js?ver=10.9">
</script>
<script id="sharing-js-js-after">
var windowOpen;
    ( function () {
        function matches( el, sel ) {
            return !! (
                el.matches && el.matches( sel ) ||
                el.msMatchesSelector && el.msMatchesS
elector( sel )
        );
    }

    document.body.addEventListener( 'click', function ( e
vent ) {
        if ( ! event.target ) {
            return;
        }

        var el;
        if ( matches( event.target, 'a.share-facboo
k' ) ) {
            el = event.target;
        } else if ( event.target.parentNode && matche
s( event.target.parentNode, 'a.share-facebook' ) ) {
            el = event.target.parentNode;
        }

        if ( el ) {
            event.preventDefault();

            // If there's another sharing window
            // open, close it.
            if ( typeof windowOpen !== 'undefined
d' ) {
                windowOpen.close();
            }
            windowOpen = window.open( el.getAttribute(
'href' ), 'wpcomfacebook', 'menubar=1,resizable=1,width=600,height=400' );
            return false;
        }
    } );
} )();

var windowOpen;
    ( function () {
        function matches( el, sel ) {
            return !! (
                el.matches && el.matches( sel ) ||
                el.msMatchesSelector && el.msMatchesS
elector( sel )
        );
    }

    document.body.addEventListener( 'click', function ( e
vent ) {
        if ( ! event.target ) {
            return;
        }
    }

```

```
index
var el;
if ( matches( event.target, 'a.share-twitter' ) ) {
    el = event.target;
} else if ( event.target.parentNode && matches( event.target.parentNode, 'a.share-twitter' ) ) {
    el = event.target.parentNode;
}

if ( el ) {
    event.preventDefault();
    // If there's another sharing window open, close it.
    if ( typeof windowOpen !== 'undefined' ) {
        windowOpen.close();
    }
    windowOpen = window.open( el.getAttribute( 'href' ), 'wpcomtwitter', 'menubar=1,resizable=1,width=600,height=350' );
    return false;
}
} );
} )();
</script>
<script defer="" src="https://stats.wp.com/e-202222.js">
</script>
<script>
_stq = window._stq || [];
_stq.push([ 'view', {v:'ext',j:'1:10.9',blog:'5955919',post:'75',tz:'-4',sr
v:'www.usinflationcalculator.com'} ]);
_stq.push([ 'clickTrackerInit', '5955919', '75' ]);
</script>
</body>
</html>
```

```
In [ ]: # Exporting the HTML to a file
        with open('output/inflation_rate_response.html', 'wb') as file:
            file.write(soup.prettify('utf-8'))
```

```
In [ ]: # creating list with all tables  
tables = soup.find_all('table')
```

```
In [ ]: # Inspect the value of the variable  
tables
```

```
Out[ ]: [<table cellpadding="0" cellspacing="0" width="110%>
<tr height="17">
<td align="right" height="17"><strong>Year</strong></td>
<td align="right"><strong>Jan</strong></td>
<td align="right"><strong>Feb</strong></td>
<td align="right"><strong>Mar</strong></td>
<td align="right"><strong>Apr</strong></td>
<td align="right"><strong>May</strong></td>
<td align="right"><strong>Jun</strong></td>
<td align="right"><strong>Jul</strong></td>
<td align="right"><strong>Aug</strong></td>
<td align="right"><strong>Sep</strong></td>
<td align="right"><strong>Oct</strong></td>
<td align="right"><strong>Nov</strong></td>
<td align="right"><strong>Dec</strong></td>
<td align="right"><strong>Ave</strong></td>
</tr>
<tr>
<td align="right" height="17"><strong>2022</strong></td>
<td align="right">7.5</td>
<td align="right">7.9</td>
<td align="right">8.5</td>
<td align="right">8.3</td>
<td align="right"><em>Avail.<br/>
    June<br/>
    10</em></td>
<td align="right"> </td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2021</strong></td>
<td align="right">1.4</td>
<td align="right">1.7</td>
<td align="right">2.6</td>
<td align="right">4.2</td>
<td align="right">5.0</td>
<td align="right">5.4</td>
<td align="right">5.4</td>
<td align="right">5.3</td>
<td align="right">5.4</td>
<td align="right">6.2</td>
<td align="right">6.8</td>
<td align="right">7.0</td>
<td align="right">4.7</td>
</tr>
<tr>
<td align="right" height="17"><strong>2020</strong></td>
<td align="right">2.5</td>
<td align="right">2.3</td>
<td align="right">1.5</td>
<td align="right">0.3</td>
<td align="right">0.1</td>
<td align="right">0.6</td>
<td align="right">1.0</td>
```

```
<td align="right">1.3</td>
<td align="right">1.4</td>
<td align="right">1.2</td>
<td align="right">1.2</td>
<td align="right">1.4</td>
<td align="right">1.2</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2019</strong></td>
<td align="right">1.6</td>
<td align="right">1.5</td>
<td align="right">1.9</td>
<td align="right">2.0</td>
<td align="right">1.8</td>
<td align="right">1.6</td>
<td align="right">1.8</td>
<td align="right">1.7</td>
<td align="right">1.7</td>
<td align="right">1.8</td>
<td align="right">2.1</td>
<td align="right">2.3</td>
<td align="right">1.8</td>
</tr>
<tr>
<td align="right" height="17"><strong>2018</strong></td>
<td align="right">2.1</td>
<td align="right">2.2</td>
<td align="right">2.4</td>
<td align="right">2.5</td>
<td align="right">2.8</td>
<td align="right">2.9</td>
<td align="right">2.9</td>
<td align="right">2.7</td>
<td align="right">2.3</td>
<td align="right">2.5</td>
<td align="right">2.2</td>
<td align="right">1.9</td>
<td align="right">2.4</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2017</strong></td>
<td align="right">2.5</td>
<td align="right">2.7</td>
<td align="right">2.4</td>
<td align="right">2.2</td>
<td align="right">1.9</td>
<td align="right">1.6</td>
<td align="right">1.7</td>
<td align="right">1.9</td>
<td align="right">2.2</td>
<td align="right">2.0</td>
<td align="right">2.2</td>
<td align="right">2.1</td>
<td align="right">2.1</td>
</tr>
<tr>
<td align="right" height="17"><strong>2016</strong></td>
<td align="right">1.4</td>
<td align="right">1.0</td>
<td align="right">0.9</td>
```

```
<td align="right">1.1</td>
<td align="right">1.0</td>
<td align="right">1.0</td>
<td align="right">0.8</td>
<td align="right">1.1</td>
<td align="right">1.5</td>
<td align="right">1.6</td>
<td align="right">1.7</td>
<td align="right">2.1</td>
<td align="right">1.3</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2015</strong></td>
<td align="right">-0.1</td>
<td align="right">0.0</td>
<td align="right">-0.1</td>
<td align="right">-0.2</td>
<td align="right">0.0</td>
<td align="right">0.1</td>
<td align="right">0.2</td>
<td align="right">0.2</td>
<td align="right">0.0</td>
<td align="right">0.2</td>
<td align="right">0.5</td>
<td align="right">0.7</td>
<td align="right">0.1</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2014</strong></td>
<td align="right">1.6</td>
<td align="right">1.1</td>
<td align="right">1.5</td>
<td align="right">2.0</td>
<td align="right">2.1</td>
<td align="right">2.1</td>
<td align="right">2.0</td>
<td align="right">1.7</td>
<td align="right">1.7</td>
<td align="right">1.7</td>
<td align="right">1.3</td>
<td align="right">0.8</td>
<td align="right">1.6</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2013</strong></td>
<td align="right">1.6</td>
<td align="right">2.0</td>
<td align="right">1.5</td>
<td align="right">1.1</td>
<td align="right">1.4</td>
<td align="right">1.8</td>
<td align="right">2.0</td>
<td align="right">1.5</td>
<td align="right">1.2</td>
<td align="right">1.0</td>
<td align="right">1.2</td>
<td align="right">1.5</td>
<td align="right">1.5</td>
</tr>
<tr height="17">
```

```
<td align="right" height="17"><strong>2012</strong></td>
<td align="right">2.9</td>
<td align="right">2.9</td>
<td align="right">2.7</td>
<td align="right">2.3</td>
<td align="right">1.7</td>
<td align="right">1.7</td>
<td align="right">1.4</td>
<td align="right">1.7</td>
<td align="right">2.0</td>
<td align="right">2.2</td>
<td align="right">1.8</td>
<td align="right">1.7</td>
<td align="right">2.1</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2011</strong></td>
<td align="right">1.6</td>
<td align="right">2.1</td>
<td align="right">2.7</td>
<td align="right">3.2</td>
<td align="right">3.6</td>
<td align="right">3.6</td>
<td align="right">3.6</td>
<td align="right">3.8</td>
<td align="right">3.9</td>
<td align="right">3.5</td>
<td align="right">3.4</td>
<td align="right">3.0</td>
<td align="right">3.2</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2010</strong></td>
<td align="right">2.6</td>
<td align="right">2.1</td>
<td align="right">2.3</td>
<td align="right">2.2</td>
<td align="right">2.0</td>
<td align="right">1.1</td>
<td align="right">1.2</td>
<td align="right">1.1</td>
<td align="right">1.1</td>
<td align="right">1.2</td>
<td align="right">1.1</td>
<td align="right">1.5</td>
<td align="right">1.6</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2009</strong></td>
<td align="right">0</td>
<td align="right">0.2</td>
<td align="right">-0.4</td>
<td align="right">-0.7</td>
<td align="right">-1.3</td>
<td align="right">-1.4</td>
<td align="right">-2.1</td>
<td align="right">-1.5</td>
<td align="right">-1.3</td>
<td align="right">-0.2</td>
<td align="right">1.8</td>
```

```
<td align="right">2.7</td>
<td align="right">-0.4</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2008</strong></td>
<td align="right">4.3</td>
<td align="right">4.0</td>
<td align="right">4.0</td>
<td align="right">3.9</td>
<td align="right">4.2</td>
<td align="right">5.0</td>
<td align="right">5.6</td>
<td align="right">5.4</td>
<td align="right">4.9</td>
<td align="right">3.7</td>
<td align="right">1.1</td>
<td align="right">0.1</td>
<td align="right">3.8</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2007</strong></td>
<td align="right">2.1</td>
<td align="right">2.4</td>
<td align="right">2.8</td>
<td align="right">2.6</td>
<td align="right">2.7</td>
<td align="right">2.7</td>
<td align="right">2.4</td>
<td align="right">2.0</td>
<td align="right">2.8</td>
<td align="right">3.5</td>
<td align="right">4.3</td>
<td align="right">4.1</td>
<td align="right">2.8</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2006</strong></td>
<td align="right">4.0</td>
<td align="right">3.6</td>
<td align="right">3.4</td>
<td align="right">3.5</td>
<td align="right">4.2</td>
<td align="right">4.3</td>
<td align="right">4.1</td>
<td align="right">3.8</td>
<td align="right">2.1</td>
<td align="right">1.3</td>
<td align="right">2.0</td>
<td align="right">2.5</td>
<td align="right">3.2</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2005</strong></td>
<td align="right">3.0</td>
<td align="right">3.0</td>
<td align="right">3.1</td>
<td align="right">3.5</td>
<td align="right">2.8</td>
<td align="right">2.5</td>
<td align="right">3.2</td>
```

```
<td align="right">3.6</td>
<td align="right">4.7</td>
<td align="right">4.3</td>
<td align="right">3.5</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2004</strong></td>
<td align="right">1.9</td>
<td align="right">1.7</td>
<td align="right">1.7</td>
<td align="right">2.3</td>
<td align="right">3.1</td>
<td align="right">3.3</td>
<td align="right">3.0</td>
<td align="right">2.7</td>
<td align="right">2.5</td>
<td align="right">3.2</td>
<td align="right">3.5</td>
<td align="right">3.3</td>
<td align="right">2.7</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2003</strong></td>
<td align="right">2.6</td>
<td align="right">3.0</td>
<td align="right">3.0</td>
<td align="right">2.2</td>
<td align="right">2.1</td>
<td align="right">2.1</td>
<td align="right">2.2</td>
<td align="right">2.3</td>
<td align="right">2.0</td>
<td align="right">1.8</td>
<td align="right">1.9</td>
<td align="right">2.3</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2002</strong></td>
<td align="right">1.1</td>
<td align="right">1.1</td>
<td align="right">1.5</td>
<td align="right">1.6</td>
<td align="right">1.2</td>
<td align="right">1.1</td>
<td align="right">1.5</td>
<td align="right">1.8</td>
<td align="right">1.5</td>
<td align="right">2.0</td>
<td align="right">2.2</td>
<td align="right">2.4</td>
<td align="right">1.6</td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2001</strong></td>
<td align="right">3.7</td>
<td align="right">3.5</td>
<td align="right">2.9</td>
```

```
<td align="right">3.3</td>
<td align="right">3.6</td>
<td align="right">3.2</td>
<td align="right">2.7</td>
<td align="right">2.7</td>
<td align="right">2.6</td>
<td align="right">2.1</td>
<td align="right">1.9</td>
<td align="right">1.6</td>
<td align="right">2.8</td>
</tr>
<tr height="17">
<td align="right" height="17"><strong>2000</strong></td>
<td align="right">2.7</td>
<td align="right">3.2</td>
<td align="right">3.8</td>
<td align="right">3.1</td>
<td align="right">3.2</td>
<td align="right">3.7</td>
<td align="right">3.7</td>
<td align="right">3.4</td>
<td align="right">3.5</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
</tr>
</table>,
<table ;="" class="smallBox5" width="180px"><tr><td valign="middle"><h3 ;="" align="center" style="margin-bottom:2px; border-bottom:none"><a href="https://www.usinflationcalculator.com/" title="US Inflation Calculator">Try Inflation Calculator!</a></h3>
<p ;="" align="center" style="margin-bottom:2px; border-bottom:none"> </p></td></tr>
</table>,
<table class="smallBox5" width="230px">
<tbody>
<tr>
<td>
<h3 align="center" style="margin-bottom: 0px;"><a href="http://www.usinflationcalculator.com/inflation/current-inflation-rates/" title="Current US Inflation Rates">Inflation Rate</a> <u>8.3%</u></h3>
</td>
</tr>
<tr>
<td>
<hr/>
</td>
</tr>
<tr>
<td>
<hr/>
</td>
</tr>
<tr>
<td>
<h3 align="center" style="margin-bottom: 0px; margin-top: 0px; padding-top: 2px;">Consumer Price Index (CPI) 289.109</h3>
</td>
</tr>
<tr>
<td>
<hr/>
</td>
</tr>
<tr>
<td>
<hr/>
</td>
</tr>
<tr>
```

```
<td>
<p align="center" class="style1">Released on May 11 for April 2022.<br/>
<a href="http://www.usinflationcalculator.com/inflation/consumer-price-index-release
-schedule/" title="Consumer Price Index Release Schedule">Next release</a> on June 10
for May 2022.</p>
</td>
</tr>
</tbody>
</table>]
```

```
In [ ]: #since there is only one table, set table as the first table in tables
table = tables[0]
#display table
table
```

```
Out[ ]: <table cellpadding="0" cellspacing="0" width="110%>
<tr height="17">
<td align="right" height="17"><strong>Year</strong></td>
<td align="right"><strong>Jan</strong></td>
<td align="right"><strong>Feb</strong></td>
<td align="right"><strong>Mar</strong></td>
<td align="right"><strong>Apr</strong></td>
<td align="right"><strong>May</strong></td>
<td align="right"><strong>Jun</strong></td>
<td align="right"><strong>Jul</strong></td>
<td align="right"><strong>Aug</strong></td>
<td align="right"><strong>Sep</strong></td>
<td align="right"><strong>Oct</strong></td>
<td align="right"><strong>Nov</strong></td>
<td align="right"><strong>Dec</strong></td>
<td align="right"><strong>Ave</strong></td>
</tr>
<tr>
<td align="right" height="17"><strong>2022</strong></td>
<td align="right">7.5</td>
<td align="right">7.9</td>
<td align="right">8.5</td>
<td align="right">8.3</td>
<td align="right"><em>Avail.<br/>
    June<br/>
    10</em></td>
<td align="right"> </td>
</tr>
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2021</strong></td>
<td align="right">1.4</td>
<td align="right">1.7</td>
<td align="right">2.6</td>
<td align="right">4.2</td>
<td align="right">5.0</td>
<td align="right">5.4</td>
<td align="right">5.4</td>
<td align="right">5.3</td>
<td align="right">5.4</td>
<td align="right">6.2</td>
<td align="right">6.8</td>
<td align="right">7.0</td>
<td align="right">4.7</td>
</tr>
<tr>
<td align="right" height="17"><strong>2020</strong></td>
<td align="right">2.5</td>
<td align="right">2.3</td>
<td align="right">1.5</td>
<td align="right">0.3</td>
<td align="right">0.1</td>
<td align="right">0.6</td>
<td align="right">1.0</td>
```

```
<td align="right">1.3</td>
<td align="right">1.4</td>
<td align="right">1.2</td>
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<td align="right">4.3</td>
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<td align="right">2.5</td>
<td align="right">3.2</td>
</tr>,
<tr bgcolor="#dae9fc">
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<td align="right">3.0</td>
<td align="right">3.0</td>
<td align="right">3.1</td>
<td align="right">3.5</td>
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<td align="right">2.5</td>
<td align="right">3.2</td>
<td align="right">3.6</td>
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<td align="right">4.7</td>
<td align="right">4.3</td>
<td align="right">3.5</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
</tr>,
<tr height="17">
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<td align="right">1.9</td>
<td align="right">1.7</td>
<td align="right">1.7</td>
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</tr>,
<tr bgcolor="#dae9fc">
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<td align="right">1.9</td>
<td align="right">2.3</td>
</tr>,
<tr height="17">
<td align="right" height="17"><strong>2002</strong></td>
<td align="right">1.1</td>
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<td align="right">2.0</td>
<td align="right">2.2</td>
<td align="right">2.4</td>
<td align="right">1.6</td>
</tr>,
<tr bgcolor="#dae9fc">
<td align="right" height="17"><strong>2001</strong></td>
<td align="right">3.7</td>
<td align="right">3.5</td>
<td align="right">2.9</td>
<td align="right">3.3</td>
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```

<td align="right">3.6</td>
<td align="right">3.2</td>
<td align="right">2.7</td>
<td align="right">2.7</td>
<td align="right">2.6</td>
<td align="right">2.1</td>
<td align="right">1.9</td>
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</tr>,
<tr height="17">
<td align="right" height="17"><strong>2000</strong></td>
<td align="right">2.7</td>
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<td align="right">3.7</td>
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<td align="right">3.4</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
<td align="right">3.4</td>
</tr>]

```

```

In [ ]: #Gets all the column headers of our table
#create an empty list name it headers
headers = []
#Loop through the first row which contains the header names
#save the text in the table header tag after stripping any extra spaces as title
#append this title to the headers list
for i in table.find_all('tr')[0]:
    title = i.text.strip()
    if title != '':
        headers.append(title)

#display headers in a list
headers

```

```

Out[ ]: ['Year',
 'Jan',
 'Feb',
 'Mar',
 'Apr',
 'May',
 'Jun',
 'Jul',
 'Aug',
 'Sep',
 'Oct',
 'Nov',
 'Dec',
 'Ave']

```

```

In [ ]: #Creates a dataframe using the column headers from our table
df = pd.DataFrame(columns = headers)

```

```
#display the header in a dataframe
df
```

```
Out[ ]: Year Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave
```

```
In [ ]: #create a for loop to iterate all the rows in the table
#retrieve the text in the row which is the value we want
#get the length of the dataframe
#populate the contents of the dataframe iteratively by reading each row
#increment the length of the dataframe and add the row to the end of the dataframe
for j in table.find_all('tr')[1:]:
    row_data = j.find_all('td')
    row = [tr.text for tr in row_data]
    length = len(df)
    df.loc[length] = row
```

```
In [ ]: #display the dataframe
df.head()
```

```
Out[ ]: Year Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave
```

<b>0</b>	2022	7.5	7.9	8.5	8.3	Avail.\nJune\n 10							
<b>1</b>	2021	1.4	1.7	2.6	4.2		5.0	5.4	5.4	5.3	5.4	6.2	6.8
<b>2</b>	2020	2.5	2.3	1.5	0.3		0.1	0.6	1.0	1.3	1.4	1.2	1.2
<b>3</b>	2019	1.6	1.5	1.9	2.0		1.8	1.6	1.8	1.7	1.7	1.8	2.1
<b>4</b>	2018	2.1	2.2	2.4	2.5		2.8	2.9	2.9	2.7	2.3	2.5	2.2

```
In [ ]: # set year, month and inflation rate as the column name and remove unneeded value
months=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec']
df_inflation = pd.melt(df, id_vars = 'Year', value_vars=months, var_name='Month', value_name='Rate')
df_inflation['Month']=pd.Categorical(df_inflation['Month'], categories=months, ordered=False)
df_inflation.sort_values(by=['Year','Month'], inplace=True)
```

```
In [ ]: # display the head of the dataframe
df_inflation.head()
```

```
Out[ ]: Year Month Inflation Rate
```

<b>22</b>	2000	Jan	2.7
<b>45</b>	2000	Feb	3.2
<b>68</b>	2000	Mar	3.8
<b>91</b>	2000	Apr	3.1
<b>114</b>	2000	May	3.2

```
In [ ]: # save it to a csv file
# df_inflation.to_csv('data/inflation_rate_clean.csv')
```

## Scrape the Gas Price Website

```
In [ ]: # Define a variable for the url of the site  
site_gas = "https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_nu"

In [ ]: # Making a get request and assign the result to a variable response  
response_gas = requests.get(site_gas)

#Check that the response was processed correctly  
response_gas.status_code

Out[ ]: 200

In [ ]: # Extracting the HTML  
#assign a variable html to response content.  
html_gas = response_gas.content

# Checking that the reply is indeed an HTML code by inspecting the first 200 symbols  
html_gas[:500]

Out[ ]: b"<!DOCTYPE HTML PUBLIC '-//W3C//DTD HTML 4.01 Transitional//EN'>\r <html>\r <head>\r <meta http-equiv='X-UA-Compatible' content='IE=9' />\r <title>U.S. All Grades All For  
mulations Retail Gasoline Prices (Dollars per Gallon)</title>\r <script src='../inclu  
des/TableFloaterTitle.js'></script>\r <link rel='StyleSheet' href='../Styles/Pet_wrap  
per3.css' TYPE='text/css'>\r <link rel='StyleSheet' href='../Styles/leaf_new2.css' TY  
PE='text/css'>\r <link rel='StyleSheet' href='/styles/Eia_sitewideF.css' type='text/'>

In [ ]: #Convert HTML to a BeautifulSoup object, using the default parser of html  
#Create a BeautifulSoup object and store it in a variable named soup.  
soup_gas = BeautifulSoup(html_gas, "html.parser")

In [ ]: #using prettify() method to turn a Beautiful Soup parse tree into a nicely formatted L  
#with a separate line for each tag and each string:  
print(soup_gas.prettify())
```

```
<!DOCTYPE HTML PUBLIC '-//W3C//DTD HTML 4.01 Transitional//EN'>
<html>
  <head>
    <meta content="IE=9" http-equiv="X-UA-Compatible"/>
    <title>
      U.S. All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)
    </title>
    <script src="../includes/TableFloaterTitle.js">
    </script>
    <link href="../Styles/Pet_wrapper3.css" rel="StyleSheet" type="text/css"/>
    <link href="../Styles/leaf_new2.css" rel="StyleSheet" type="text/css"/>
    <link href="/styles/Eia_sitewideF.css" rel="StyleSheet" type="text/css">
    <!-- Header Script -->
    <script language="JavaScript" src="/styles/eia_header.js" type="text/javascript">
    </script>
    <!-- Header Script -->
    <script src="/global/includes/dnavs/leaf_handler.cfm" type="text/javascript">
    </script>
    <!-- Footer Script -->
    <script language="JavaScript" src="/styles/eia_footer.js" type="text/javascript">
    </script>
    <!-- Footer Script -->
  </link>
</head>
<body>
  <script language="JavaScript" type="text/javascript">
    InsertEIAHeaderCode();
  </script>
  <table border="0" cellpadding="0" cellspacing="0" width="675">
    <tr>
      <td class="K">
        </td>
    </tr>
    <tr>
      <td height="12">
        </td>
    </tr>
    <tr>
      <td>
        <table border="0" cellpadding="0" cellspacing="0" width="675">
          <tr>
            <td width="400">
              <table border="2" bordercolordark="#6699cc" bordercolorlight="#6699cc" cellpadding="0" cellspacing="0" style="border: thin;">
                <tr>
                  <td>
                    <table border="0" cellpadding="0" cellspacing="0">
                      <tr>
                        <td class="J">
                          View History:
                        </td>
                        <td>
                          <a href="LeafHandler.ashx?n=pet&s=emm_epm0_pte_nus_dpg&f=w">
                            
                          </a>
                        </td>
                        <td class="F">
                          <a class="NavChunk" href="LeafHandler.ashx?n=pet&s=emm_epm0_pte_nus_dpg&f=w">
                        </td>
                      </tr>
                    </table>
                  </td>
                </tr>
              </table>
            </td>
          </tr>
        </table>
      </td>
    </tr>
  </table>
</body>
```

```

        Weekly
    </a>
</td>
<td>
    <a href="LeafHandler.ashx?n=pet&s=emm_epm0_pte_nus_dpg&f=m">
        
    </a>
</td>
<td class="F">
    <a class="NavChunk" href="LeafHandler.ashx?n=pet&s=emm_epm0_pte_nus
_dpg&f=m">
        Monthly
    </a>
</td>
<td>
    <a href="LeafHandler.ashx?n=pet&s=emm_epm0_pte_nus_dpg&f=a">
        
    </a>
</td>
<td class="F">
    <a class="NavChunk" href="LeafHandler.ashx?n=pet&s=emm_epm0_pte_nus
_dpg&f=a">
        Annual
    </a>
</td>
</tr>
</table>
</td>
</tr>
</table>
</td>
<td align="right" class="F" width="375">
    <a class="crumb" href="../hist_xls/EMM_EPM0_PTE_NUS_DPGm.xls">
        Download Data (XLS File)
    </a>
</td>
</tr>
</table>
</td>
</tr>
<tr>
    <td height="15">
    </td>
</tr>
<tr>
    <td>
        
    </td>
</tr>
<tr>
    <td height="15">
    </td>
</tr>
-->>idth='95%'></td>&nbsp;use back button to return to prior data&nbsp;</td>
<tr>
    <td align="center" bgcolor="#ffffff" class="Title1">
        U.S. All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)
    </td>

```

```
</td>
</tr>
<tr>
<td height="2">
</td>
</tr>
</table>
<table (dollars="" all="" border="0" cellpadding="2" cellspacing="0" formulations
="" gallon="" gasoline="" grades="" per="" prices="" retail="" summary="U.S." width
="600">
<table border="0" cellpadding="2" cellspacing="0" width="675">
<table border="0" cellpadding="2" cellspacing="0" class="FloatTitle" width="675">
<thead>
<tr bgcolor="#993333">
<th class="G2">
Year
</th>
<th class="G">
Jan
</th>
<th class="G">
Feb
</th>
<th class="G">
Mar
</th>
<th class="G">
Apr
</th>
<th class="G">
May
</th>
<th class="G">
Jun
</th>
<th class="G">
Jul
</th>
<th class="G">
Aug
</th>
<th class="G">
Sep
</th>
<th class="G">
Oct
</th>
<th class="G">
Nov
</th>
<th class="G">
Dec
</th>
</tr>
</thead>
<tbody>
<tr>
<td class="B4">
1993
</td>
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<td class="B3">
</td>
<td class="B3">
</td>
<td class="B3">
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<td class="B3">
1.078
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<td class="B3">
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<td class="B3">
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<td class="B3">
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    1.155
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  <td class="B3">
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  <td class="B3">
    1.129
  </td>
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<tr>
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  <td class="B3">
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  <td class="B3">
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  <td class="B3">
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<tr>
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0.987
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  1.666
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    1.557
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  2002
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  1.486
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<td class="B3">
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<tr>
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</td>
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  1.655
```

```
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  1.734
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</td>
<td class="B3">
  1.606
</td>
<td class="B3">
  1.555
</td>
<td class="B3">
  1.522
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</tr>
<tr>
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    2004
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    1.778
  </td>
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    1.839
  </td>
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  </td>
  <td class="B3">
    2.013
  </td>
  <td class="B3">
    1.954
  </td>
  <td class="B3">
    1.920
  </td>
```

```
<td class="B3">
  1.912
</td>
<td class="B3">
  2.042
</td>
<td class="B3">
  2.023
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with open('output/gas_price.html', 'wb') as file:
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In [ ]: # creating list with all tables
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```
In [ ]: # print all the classes for each table
print('Classes of each table:')
for table in soup_gas.find_all('table'):
    print(table.get('class'))
```

Classes of each table:

None  
None  
None  
None  
None  
None  
None  
['FloatTitle']  
None  
None

```
In [ ]: # our table is Located under class 'FloatTitle'
# retrieve the table which has the class
table_gas = soup_gas.find('table', class_='FloatTitle')
```

```
In [ ]: # display the gas table
table_gas
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<tr> <td class="B4"> 2020</td> <td class="B3">2.636</td> <td class="B3">2.533</td>
<td class="B3">2.329</td> <td class="B3">1.938</td> <td class="B3">1.961</td> <td cla
ss="B3">2.170</td> <td class="B3">2.272</td> <td class="B3">2.272</td> <td class="B
3">2.274</td> <td class="B3">2.248</td> <td class="B3">2.200</td> <td class="B3">2.28
4</td> </tr>,
<tr> <td class="B4"> 2021</td> <td class="B3">2.420</td> <td class="B3">2.587</td>
<td class="B3">2.898</td> <td class="B3">2.948</td> <td class="B3">3.076</td> <td cla
ss="B3">3.157</td> <td class="B3">3.231</td> <td class="B3">3.255</td> <td class="B
3">3.272</td> <td class="B3">3.384</td> <td class="B3">3.491</td> <td class="B3">3.40
6</td> </tr>,
<tr> <td class="B4"> 2022</td> <td class="B3">3.413</td> <td class="B3">3.611</td>
<td class="B3">4.322</td> <td class="B3">4.213</td> <td class="B3"></td> <td class="B
3"></td> <td class="B3"></td> <td class="B3"></td> <td class="B3"></td> <td class="B
3"></td> <td class="B3"></td> </tr>]

```

In [ ]: # Inspecting the contents of first row  
`table_gas.find_all('tr')[0].contents`

```
Out[ ]: ['',
          <th class="G2">Year</th>,
          '',
          <th class="G">Jan</th>,
          '',
          <th class="G">Feb</th>,
          '',
          <th class="G">Mar</th>,
          '',
          <th class="G">Apr</th>,
          '',
          <th class="G">May</th>,
          '',
          <th class="G">Jun</th>,
          '',
          <th class="G">Jul</th>,
          '',
          <th class="G">Aug</th>,
          '',
          <th class="G">Sep</th>,
          '',
          <th class="G">Oct</th>,
          '',
          <th class="G">Nov</th>,
          '',
          <th class="G">Dec</th>,
          []]
```

```
In [ ]: #Gets all the column headers of our table
#create an empty list name it headers
headers_gas = []
#Loop through the first row which contains the header names
#save the text in the table header tag after stripping any extra spaces as title
#append this title to the headers list
for i in table_gas.find_all('th'):
    title = i.text.strip()
    if title != '':
        headers_gas.append(title)

#display headers in a list
headers_gas
```

```
Out[ ]: ['Year',
          'Jan',
          'Feb',
          'Mar',
          'Apr',
          'May',
          'Jun',
          'Jul',
          'Aug',
          'Sep',
          'Oct',
          'Nov',
          'Dec']
```

```
In [ ]: #Creates a dataframe using the column headers from our table
df_gas = pd.DataFrame(columns = headers_gas[:14])
```

```
#display the header in a dataframe  
df_gas
```

```
Out[ ]: Year Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
```

```
In [ ]: # Get all the rows of table_gas  
# create an empty table that will store all the data  
table_data=[]  
for tr in table_gas.find_all('tr'):  
    t_row={}  
    #Each table row is stored in the form of  
    #t_row= {'Year': '', 'Jan': '', 'Feb': ''.....'Dec': ''}  
  
    #find all td's(13) in tr and zip it with headers_gas  
    for td, th in zip(tr.find_all('td'), headers_gas):  
        t_row[th] = td.text.strip()  
    table_data.append(t_row)
```

```
In [ ]: # display table_data  
table_data
```

```
Out[ ]: [{}],  
        {'Year': '1993',  
         'Jan': '',  
         'Feb': '',  
         'Mar': '',  
         'Apr': '1.078',  
         'May': '1.100',  
         'Jun': '1.097',  
         'Jul': '1.078',  
         'Aug': '1.062',  
         'Sep': '1.050',  
         'Oct': '1.092',  
         'Nov': '1.066',  
         'Dec': '1.014'},  
        {'Year': '1994',  
         'Jan': '0.998',  
         'Feb': '1.009',  
         'Mar': '1.008',  
         'Apr': '1.027',  
         'May': '1.047',  
         'Jun': '1.078',  
         'Jul': '1.106',  
         'Aug': '1.155',  
         'Sep': '1.144',  
         'Oct': '1.114',  
         'Nov': '1.119',  
         'Dec': '1.129'},  
        {'Year': ''},  
        {'Year': '1995',  
         'Jan': '1.130',  
         'Feb': '1.120',  
         'Mar': '1.119',  
         'Apr': '1.157',  
         'May': '1.225',  
         'Jun': '1.239',  
         'Jul': '1.201',  
         'Aug': '1.170',  
         'Sep': '1.158',  
         'Oct': '1.134',  
         'Nov': '1.109',  
         'Dec': '1.118'},  
        {'Year': '1996',  
         'Jan': '1.137',  
         'Feb': '1.136',  
         'Mar': '1.183',  
         'Apr': '1.275',  
         'May': '1.324',  
         'Jun': '1.300',  
         'Jul': '1.272',  
         'Aug': '1.251',  
         'Sep': '1.247',  
         'Oct': '1.249',  
         'Nov': '1.278',  
         'Dec': '1.282'},  
        {'Year': '1997',  
         'Jan': '1.283',  
         'Feb': '1.276',  
         'Mar': '1.251',  
         'Apr': '1.244',  
         'May': '1.245',
```

```
'Jun': '1.242',
'Jul': '1.220',
'Aug': '1.268',
'Sep': '1.276',
'Oct': '1.242',
'Nov': '1.216',
'Dec': '1.177'},
{'Year': '1998',
'Jan': '1.132',
'Feb': '1.096',
'Mar': '1.064',
'Apr': '1.077',
'May': '1.105',
'Jun': '1.103',
'Jul': '1.094',
'Aug': '1.065',
'Sep': '1.049',
'Oct': '1.059',
'Nov': '1.036',
'Dec': '0.987'},
{'Year': '1999',
'Jan': '0.980',
'Feb': '0.962',
'Mar': '1.022',
'Apr': '1.171',
'May': '1.171',
'Jun': '1.154',
'Jul': '1.197',
'Aug': '1.260',
'Sep': '1.295',
'Oct': '1.285',
'Nov': '1.292',
'Dec': '1.313'},
{'Year': ''},
{'Year': '2000',
'Jan': '1.329',
'Feb': '1.415',
'Mar': '1.556',
'Apr': '1.506',
'May': '1.526',
'Jun': '1.666',
'Jul': '1.591',
'Aug': '1.506',
'Sep': '1.588',
'Oct': '1.571',
'Nov': '1.557',
'Dec': '1.483'},
{'Year': '2001',
'Jan': '1.487',
'Feb': '1.490',
'Mar': '1.450',
'Apr': '1.591',
'May': '1.738',
'Jun': '1.658',
'Jul': '1.466',
'Aug': '1.461',
'Sep': '1.557',
'Oct': '1.357',
'Nov': '1.212',
'Dec': '1.127'},
```

```
{'Year': '2002',
 'Jan': '1.148',
 'Feb': '1.155',
 'Mar': '1.289',
 'Apr': '1.439',
 'May': '1.434',
 'Jun': '1.424',
 'Jul': '1.438',
 'Aug': '1.438',
 'Sep': '1.441',
 'Oct': '1.486',
 'Nov': '1.461',
 'Dec': '1.429'},
{'Year': '2003',
 'Jan': '1.500',
 'Feb': '1.655',
 'Mar': '1.734',
 'Apr': '1.633',
 'May': '1.539',
 'Jun': '1.533',
 'Jul': '1.554',
 'Aug': '1.661',
 'Sep': '1.721',
 'Oct': '1.606',
 'Nov': '1.555',
 'Dec': '1.522'},
{'Year': '2004',
 'Jan': '1.614',
 'Feb': '1.690',
 'Mar': '1.778',
 'Apr': '1.839',
 'May': '2.023',
 'Jun': '2.013',
 'Jul': '1.954',
 'Aug': '1.920',
 'Sep': '1.912',
 'Oct': '2.042',
 'Nov': '2.023',
 'Dec': '1.887'},
{'Year': ''},
{'Year': '2005',
 'Jan': '1.875',
 'Feb': '1.953',
 'Mar': '2.120',
 'Apr': '2.285',
 'May': '2.205',
 'Jun': '2.198',
 'Jul': '2.333',
 'Aug': '2.529',
 'Sep': '2.951',
 'Oct': '2.765',
 'Nov': '2.303',
 'Dec': '2.229'},
{'Year': '2006',
 'Jan': '2.360',
 'Feb': '2.326',
 'Mar': '2.468',
 'Apr': '2.787',
 'May': '2.953',
 'Jun': '2.930',
```

```
'Jul': '3.025',
'Aug': '2.999',
'Sep': '2.606',
'Oct': '2.293',
'Nov': '2.275',
'Dec': '2.359'},
{'Year': '2007',
'Jan': '2.289',
'Feb': '2.323',
'Mar': '2.609',
'Apr': '2.891',
'May': '3.187',
'Jun': '3.102',
'Jul': '3.011',
'Aug': '2.834',
'Sep': '2.849',
'Oct': '2.853',
'Nov': '3.128',
'Dec': '3.070'},
{'Year': '2008',
'Jan': '3.095',
'Feb': '3.078',
'Mar': '3.293',
'Apr': '3.507',
'May': '3.815',
'Jun': '4.105',
'Jul': '4.114',
'Aug': '3.833',
'Sep': '3.756',
'Oct': '3.112',
'Nov': '2.208',
'Dec': '1.745'},
{'Year': '2009',
'Jan': '1.840',
'Feb': '1.975',
'Mar': '2.011',
'Apr': '2.102',
'May': '2.316',
'Jun': '2.681',
'Jul': '2.582',
'Aug': '2.670',
'Sep': '2.609',
'Oct': '2.605',
'Nov': '2.706',
'Dec': '2.663'},
{'Year': ''},
{'Year': '2010',
'Jan': '2.769',
'Feb': '2.699',
'Mar': '2.824',
'Apr': '2.900',
'May': '2.890',
'Jun': '2.785',
'Jul': '2.782',
'Aug': '2.783',
'Sep': '2.757',
'Oct': '2.853',
'Nov': '2.913',
'Dec': '3.048'},
{'Year': '2011',
```

```
'Jan': '3.148',
'Feb': '3.264',
'Mar': '3.615',
'Apr': '3.852',
'May': '3.960',
'Jun': '3.735',
'Jul': '3.705',
'Aug': '3.696',
'Sep': '3.667',
'Oct': '3.506',
'Nov': '3.443',
'Dec': '3.326'},
{'Year': '2012',
'Jan': '3.440',
'Feb': '3.640',
'Mar': '3.907',
'Apr': '3.958',
'May': '3.791',
'Jun': '3.596',
'Jul': '3.498',
'Aug': '3.780',
'Sep': '3.910',
'Oct': '3.812',
'Nov': '3.521',
'Dec': '3.381'},
{'Year': '2013',
'Jan': '3.391',
'Feb': '3.736',
'Mar': '3.779',
'Apr': '3.638',
'May': '3.675',
'Jun': '3.689',
'Jul': '3.661',
'Aug': '3.645',
'Sep': '3.604',
'Oct': '3.420',
'Nov': '3.322',
'Dec': '3.357'},
{'Year': '2014',
'Jan': '3.392',
'Feb': '3.434',
'Mar': '3.606',
'Apr': '3.735',
'May': '3.750',
'Jun': '3.766',
'Jul': '3.688',
'Aug': '3.565',
'Sep': '3.484',
'Oct': '3.255',
'Nov': '2.997',
'Dec': '2.632'},
{'Year': ''},
{'Year': '2015',
'Jan': '2.208',
'Feb': '2.301',
'Mar': '2.546',
'Apr': '2.555',
'May': '2.802',
'Jun': '2.885',
'Jul': '2.880',
```

```
'Aug': '2.726',
'Sep': '2.462',
'Oct': '2.387',
'Nov': '2.260',
'Dec': '2.144'},
{'Year': '2016',
'Jan': '2.057',
'Feb': '1.872',
'Mar': '2.071',
'Apr': '2.216',
'May': '2.371',
'Jun': '2.467',
'Jul': '2.345',
'Aug': '2.284',
'Sep': '2.327',
'Oct': '2.359',
'Nov': '2.295',
'Dec': '2.366'},
{'Year': '2017',
'Jan': '2.458',
'Feb': '2.416',
'Mar': '2.437',
'Apr': '2.528',
'May': '2.503',
'Jun': '2.460',
'Jul': '2.414',
'Aug': '2.494',
'Sep': '2.761',
'Oct': '2.621',
'Nov': '2.678',
'Dec': '2.594'},
{'Year': '2018',
'Jan': '2.671',
'Feb': '2.705',
'Mar': '2.709',
'Apr': '2.873',
'May': '2.987',
'Jun': '2.970',
'Jul': '2.928',
'Aug': '2.914',
'Sep': '2.915',
'Oct': '2.943',
'Nov': '2.736',
'Dec': '2.457'},
{'Year': '2019',
'Jan': '2.338',
'Feb': '2.393',
'Mar': '2.594',
'Apr': '2.881',
'May': '2.946',
'Jun': '2.804',
'Jul': '2.823',
'Aug': '2.707',
'Sep': '2.681',
'Oct': '2.724',
'Nov': '2.693',
'Dec': '2.645'},
{'Year': ''},
{'Year': '2020',
'Jan': '2.636',
```

```
'Feb': '2.533',
'Mar': '2.329',
'Apr': '1.938',
'May': '1.961',
'Jun': '2.170',
'Jul': '2.272',
'Aug': '2.272',
'Sep': '2.274',
'Oct': '2.248',
'Nov': '2.200',
'Dec': '2.284'},
{'Year': '2021',
'Jan': '2.420',
'Feb': '2.587',
'Mar': '2.898',
'Apr': '2.948',
'May': '3.076',
'Jun': '3.157',
'Jul': '3.231',
'Aug': '3.255',
'Sep': '3.272',
'Oct': '3.384',
'Nov': '3.491',
'Dec': '3.406'},
{'Year': '2022',
'Jan': '3.413',
'Feb': '3.611',
'Mar': '4.322',
'Apr': '4.213',
'May': '',
'Jun': '',
'Jul': '',
'Aug': '',
'Sep': '',
'Oct': '',
'Nov': '',
'Dec': ''}]
```

```
In [ ]: # create a dataframe called df_gas and store table_data in it
df_gas = pd.DataFrame(table_data)

# display df_gas
df_gas
```

Out[ ]:	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>0</b>	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
<b>1</b>	1993				1.078	1.100	1.097	1.078	1.062	1.050	1.092	1.066	1.014
<b>2</b>	1994	0.998	1.009	1.008	1.027	1.047	1.078	1.106	1.155	1.144	1.114	1.119	1.129
<b>3</b>		NaN											
<b>4</b>	1995	1.130	1.120	1.119	1.157	1.225	1.239	1.201	1.170	1.158	1.134	1.109	1.118
<b>5</b>	1996	1.137	1.136	1.183	1.275	1.324	1.300	1.272	1.251	1.247	1.249	1.278	1.282
<b>6</b>	1997	1.283	1.276	1.251	1.244	1.245	1.242	1.220	1.268	1.276	1.242	1.216	1.177
<b>7</b>	1998	1.132	1.096	1.064	1.077	1.105	1.103	1.094	1.065	1.049	1.059	1.036	0.987
<b>8</b>	1999	0.980	0.962	1.022	1.171	1.171	1.154	1.197	1.260	1.295	1.285	1.292	1.313
<b>9</b>		NaN											
<b>10</b>	2000	1.329	1.415	1.556	1.506	1.526	1.666	1.591	1.506	1.588	1.571	1.557	1.483
<b>11</b>	2001	1.487	1.490	1.450	1.591	1.738	1.658	1.466	1.461	1.557	1.357	1.212	1.127
<b>12</b>	2002	1.148	1.155	1.289	1.439	1.434	1.424	1.438	1.438	1.441	1.486	1.461	1.429
<b>13</b>	2003	1.500	1.655	1.734	1.633	1.539	1.533	1.554	1.661	1.721	1.606	1.555	1.522
<b>14</b>	2004	1.614	1.690	1.778	1.839	2.023	2.013	1.954	1.920	1.912	2.042	2.023	1.887
<b>15</b>		NaN											
<b>16</b>	2005	1.875	1.953	2.120	2.285	2.205	2.198	2.333	2.529	2.951	2.765	2.303	2.229
<b>17</b>	2006	2.360	2.326	2.468	2.787	2.953	2.930	3.025	2.999	2.606	2.293	2.275	2.359
<b>18</b>	2007	2.289	2.323	2.609	2.891	3.187	3.102	3.011	2.834	2.849	2.853	3.128	3.070
<b>19</b>	2008	3.095	3.078	3.293	3.507	3.815	4.105	4.114	3.833	3.756	3.112	2.208	1.745
<b>20</b>	2009	1.840	1.975	2.011	2.102	2.316	2.681	2.582	2.670	2.609	2.605	2.706	2.663
<b>21</b>		NaN											
<b>22</b>	2010	2.769	2.699	2.824	2.900	2.890	2.785	2.782	2.783	2.757	2.853	2.913	3.048
<b>23</b>	2011	3.148	3.264	3.615	3.852	3.960	3.735	3.705	3.696	3.667	3.506	3.443	3.326
<b>24</b>	2012	3.440	3.640	3.907	3.958	3.791	3.596	3.498	3.780	3.910	3.812	3.521	3.381
<b>25</b>	2013	3.391	3.736	3.779	3.638	3.675	3.689	3.661	3.645	3.604	3.420	3.322	3.357
<b>26</b>	2014	3.392	3.434	3.606	3.735	3.750	3.766	3.688	3.565	3.484	3.255	2.997	2.632
<b>27</b>		NaN											
<b>28</b>	2015	2.208	2.301	2.546	2.555	2.802	2.885	2.880	2.726	2.462	2.387	2.260	2.144
<b>29</b>	2016	2.057	1.872	2.071	2.216	2.371	2.467	2.345	2.284	2.327	2.359	2.295	2.366
<b>30</b>	2017	2.458	2.416	2.437	2.528	2.503	2.460	2.414	2.494	2.761	2.621	2.678	2.594
<b>31</b>	2018	2.671	2.705	2.709	2.873	2.987	2.970	2.928	2.914	2.915	2.943	2.736	2.457
<b>32</b>	2019	2.338	2.393	2.594	2.881	2.946	2.804	2.823	2.707	2.681	2.724	2.693	2.645

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>33</b>	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
<b>34</b>	2020	2.636	2.533	2.329	1.938	1.961	2.170	2.272	2.272	2.274	2.248	2.200
<b>35</b>	2021	2.420	2.587	2.898	2.948	3.076	3.157	3.231	3.255	3.272	3.384	3.491
<b>36</b>	2022	3.413	3.611	4.322	4.213							

```
In [ ]: #remove all the rows that contain null values
df_gas = df_gas.dropna()
df_gas
```

Out[ ]:	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1993				1.078	1.100	1.097	1.078	1.062	1.050	1.092	1.066	1.014
2	1994	0.998	1.009	1.008	1.027	1.047	1.078	1.106	1.155	1.144	1.114	1.119	1.129
4	1995	1.130	1.120	1.119	1.157	1.225	1.239	1.201	1.170	1.158	1.134	1.109	1.118
5	1996	1.137	1.136	1.183	1.275	1.324	1.300	1.272	1.251	1.247	1.249	1.278	1.282
6	1997	1.283	1.276	1.251	1.244	1.245	1.242	1.220	1.268	1.276	1.242	1.216	1.177
7	1998	1.132	1.096	1.064	1.077	1.105	1.103	1.094	1.065	1.049	1.059	1.036	0.987
8	1999	0.980	0.962	1.022	1.171	1.171	1.154	1.197	1.260	1.295	1.285	1.292	1.313
10	2000	1.329	1.415	1.556	1.506	1.526	1.666	1.591	1.506	1.588	1.571	1.557	1.483
11	2001	1.487	1.490	1.450	1.591	1.738	1.658	1.466	1.461	1.557	1.357	1.212	1.127
12	2002	1.148	1.155	1.289	1.439	1.434	1.424	1.438	1.438	1.441	1.486	1.461	1.429
13	2003	1.500	1.655	1.734	1.633	1.539	1.533	1.554	1.661	1.721	1.606	1.555	1.522
14	2004	1.614	1.690	1.778	1.839	2.023	2.013	1.954	1.920	1.912	2.042	2.023	1.887
16	2005	1.875	1.953	2.120	2.285	2.205	2.198	2.333	2.529	2.951	2.765	2.303	2.229
17	2006	2.360	2.326	2.468	2.787	2.953	2.930	3.025	2.999	2.606	2.293	2.275	2.359
18	2007	2.289	2.323	2.609	2.891	3.187	3.102	3.011	2.834	2.849	2.853	3.128	3.070
19	2008	3.095	3.078	3.293	3.507	3.815	4.105	4.114	3.833	3.756	3.112	2.208	1.745
20	2009	1.840	1.975	2.011	2.102	2.316	2.681	2.582	2.670	2.609	2.605	2.706	2.663
22	2010	2.769	2.699	2.824	2.900	2.890	2.785	2.782	2.783	2.757	2.853	2.913	3.048
23	2011	3.148	3.264	3.615	3.852	3.960	3.735	3.705	3.696	3.667	3.506	3.443	3.326
24	2012	3.440	3.640	3.907	3.958	3.791	3.596	3.498	3.780	3.910	3.812	3.521	3.381
25	2013	3.391	3.736	3.779	3.638	3.675	3.689	3.661	3.645	3.604	3.420	3.322	3.357
26	2014	3.392	3.434	3.606	3.735	3.750	3.766	3.688	3.565	3.484	3.255	2.997	2.632
28	2015	2.208	2.301	2.546	2.555	2.802	2.885	2.880	2.726	2.462	2.387	2.260	2.144
29	2016	2.057	1.872	2.071	2.216	2.371	2.467	2.345	2.284	2.327	2.359	2.295	2.366
30	2017	2.458	2.416	2.437	2.528	2.503	2.460	2.414	2.494	2.761	2.621	2.678	2.594
31	2018	2.671	2.705	2.709	2.873	2.987	2.970	2.928	2.914	2.915	2.943	2.736	2.457
32	2019	2.338	2.393	2.594	2.881	2.946	2.804	2.823	2.707	2.681	2.724	2.693	2.645
34	2020	2.636	2.533	2.329	1.938	1.961	2.170	2.272	2.272	2.274	2.248	2.200	2.284
35	2021	2.420	2.587	2.898	2.948	3.076	3.157	3.231	3.255	3.272	3.384	3.491	3.406
36	2022	3.413	3.611	4.322	4.213								

In [ ]: # drop data in year 1993-1999 and Apr in 2022  
df\_gas = df\_gas.drop([1, 2, 4, 5, 6, 7, 8])

In [ ]: # change the format of the dataframe

```

months=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec']

df_gas_new = pd.melt(df_gas, id_vars = 'Year', value_vars=months, var_name='Month', value_name='Price')

df_gas_new['Month']=pd.Categorical(df_gas_new['Month'], categories=months, ordered=True)
df_gas_new.sort_values(by=['Year','Month'], inplace=True)
df_gas_new

```

Out[ ]:

	Year	Month	Gas Price
0	2000	Jan	1.329
23	2000	Feb	1.415
46	2000	Mar	1.556
69	2000	Apr	1.506
92	2000	May	1.526
...	...	...	...
183	2022	Aug	
206	2022	Sep	
229	2022	Oct	
252	2022	Nov	
275	2022	Dec	

276 rows × 3 columns

## Load/Clean Data

In [ ]:

```
# Load dfs - data will be 01/2000 to 03/2022, 22 years and 3 month is 267 month,
df_bs = pd.read_excel('data/df_cvx_bs_quarter.xlsx', engine='openpyxl')
df_is = pd.read_excel('data/df_cvx_is_quarter.xlsx', engine='openpyxl')
df_stock = pd.read_csv('data/CVXstockPrice.csv')
df_inflation = pd.read_csv('data/clean_inflation_rate.csv')
df_gas = pd.read_excel('data/gasPrices.xlsx', engine='openpyxl')
```

Stcok DF

In [ ]:

```
# we just need adjusted close , volume
dfstock1 = df_stock.iloc[:,[0,5,6]]

# create year column and month column
dfstock1['year'] = df_stock.date.apply(lambda x : x.split('-')[0])
dfstock1['month'] = df_stock.date.apply(lambda x : x.split('-')[1])
dfstock1.tail()

# drop useless columns
dfstock2 = dfstock1.iloc[2:-1,1:]
# reset index
dfstock3 = dfstock2.reset_index(drop=True)

# convert month into int
dfstock3.month = dfstock3.month.apply(lambda x: int(x))
```

```
#assign to finaldf
dfstockf = dfstock3.sort_values(by=['year','month'])
dfstockf
```

Out[ ]:

	5. adjusted close	6. volume	year	month
<b>266</b>	18.2953	37687500.0	2000	1
<b>265</b>	16.4760	42961800.0	2000	2
<b>264</b>	20.3915	51176100.0	2000	3
<b>263</b>	18.7790	31502600.0	2000	4
<b>262</b>	20.5234	30692800.0	2000	5
...	...	...	...	...
<b>4</b>	110.7529	224686287.0	2021	11
<b>3</b>	115.1489	221128758.0	2021	12
<b>2</b>	128.8667	300049707.0	2022	1
<b>1</b>	142.7935	282783725.0	2022	2
<b>0</b>	161.4657	526661468.0	2022	3

267 rows × 4 columns

### Balance Sheet DF

In [ ]:

```
# df_BalanceSheet - Clean Balance Sheet
# transpose df
df_bs1 = df_bs.T

# assign column names
df_bs1.columns = df_bs1.iloc[0,:]

# reset index and drop first row
df_bs2 = df_bs1.reset_index().iloc[1:,:]
df_bs2.head(3)
```

Out[ ]:

Unnamed: 0	index	Cash & Short-Term Investments	Cash Only	Total Short Term Investments	Short-Term Receivables	Accounts Receivables, Net	Accounts Receivables, Gross	Debt/Dou Acc
<b>1</b>	MAR '22	12.02	11.99	0.03	23.26	23.2	23.51	
<b>2</b>	DEC '21	6.01	5.97	0.04	18.42	18.17	18.47	
<b>3</b>	SEP '21	6.28	6.24	0.03	16.57	16.16	16.45	

3 rows × 9 columns

```
In [ ]: # see the columns
df_bs2.columns
```

```
Out[ ]: Index(['index', 'Cash & Short-Term Investments', 'Cash Only',
       'Total Short Term Investments', 'Short-Term Receivables',
       'Accounts Receivables, Net', 'Accounts Receivables, Gross',
       'Bad Debt/Doubtful Accounts', 'Other Receivables', 'Inventories',
       'Finished Goods', 'Raw Materials', 'Other Current Assets',
       'Miscellaneous Current Assets', 'Total Current Assets',
       'Net Property, Plant & Equipment',
       'Property, Plant & Equipment - Gross',
       'Operating Lease Right-of-Use Assets', 'Accumulated Depreciation',
       'Total Long-Term Investments ', 'LT Investment - Affiliate Companies',
       'Other Long-Term Investments', 'Long-Term Note Receivable',
       'Intangible Assets', 'Goodwill', 'Deferred Tax Assets', 'Other Assets',
       'Tangible Other Assets', 'Total Assets',
       'Liabilities & Shareholders' Equity', 'ST Debt & Curr. Portion LT Debt',
       'Accounts Payable', 'Income Tax Payable', 'Other Current Liabilities',
       'Miscellaneous Current Liabilities', 'Total Current Liabilities',
       'Long-Term Debt', 'Long-Term Debt excl Lease Obligations',
       'Capital and Operating Lease Obligations',
       'Provision for Risks & Charges', 'Deferred Tax Liabilities',
       'Other Liabilities', 'Other Liabilities (excl. Deferred Income)',
       'Total Liabilities', 'Common Equity', 'Common Stock Par/Carry Value',
       'Additional Paid-In Capital/Capital Surplus', 'Retained Earnings',
       'Cumulative Translation Adjustment/Unrealized For. Exch. Gain',
       'Unrealized Gain/Loss Marketable Securities',
       'Other Appropriated Reserves', 'Treasury Stock',
       'Repurchased Stock Value', 'Total Shareholders' Equity',
       'Accumulated Minority Interest', 'Total Equity',
       'Total Liabilities & Shareholders' Equity', 'Per Share',
       'Book Value per Share', 'Tangible Book Value per Share'],
      dtype='object', name='Unnamed: 0')
```

```
In [ ]: # select the needed columns
df_bs3 = df_bs2[['index', 'Total Assets', 'Total Equity']].iloc[:89,:]
df_bs3.shape
```

```
Out[ ]: (89, 3)
```

```
In [ ]: # since data is quarterly, we will append the data until we have 267 month
dfbs4 = df_bs3
dfbs5 = dfbs4.append(df_bs3)
dfbs6 = dfbs5.append(df_bs3)
dfbs6.shape
```

```
Out[ ]: (267, 3)
```

```
In [ ]: # convert year and month
dfbs6['year'] = dfbs6['index'].apply(lambda x : int(x.split(' \\'')[1]) + 2000)
dfbs6['month'] = dfbs6['index'].apply(lambda x : convMonth(x.split(' \\'')[0]))
dfbs6.head()
```

	Unnamed: 0	index	Total Assets	Total Equity	year	month
1	MAR '22		249.05	147.1	2022	3
2	DEC '21		239.54	139.94	2021	12
3	SEP '21		239.95	136.72	2021	9
4	JUN '21		242.81	133.91	2021	6
5	MAR '21		241.65	132.93	2021	3

```
In [ ]: dfbsf = dfbs6.sort_values(by=['year','month'])
dfbsf.shape
```

```
Out[ ]: (267, 5)
```

```
In [ ]:
```

### Income Statement DF

```
In [ ]: # Income Statement - Clean Balance Sheet
# transpose df
df_is1 = df_is.T

# assign column names
df_is1.columns = df_is1.iloc[0,:]

# reset index and drop first row
df_is2 = df_is1.reset_index().iloc[1:,:]
df_is2.head(3)
```

```
Out[ ]:
```

	Unnamed: 0	index	Sales	Cost of Goods Sold (COGS) incl. D&A	COGS excluding D&A	Depreciation & Amortization Expense	Depreciation	Gross Income	SG&A Expense	Other SG&A
1	MAR '22	53187.0	42045.0	38256.0		3789.0	3789.0	11142.0	1031.0	1031.0
2	DEC '21	46207.0	37420.0	32958.0		4462.0	4462.0	8787.0	1357.0	1357.0
3	SEP '21	42349.0	33628.0	29288.0		4340.0	4340.0	8721.0	757.0	757.0

3 rows × 48 columns

```
In [ ]: # see the columns
df_is2.columns
```

```
Out[ ]: Index(['index', 'Sales', 'Cost of Goods Sold (COGS) incl. D&A',
   'COGS excluding D&A', 'Depreciation & Amortization Expense',
   'Depreciation', 'Gross Income', 'SG&A Expense', 'Other SG&A',
   'Other Operating Expense', 'EBIT (Operating Income)',
   'Nonoperating Income - Net', 'Equity in Earnings of Affiliates',
   'Other Income (Expense)', 'Interest Expense', 'Gross Interest Expense',
   'Interest Capitalized', 'Unusual Expense - Net', 'Impairments',
   'Property,Plant & Equipment', 'Financial Fixed Assets',
   'Restructuring Expense', 'Unrealized Valuation Gain/Loss',
   'Hedges/Derivatives', 'Excpl Chrgs - Others', 'Calamitous Events',
   'Pretax Income', 'Income Taxes', 'Equity in Earnings of Affiliates',
   'Consolidated Net Income', 'Minority Interest', 'Net Income',
   'Discontinued Operations', 'Net Income available to Common',
   'Per Share', 'EPS (recurring)', 'Basic Shares Outstanding',
   'Total Shares Outstanding', 'EPS (diluted)',
   'Diluted Shares Outstanding', 'Total Shares Outstanding',
   'Earnings Persistence', 'Dividends per Share', 'Payout Ratio', 'EBITDA',
   'EBITDA', 'EBIT', 'Depreciation & Amortization Expense'],
  dtype='object', name='Unnamed: 0')
```

```
In [ ]: # select needed columns
df_is3 = df_is2[['index', 'Sales', 'Net Income']].iloc[:89,:]
df_is3.shape
```

```
Out[ ]: (89, 3)
```

```
In [ ]: # append df to 267 month
dfis4 = df_is3
dfis5 = dfis4.append(df_is3)
dfis6 = dfis5.append(df_is3)
```

```
In [ ]: # 22 year 3 month = 267 month
dfis6.shape
```

```
Out[ ]: (267, 3)
```

```
In [ ]: # create year and month columns
dfis6['year'] = dfis6['index'].apply(lambda x : int(x.split(' \\'')[1]) + 2000)
dfis6['month'] = dfis6['index'].apply(lambda x : convMonth(x.split(' \\'')[0]))
dfis6.head()
```

	Unnamed: 0	index	Sales	Net Income	year	month
1	MAR '22	53187.0	6259.0	2022	3	
2	DEC '21	46207.0	5055.0	2021	12	
3	SEP '21	42349.0	6111.0	2021	9	
4	JUN '21	36385.0	3082.0	2021	6	
5	MAR '21	31350.0	1377.0	2021	3	

```
In [ ]: # sort by values
dfisf = dfis6.sort_values(by=['year', 'month'])
dfisf.shape
```

```
Out[ ]: (267, 5)
```

## Inflation DF

```
In [ ]: # format inflation df
dfi1 = df_inflation.iloc[:267,:]
dfi1
```

Out[ ]:

	Unnamed: 0	Year	Month	Inflation Rate
<b>0</b>	22	2000	Jan	2.7
<b>1</b>	45	2000	Feb	3.2
<b>2</b>	68	2000	Mar	3.8
<b>3</b>	91	2000	Apr	3.1
<b>4</b>	114	2000	May	3.2
...	...	...	...	...
<b>262</b>	231	2021	Nov	6.8
<b>263</b>	254	2021	Dec	7.0
<b>264</b>	0	2022	Jan	7.5
<b>265</b>	23	2022	Feb	7.9
<b>266</b>	46	2022	Mar	8.5

267 rows × 4 columns

## Gas DF

```
In [ ]: df_gas.Date = df_gas.Date.astype(str)
```

```
In [ ]: df_gas['year'] = df_gas.Date.apply(lambda x : x.split('-')[0])
df_gas['month'] = df_gas.Date.apply(lambda x : x.split('-')[1])
df_gas
```

Out[ ]:

Date

## U.S. All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)

<b>0</b>	1993-04-15	1.078	1993	04
<b>1</b>	1993-05-15	1.100	1993	05
<b>2</b>	1993-06-15	1.097	1993	06
<b>3</b>	1993-07-15	1.078	1993	07
<b>4</b>	1993-08-15	1.062	1993	08
...	...	...	...	...
<b>343</b>	2021-11-15	3.491	2021	11
<b>344</b>	2021-12-15	3.406	2021	12
<b>345</b>	2022-01-15	3.413	2022	01
<b>346</b>	2022-02-15	3.611	2022	02
<b>347</b>	2022-03-15	4.322	2022	03

348 rows × 4 columns

```
In [ ]: # get dfgas1  
dfgas1 = df_gas.iloc[81:,:]
```

```
# assign new df
dfmerge2 = dfmerge1

# convert into millions
dfmerge2.equity = dfmerge1.equity * 1000
dfmerge2.assets = dfmerge1.assets * 1000
# convert into 3 month average
dfmerge2.sales = dfmerge1.sales/3
dfmerge2.netIncome = dfmerge1.netIncome/3
dfmerge2.year = dfmerge2.year.astype(int)
dfmerge2.inflation = dfmerge2.inflation.astype(float)
```

In [ ]: dfmerge2.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 267 entries, 0 to 266
Data columns (total 10 columns):
 #   Column           Non-Null Count  Dtype  
---  --  
 0   adjustedClose    267 non-null    float64 
 1   volume           267 non-null    float64 
 2   year             267 non-null    int32  
 3   month            267 non-null    int64  
 4   sales            267 non-null    float64 
 5   netIncome         267 non-null    float64 
 6   assets            267 non-null    float64 
 7   equity            267 non-null    float64 
 8   inflation         267 non-null    float64 
 9   gas               267 non-null    float64 
dtypes: float64(8), int32(1), int64(1)
memory usage: 19.9 KB
```

In [ ]: # save to csv  
# dfmerge2.to\_csv('data/final\_df.csv')

Make Final DF after cleaning

```
# read csv file into a dataframe
df_merge = pd.read_csv('data/final_df.csv', index_col=0)

# change the column names
df_merge.rename(columns = {'adjustedClose':'AdjustedClose', 'volume':'Volume', 'year': 'Sales', 'netIncome':'NetIncome', 'assets':'Assets', 'gas':'GasPrice'}, inplace = True)

# show the renamed dataframe
df_merge
```

Out[ ]:	AdjustedClose	Volume	Year	Month	Sales	NetIncome	Assets	Equity	Inflati
<b>0</b>	18.2953	37687500.0	2000	1	3481.000000	348.000000	41250.0	18010.0	
<b>1</b>	16.4760	42961800.0	2000	2	3481.000000	348.000000	41250.0	18010.0	
<b>2</b>	20.3915	51176100.0	2000	3	3481.000000	348.000000	41250.0	18010.0	
<b>3</b>	18.7790	31502600.0	2000	4	3987.333333	372.000000	41380.0	18750.0	
<b>4</b>	20.5234	30692800.0	2000	5	3987.333333	372.000000	41380.0	18750.0	
...	...	...	...	...	...	...	...	...	...
<b>262</b>	110.7529	224686287.0	2021	11	15402.333333	1685.000000	239540.0	139940.0	
<b>263</b>	115.1489	221128758.0	2021	12	15402.333333	1685.000000	239540.0	139940.0	
<b>264</b>	128.8667	300049707.0	2022	1	17729.000000	2086.333333	249050.0	147100.0	
<b>265</b>	142.7935	282783725.0	2022	2	17729.000000	2086.333333	249050.0	147100.0	
<b>266</b>	161.4657	526661468.0	2022	3	17729.000000	2086.333333	249050.0	147100.0	

267 rows × 10 columns

In [ ]: `# reorder the column  
df_merge=df_merge[['Year', 'Month', 'InflationRate', 'GasPrice', 'Sales', 'NetIncome',  
 'Volume', 'AdjustedClose']]  
# display the final dataframe  
df_merge.head()`

Out[ ]:	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	Adj
<b>0</b>	2000	1	2.7	1.329	3481.000000	348.0	41250.0	18010.0	37687500.0	
<b>1</b>	2000	2	3.2	1.415	3481.000000	348.0	41250.0	18010.0	42961800.0	
<b>2</b>	2000	3	3.8	1.556	3481.000000	348.0	41250.0	18010.0	51176100.0	
<b>3</b>	2000	4	3.1	1.506	3987.333333	372.0	41380.0	18750.0	31502600.0	
<b>4</b>	2000	5	3.2	1.526	3987.333333	372.0	41380.0	18750.0	30692800.0	

In [ ]: `# change the volume unit to million  
df_merge.Volume = df_merge.Volume/1000000  
df_merge`

Out[ ]:	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume
0	2000	1	2.7	1.329	3481.000000	348.000000	41250.0	18010.0	37.687500
1	2000	2	3.2	1.415	3481.000000	348.000000	41250.0	18010.0	42.961800
2	2000	3	3.8	1.556	3481.000000	348.000000	41250.0	18010.0	51.176100
3	2000	4	3.1	1.506	3987.333333	372.000000	41380.0	18750.0	31.502600
4	2000	5	3.2	1.526	3987.333333	372.000000	41380.0	18750.0	30.692800
...	...	...	...	...	...	...	...	...	...
262	2021	11	6.8	3.491	15402.333333	1685.000000	239540.0	139940.0	224.686287
263	2021	12	7.0	3.406	15402.333333	1685.000000	239540.0	139940.0	221.128758
264	2022	1	7.5	3.413	17729.000000	2086.333333	249050.0	147100.0	300.049707
265	2022	2	7.9	3.611	17729.000000	2086.333333	249050.0	147100.0	282.783725
266	2022	3	8.5	4.322	17729.000000	2086.333333	249050.0	147100.0	526.661468

267 rows × 10 columns

```
In [ ]: #formatting float column
#change the value of sales column to two decimal digits
df_merge[['Sales', 'NetIncome']] = df_merge[['Sales', 'NetIncome']].round(decimals=2)
# display the cleaned dataframe
df_merge
```

Out[ ]:	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	Ad
0	2000	1	2.7	1.329	3481.00	348.00	41250.0	18010.0	37.687500	
1	2000	2	3.2	1.415	3481.00	348.00	41250.0	18010.0	42.961800	
2	2000	3	3.8	1.556	3481.00	348.00	41250.0	18010.0	51.176100	
3	2000	4	3.1	1.506	3987.33	372.00	41380.0	18750.0	31.502600	
4	2000	5	3.2	1.526	3987.33	372.00	41380.0	18750.0	30.692800	
...	...	...	...	...	...	...	...	...	...	...
262	2021	11	6.8	3.491	15402.33	1685.00	239540.0	139940.0	224.686287	
263	2021	12	7.0	3.406	15402.33	1685.00	239540.0	139940.0	221.128758	
264	2022	1	7.5	3.413	17729.00	2086.33	249050.0	147100.0	300.049707	
265	2022	2	7.9	3.611	17729.00	2086.33	249050.0	147100.0	282.783725	
266	2022	3	8.5	4.322	17729.00	2086.33	249050.0	147100.0	526.661468	

267 rows × 11 columns

```
In [ ]: # save it to a csv file
# df_merge.to_csv('data/df_final_merge.csv')
```

# Exploratory Data Analysis (EDA)

```
In [ ]: df_merge = pd.read_csv('data/df_final_merge.csv', index_col=0)
```

```
In [ ]: # Get the basic information about the data
df_merge.info()
```

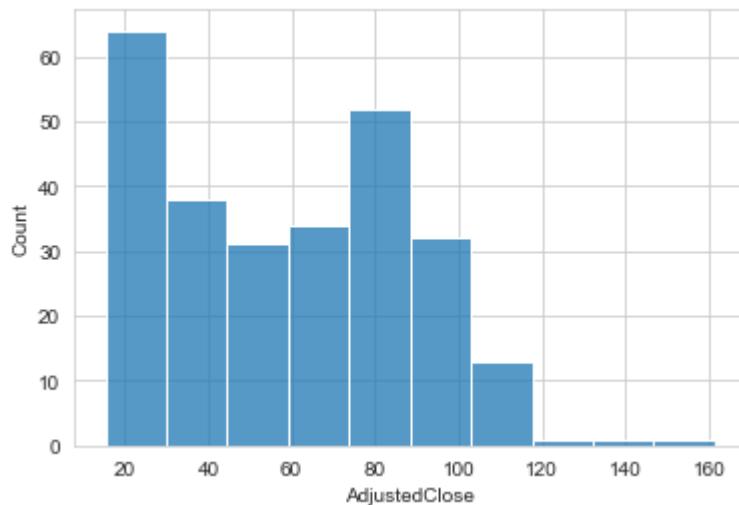
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 267 entries, 0 to 266
Data columns (total 10 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Year              267 non-null    int64  
 1   Month             267 non-null    int64  
 2   InflationRate     267 non-null    float64 
 3   GasPrice          267 non-null    float64 
 4   Sales             267 non-null    float64 
 5   NetIncome          267 non-null    float64 
 6   Assets             267 non-null    float64 
 7   Equity             267 non-null    float64 
 8   Volume             267 non-null    float64 
 9   AdjustedClose      267 non-null    float64 
dtypes: float64(8), int64(2)
memory usage: 22.9 KB
```

```
In [ ]: # Get the statistics of the data
df_merge.describe()
```

Out[ ]:	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets
<b>count</b>	267.000000	267.000000	267.000000	267.000000	267.000000	267.000000	267.000000
<b>mean</b>	2010.629213	6.449438	2.310487	2.586599	13405.051910	1021.059213	179078.202247
<b>std</b>	6.436004	3.472809	1.500965	0.745405	5095.207885	911.020372	75466.124685
<b>min</b>	2000.000000	1.000000	-2.100000	1.127000	3481.000000	-2756.670000	40970.000000
<b>25%</b>	2005.000000	3.000000	1.500000	2.023000	10054.330000	510.330000	124810.000000
<b>50%</b>	2011.000000	6.000000	2.100000	2.606000	13271.670000	1157.000000	194740.000000
<b>75%</b>	2016.000000	9.000000	3.150000	3.098500	17659.000000	1650.000000	253810.000000
<b>max</b>	2022.000000	12.000000	8.500000	4.322000	26987.330000	2631.000000	269600.000000

```
In [ ]: # check the distribution of our target column
sns.histplot(df_merge['AdjustedClose'])
```

```
Out[ ]: <AxesSubplot:xlabel='AdjustedClose', ylabel='Count'>
```



It looks like the chevron stock price is not normally distributed. The average price is falling somewhat around 60 dollars, with more price falling on 20 dollars.

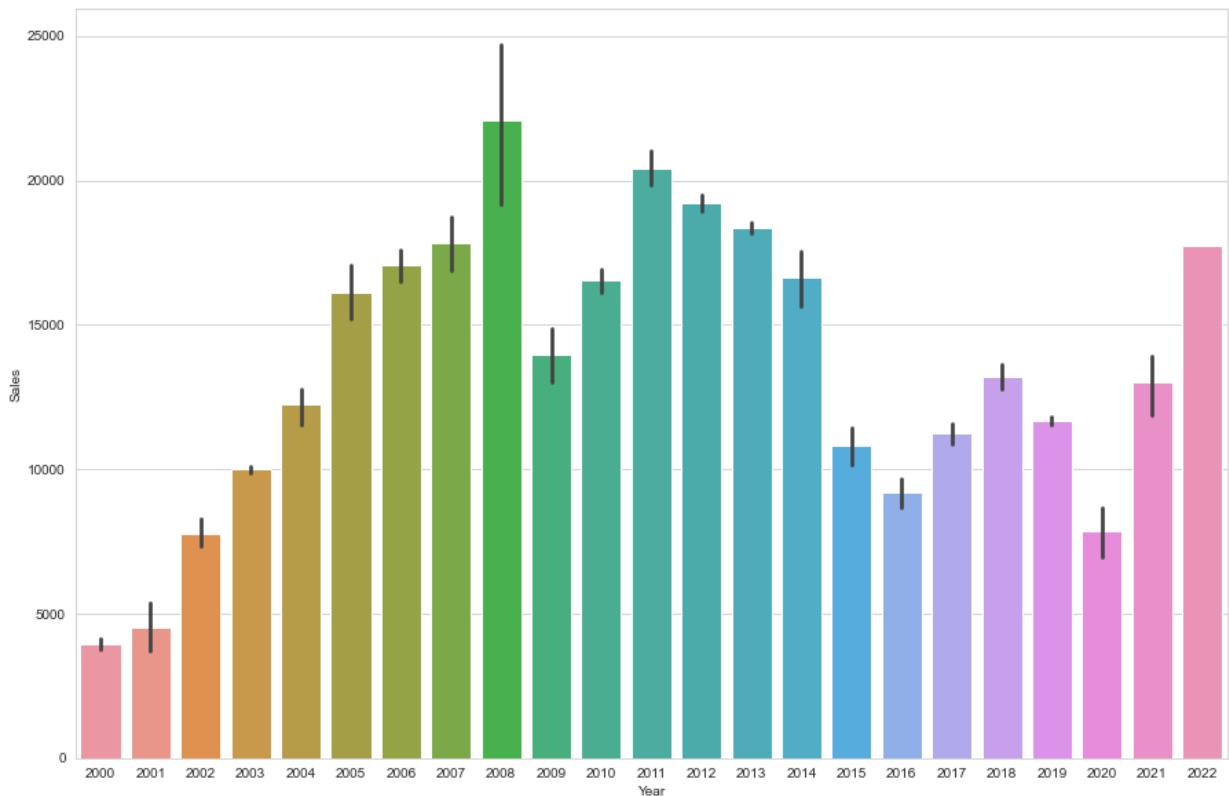
```
In [ ]: # We want to know the yearly sales change  
# we need to group the rows by year  
df_merge.groupby(['Year']).sum()
```

Out[ ]:	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	Adj
Year									
<b>2000</b>	78	40.5	18.294	47526.99	5184.99	495750.0	226830.0	459.414600	
<b>2001</b>	78	33.8	17.594	54343.02	1716.96	625740.0	302130.0	667.807600	
<b>2002</b>	78	19.0	16.582	93484.98	1132.02	928980.0	398370.0	731.539200	
<b>2003</b>	78	27.3	19.213	120031.98	7425.96	972090.0	418890.0	733.306700	
<b>2004</b>	78	32.2	22.695	146814.99	12688.02	1071390.0	504360.0	947.448650	
<b>2005</b>	78	40.6	27.746	193640.97	14098.98	1336470.0	654000.0	2082.211800	
<b>2006</b>	78	38.8	31.381	204891.99	17137.98	1577010.0	810870.0	2293.198000	
<b>2007</b>	78	34.4	34.146	214091.01	18687.99	1691910.0	893040.0	2511.090100	
<b>2008</b>	78	46.2	39.661	264957.99	23931.03	1928400.0	1005270.0	3900.184200	
<b>2009</b>	78	-4.2	28.760	167497.02	10482.99	1943430.0	1080240.0	2987.314100	
<b>2010</b>	78	19.5	34.003	198295.98	19023.99	2107950.0	1215360.0	2601.802600	
<b>2011</b>	78	38.0	42.917	245014.02	26895.00	2430090.0	1413420.0	2300.147100	
<b>2012</b>	78	25.0	44.234	230638.98	26178.99	2682330.0	1589010.0	1622.782500	
<b>2013</b>	78	17.8	42.917	220263.99	21422.97	2949150.0	1746450.0	1446.169700	
<b>2014</b>	78	19.6	41.304	199940.97	19240.98	3155250.0	1860180.0	1645.389372	
<b>2015</b>	78	1.5	30.156	129648.00	4587.00	3211830.0	1868160.0	2330.550128	
<b>2016</b>	78	15.2	27.030	110484.00	-497.01	3135780.0	1783440.0	2029.783638	
<b>2017</b>	78	25.4	30.364	134778.99	9195.00	3068040.0	1777230.0	1387.003718	
<b>2018</b>	78	29.4	33.808	158766.99	14823.99	3074520.0	1845780.0	1667.063566	
<b>2019</b>	78	21.8	32.229	140156.04	2924.01	3019980.0	1847010.0	1597.740600	
<b>2020</b>	78	14.8	27.117	94401.99	-5543.01	2768790.0	1632210.0	2832.904814	
<b>2021</b>	78	56.4	37.125	156290.97	15624.99	2891850.0	1630500.0	2639.808056	
<b>2022</b>	6	23.9	11.346	53187.00	6258.99	747150.0	441300.0	1109.494900	

◀ ▶

```
In [ ]: # Let's plot the yearly sales change with a scatterplot
plt.figure(figsize=(15, 10))
sns.barplot(data=df_merge, x='Year', y='Sales')
```

```
Out[ ]: <AxesSubplot:xlabel='Year', ylabel='Sales'>
```



The highest sales happened in 2008, and the lowest sales was in year 2000. After year 2020, the sales is very robust, increasing tremendously.

```
In [ ]: #add a new column named date to df_merge
#assign day as 1 so that the datatype of date becomes datetime
#this column is for implementing time series plotting
df_merge['Date']=pd.to_datetime(df_merge[['Year', 'Month']].assign(Day=1))
```

```
In [ ]: #display the new dataframe
df_merge
```

Out[ ]:	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	Ad
<b>0</b>	2000	1	2.7	1.329	3481.00	348.00	41250.0	18010.0	37.687500	
<b>1</b>	2000	2	3.2	1.415	3481.00	348.00	41250.0	18010.0	42.961800	
<b>2</b>	2000	3	3.8	1.556	3481.00	348.00	41250.0	18010.0	51.176100	
<b>3</b>	2000	4	3.1	1.506	3987.33	372.00	41380.0	18750.0	31.502600	
<b>4</b>	2000	5	3.2	1.526	3987.33	372.00	41380.0	18750.0	30.692800	
...	...	...	...	...	...	...	...	...	...	...
<b>262</b>	2021	11	6.8	3.491	15402.33	1685.00	239540.0	139940.0	224.686287	
<b>263</b>	2021	12	7.0	3.406	15402.33	1685.00	239540.0	139940.0	221.128758	
<b>264</b>	2022	1	7.5	3.413	17729.00	2086.33	249050.0	147100.0	300.049707	
<b>265</b>	2022	2	7.9	3.611	17729.00	2086.33	249050.0	147100.0	282.783725	
<b>266</b>	2022	3	8.5	4.322	17729.00	2086.33	249050.0	147100.0	526.661468	

267 rows × 11 columns

In [ ]: `#create a new dataframe to store columns for time series analysis  
#setting the Date as index  
df_timeseries=df_merge[['Date','GasPrice', 'Sales', 'AdjustedClose']].set_index('Date')  
#display the dataframe  
df_timeseries`

Out[ ]:

	GasPrice	Sales	AdjustedClose
Date			
<b>2000-01-01</b>	1.329	3481.00	18.2953
<b>2000-02-01</b>	1.415	3481.00	16.4760
<b>2000-03-01</b>	1.556	3481.00	20.3915
<b>2000-04-01</b>	1.506	3987.33	18.7790
<b>2000-05-01</b>	1.526	3987.33	20.5234
...	...	...	...
<b>2021-11-01</b>	3.491	15402.33	110.7529
<b>2021-12-01</b>	3.406	15402.33	115.1489
<b>2022-01-01</b>	3.413	17729.00	128.8667
<b>2022-02-01</b>	3.611	17729.00	142.7935
<b>2022-03-01</b>	4.322	17729.00	161.4657

267 rows × 3 columns

```
In [ ]: # normalize all the column data and plot them together to see the different trends
df_scaled = df_timeseries

# construct a scaler
scaler= MinMaxScaler()
df_scaled.iloc[:, :] = scaler.fit_transform(df_timeseries)
```

```
In [ ]: df_scaled
```

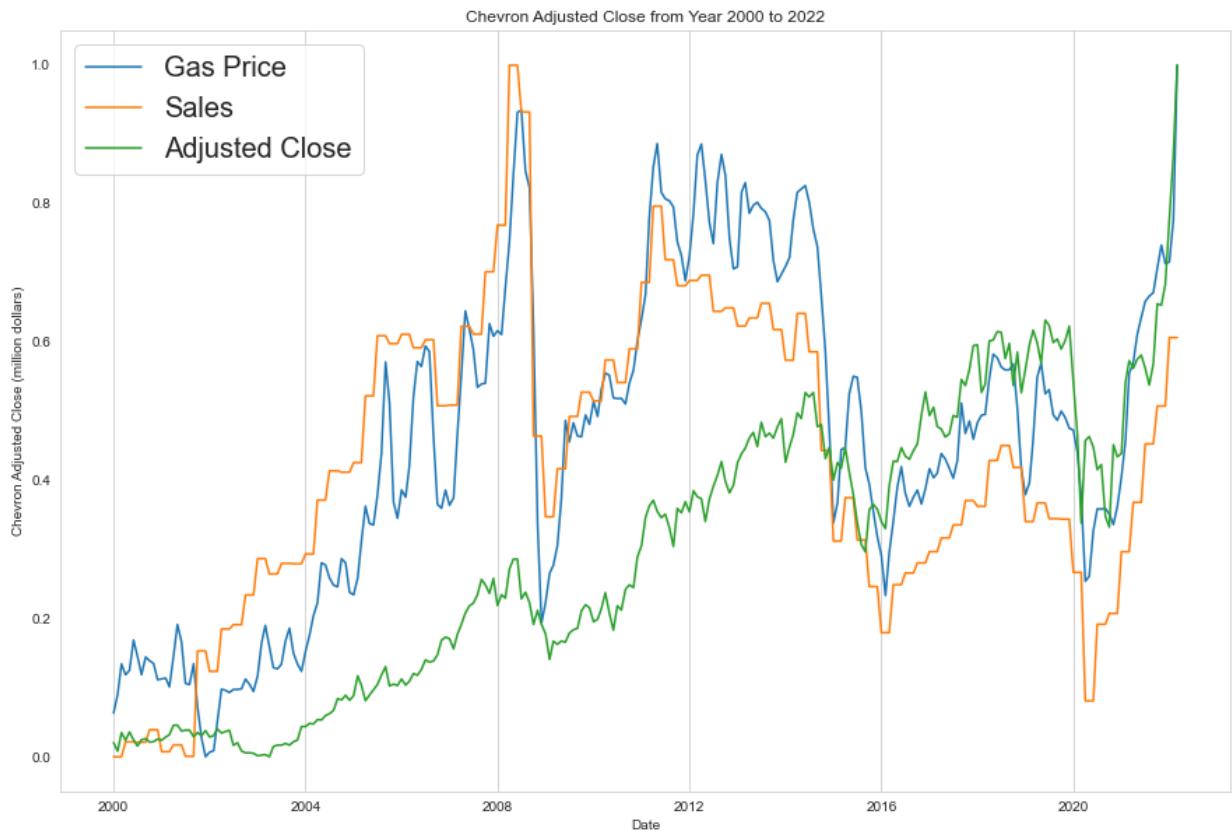
Out[ ]:

	GasPrice	Sales	AdjustedClose
Date			
2000-01-01	0.063224	0.000000	0.020562
2000-02-01	0.090141	0.000000	0.008116
2000-03-01	0.134272	0.000000	0.034902
2000-04-01	0.118623	0.021540	0.023871
2000-05-01	0.124883	0.021540	0.035805
...	...	...	...
2021-11-01	0.739906	0.507154	0.653071
2021-12-01	0.713302	0.507154	0.683144
2022-01-01	0.715493	0.606135	0.776988
2022-02-01	0.777465	0.606135	0.872262
2022-03-01	1.000000	0.606135	1.000000

267 rows × 3 columns

```
In [ ]: plt.figure(figsize=(15, 10))
plt.plot(df_scaled['GasPrice'])
plt.plot(df_scaled['Sales'])
plt.plot(df_scaled['AdjustedClose'])

plt.grid(axis='y')
plt.title('Chevron Adjusted Close from Year 2000 to 2022')
plt.xlabel('Date')
plt.ylabel('Chevron Adjusted Close (million dollars)')
plt.legend(['Gas Price', 'Sales', 'Adjusted Close'], prop={'size':20})
plt.show()
```



The gas price, sales, and adjusted close are very consistent in value, especially the gas price and sales.

## Explore the Relationship between Inflation Rate and Stock Price

- Examine whether inflation rate can predict stock price
- Convert stock price to a percent change since inflation rate is a percent change

```
In [ ]: # create a list for monthly data
df_merge['AdjustedCloseChange']=df_merge['AdjustedClose']/df_merge['AdjustedClose'].shift(1)
df_change=df_merge[['Date', 'AdjustedCloseChange', 'InflationRate']].set_index('Date')
```

```
In [ ]: df_change
```

Out[ ]:

AdjustedCloseChange InflationRate

Date	AdjustedClose	Change	InflationRate
2000-01-01	NaN	2.7	
2000-02-01	-9.944084	3.2	
2000-03-01	23.764870	3.8	
2000-04-01	-7.907707	3.1	
2000-05-01	9.289100	3.2	
...	...	...	
2021-11-01	-0.270411	6.8	
2021-12-01	3.969196	7.0	
2022-01-01	11.913097	7.5	
2022-02-01	10.807136	7.9	
2022-03-01	13.076366	8.5	

267 rows × 2 columns

In [ ]: `# drop the first row that contains null value  
df_change.drop(index='2000-01-01')`

Out[ ]:

AdjustedCloseChange InflationRate

Date	AdjustedClose	Change	InflationRate
2000-02-01	-9.944084	3.2	
2000-03-01	23.764870	3.8	
2000-04-01	-7.907707	3.1	
2000-05-01	9.289100	3.2	
2000-06-01	-8.194549	3.7	
...	...	...	
2021-11-01	-0.270411	6.8	
2021-12-01	3.969196	7.0	
2022-01-01	11.913097	7.5	
2022-02-01	10.807136	7.9	
2022-03-01	13.076366	8.5	

266 rows × 2 columns

Visualize the infaltion rate and stock price change and their relationships

In [ ]: `# set the style of the plot to be white  
sns.set_style('white')`

```

# set the figure size of the plot to be 15 width and 8 height
fig, ax1 = plt.subplots(figsize=(15, 8))

# create a twin axes sharing the xaxis
# create a new axes with an invisible x-axis and an independent y-axis positioned oppo
ax2 = ax1.twinx()

# plot inflation rate on ax1
ax1.plot(df_change.index, df_change.InflationRate,
          color="green", label="InflationRate")

#set positive adjusted close change as df_change_plus
df_change_plus=df_change[df_change['AdjustedCloseChange']>=0]

#position positive adjusted close change above x-axis
#set the line of color to be red
ax2.bar(df_change_plus.index, df_change_plus['AdjustedCloseChange'],
        color='red', alpha=0.5, width=20, label='Chevron Adjusted Close(positive)')

#create a dataframe to store negative adjusted close change
df_change_minus = df_change[df_change['AdjustedCloseChange']<0]

#position negative adjusted close change below x-axis
#set the line of color to be blue
ax2.bar(df_change_minus.index, df_change_minus['AdjustedCloseChange'],
        color='blue', alpha=0.5, width=40, label='Chevron Adjusted Close(negative)')

#set a line of value 2 in ax1 as a baseline to see the deviation of inflation rate
ax1.axhline(2, color='gray', linestyle='--')

#set the font size of tick labels
plt.tick_params(labelsize=10)

#set title and fontsize
plt.title("Inflation vs. Chevron Stock Price", fontsize=15)

#get the handler and label of legend for ax1 and ax2
handler1, label1 = ax1.get_legend_handles_labels()
handler2, label2 = ax2.get_legend_handles_labels()

#set the corresponding legend for both ax1 and ax2
#set the location to be upper left, which is location code 2
#set the pad between the axes and legend border to be 0
ax1.legend(handler1 + handler2, label1 + label2, loc=2, borderaxespad=0.)

#set x label to be Date
ax1.set_xlabel("Date")

#set y label for ax1
ax1.set_ylabel("Inflation Rate(%)")

#set y label for ax2
ax2.set_ylabel("Chevron Adjusted Price Change(%)")

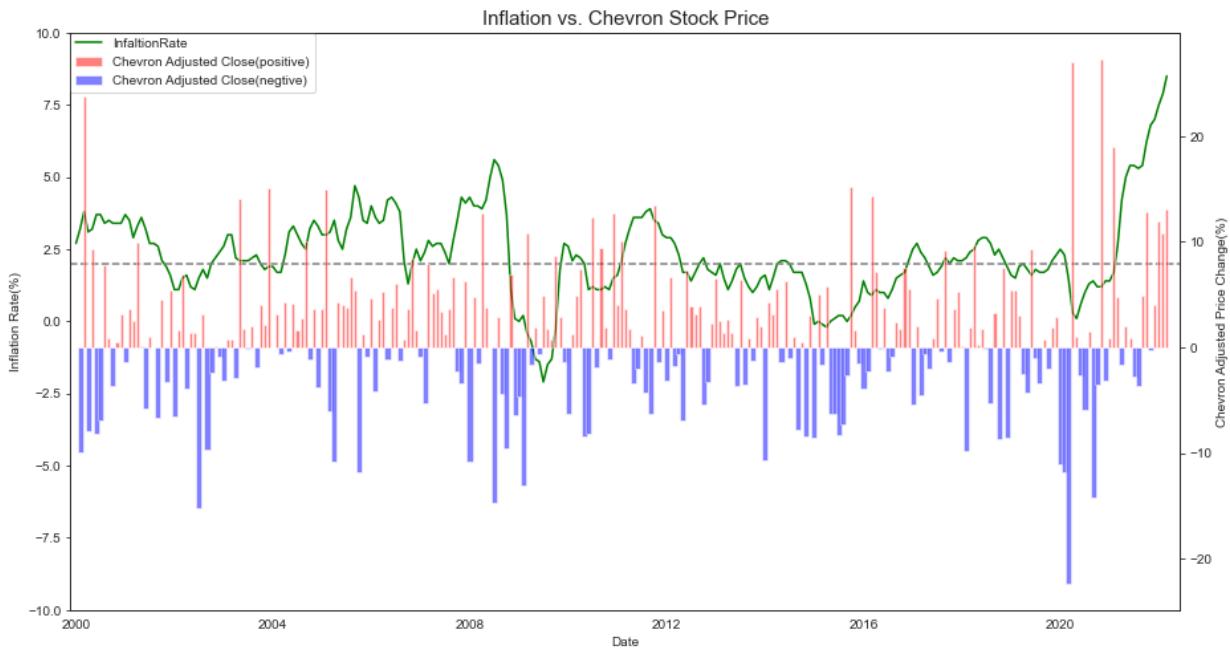
#set ylim for ax1
ax1.set_ylim([-10, 10])

#set xlim for ax1, add a little time difference from both the left and right y-axis
ax1.set_xlim([min(df_change.index) - dt.timedelta(days=40),

```

```
max(df_change.index) + dt.timedelta(days=100])]

#display the plot
plt.show()
```



- Both inflation rate and Chevron stock price are volatile.
- The inflation rate is positive most of the time, but plummets after year 2008 to a negative value. It increases dramatically after year 2020 to an unprecedented high value.
- The Chevron stock price change has more positive values than negative values, meaning it is increasing generally. However, it plummets in 2020 and rebounces in 2022.
- Although it appears that blue bars appear when inflation is bad, red bars are also present.

```
In [ ]: change_scaler = MinMaxScaler(feature_range=(-1,1))
df_change2 = df_change.copy()
df_change2.iloc[:, :] = change_scaler.fit_transform(df_change2)
df_change2
```

Out[ ]:

**AdjustedCloseChange   InflationRate**

Date	AdjustedCloseChange	InflationRate
2000-01-01	NaN	-9.433962e-02
2000-02-01	-0.499646	1.110223e-16
2000-03-01	0.857734	1.132075e-01
2000-04-01	-0.417646	-1.886792e-02
2000-05-01	0.274829	1.110223e-16
...	...	...
2021-11-01	-0.110110	6.792453e-01
2021-12-01	0.060609	7.169811e-01
2022-01-01	0.380491	8.113208e-01
2022-02-01	0.335957	8.867925e-01
2022-03-01	0.427333	1.000000e+00

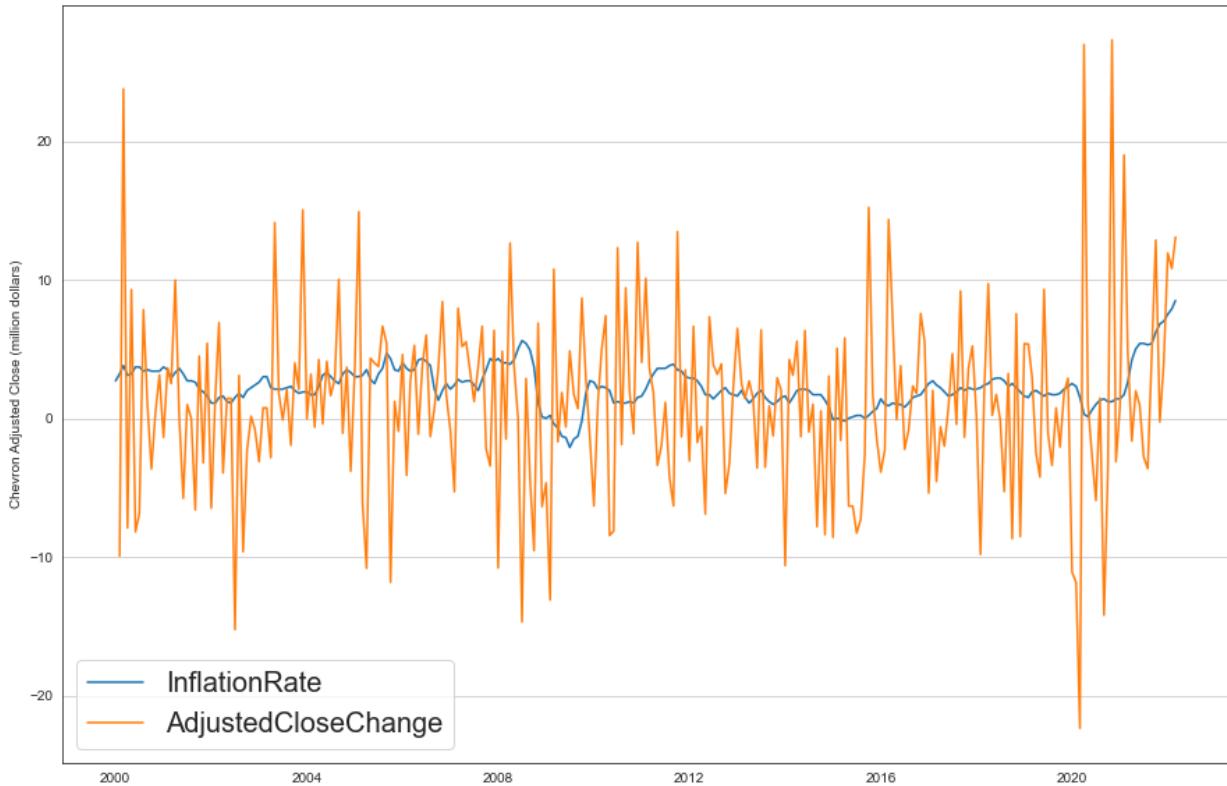
267 rows × 2 columns

In [ ]:

```
plt.figure(figsize=(15, 10))
plt.plot(df_change['InflationRate'])
plt.plot(df_change['AdjustedCloseChange'])
plt.grid(axis='y')
plt.title('Chevron Adjusted Close from Year 2000 to 2022')

plt.ylabel('Chevron Adjusted Close (million dollars)')
plt.legend(['InflationRate', 'AdjustedCloseChange'], prop={'size':20})
plt.show()
```

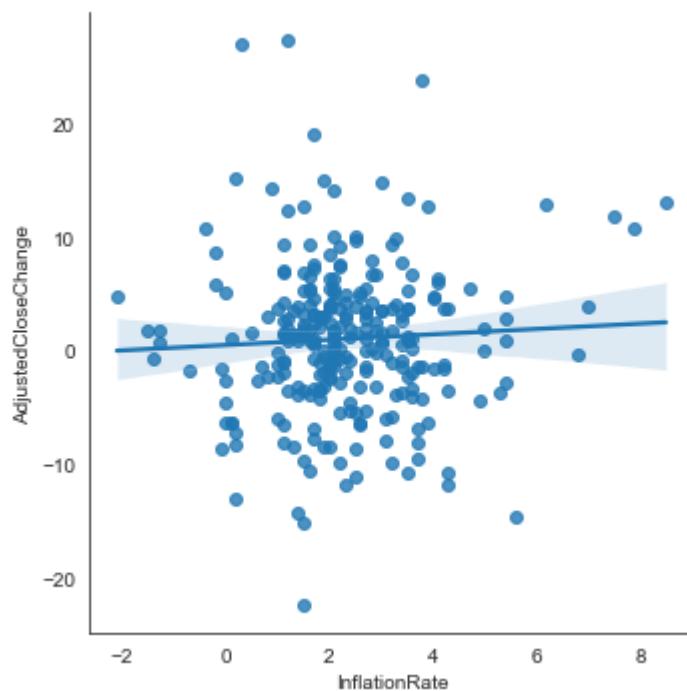
Chevron Adjusted Close from Year 2000 to 2022



As you can see stock market is way more volatile than inflation.

```
In [ ]: # Let's draw a Linear regression plot to examine the relationship between inflation rate and adjusted close change
sns.lmplot(x='InflationRate', y='AdjustedCloseChange', data=df_change)
```

```
Out[ ]: <seaborn.axisgrid.FacetGrid at 0x19dc032e4c0>
```



The trend line shows that there is a positive correlation between inflation rate and chevron stock price change. When inflation rate increases, the adjusted close change increases. However,

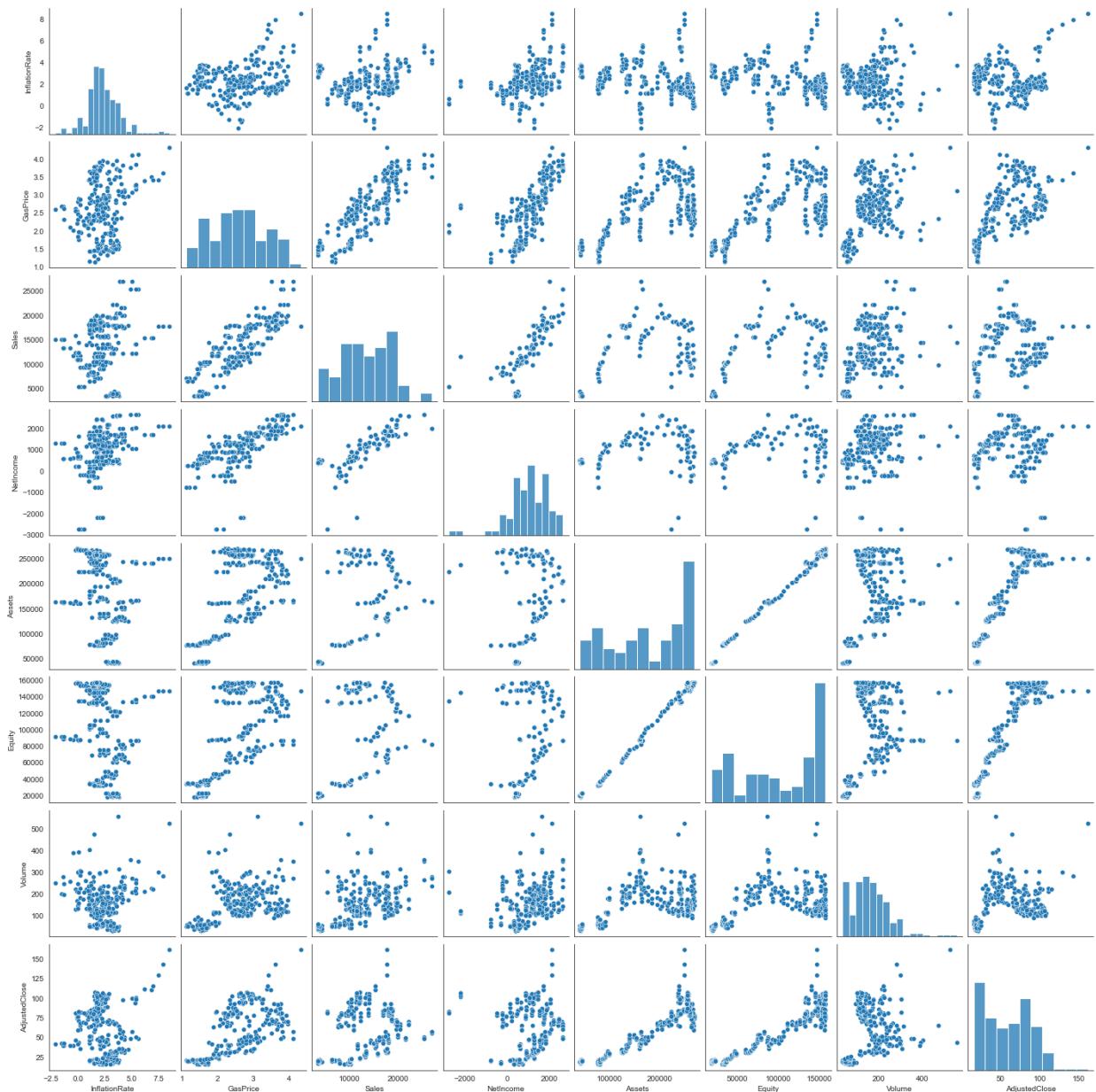
the correlation is very weak. When inflation rate is high, it doesn't necessarily mean the stock performance is good.

### Pairplot

```
In [ ]: # create a column variable to store the columns that we want to retrieve
cols = ['InflationRate', 'GasPrice', 'Sales', 'NetIncome', 'Assets', 'Equity', 'Volume', 'AdjustedClose']

# create a pairplot to visualize the relationship between any two columns
sns.pairplot(df_merge[cols], height = 2.5)

# show the plot
plt.show()
```

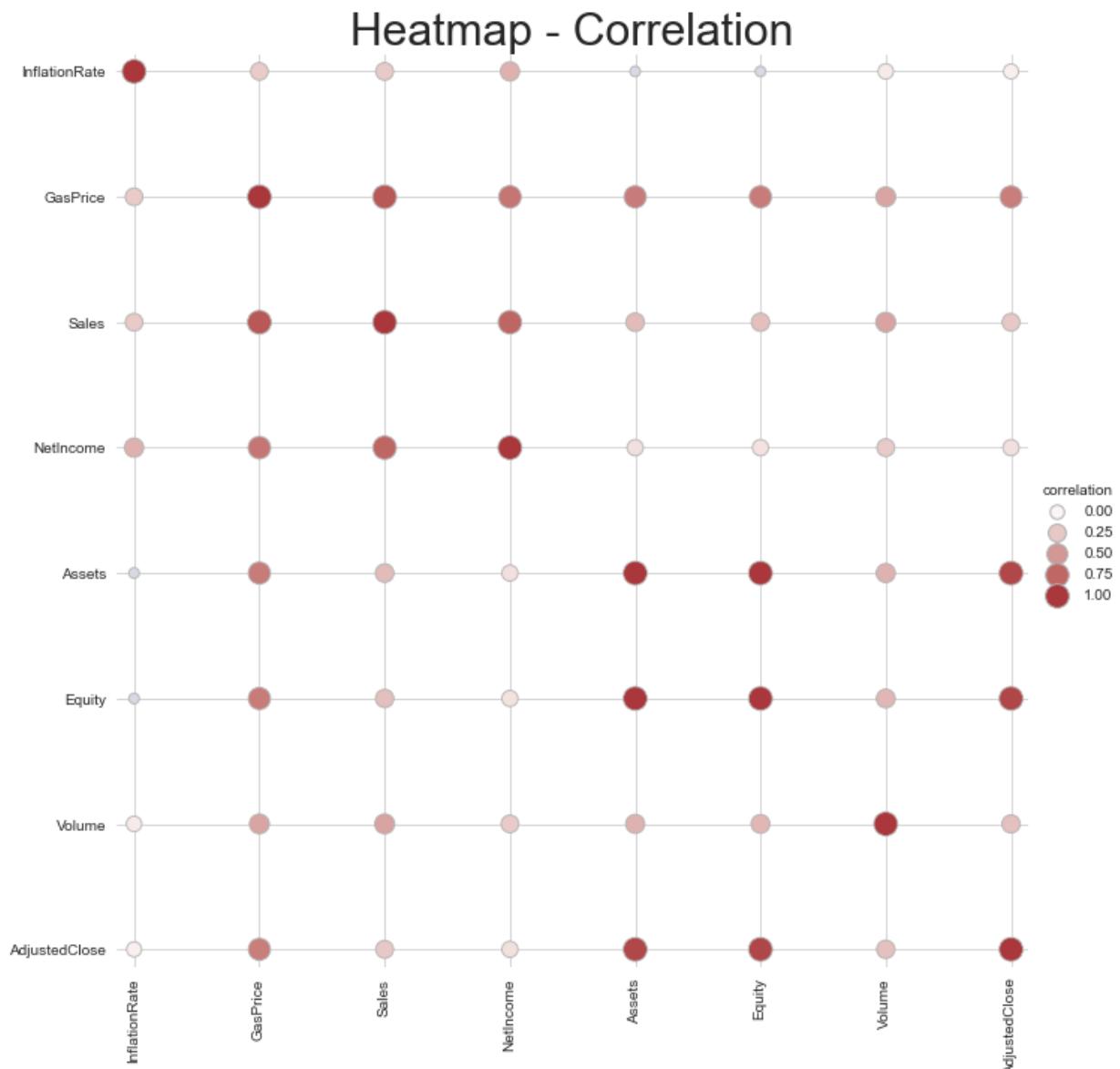


- The adjusted close has positive correlation with gas price, sales, net income, assets and equity.
- Let's draw a heatmap to see how strong they are correlated.

```
In [ ]: # plot a heatmap to explicitly show the correlation between any two features
# Compute a correlation matrix and convert to long-form
corr_mat = df_merge[cols].corr().stack().reset_index(name="correlation")
sns.set_style('whitegrid')
# Draw each cell as a scatter point with varying size and color
g = sns.relplot(data=corr_mat,x="level_0", y="level_1", hue="correlation", size="correlation")

# Tweak the figure to finalize
g.set(xlabel="", ylabel="", aspect="equal")
g.despine(left=True, bottom=True)
g.ax.margins(.02)
for label in g.ax.get_xticklabels():
    label.set_rotation(90)
for artist in g.legend.legendHandles:
    artist.set_edgecolor(".7")
plt.title('Heatmap - Correlation', fontsize=30)
```

Out[ ]: Text(0.5, 1.0, 'Heatmap - Correlation')



- The Chevron sales has a strong correlation with gas price.
- The adjusted close has moderate to strong correlation with gas price, assets, and equity.

In [ ]: df\_merge.head()

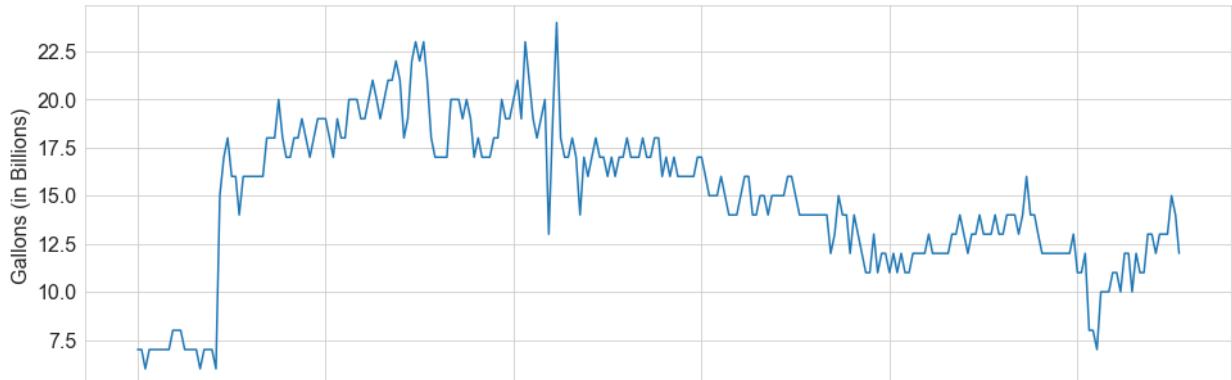
	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	AdjustedClos
0	2000	1	2.7	1.329	3481.00	348.0	41250.0	18010.0	37.6875	18.29
1	2000	2	3.2	1.415	3481.00	348.0	41250.0	18010.0	42.9618	16.47
2	2000	3	3.8	1.556	3481.00	348.0	41250.0	18010.0	51.1761	20.39
3	2000	4	3.1	1.506	3987.33	372.0	41380.0	18750.0	31.5026	18.77
4	2000	5	3.2	1.526	3987.33	372.0	41380.0	18750.0	30.6928	20.52

In [ ]: # create gallons Sold  
df\_merge['RegSales'] = (df\_merge.Sales \* 3) / 1000  
df\_merge['GallonsSold'] = (df\_merge.RegSales / df\_merge.GasPrice)  
df\_merge.GallonsSold = df\_merge.GallonsSold.astype(int)  
df\_merge['DateYM'] = pd.to\_datetime(df\_merge.Date).dt.to\_period('M')  
df\_merge.head(1)

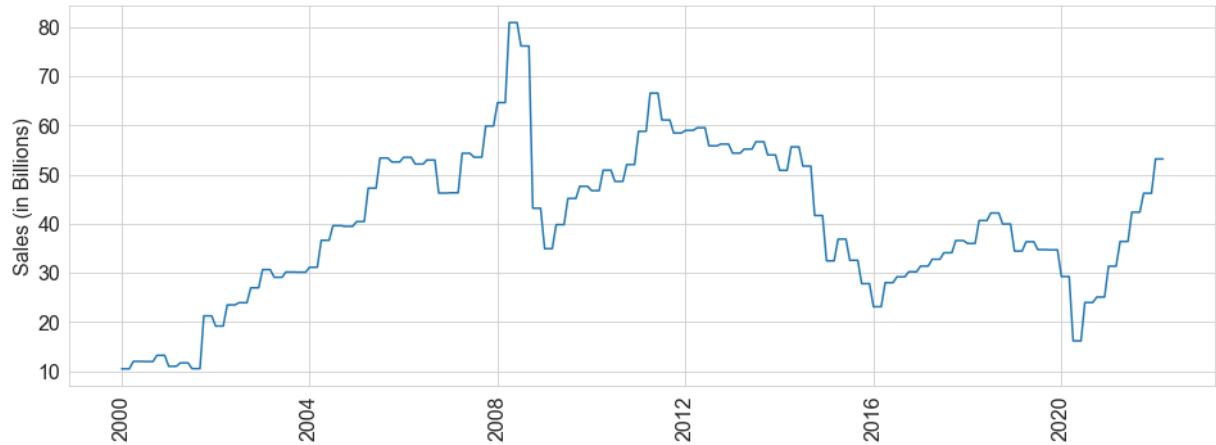
	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	AdjustedClos
0	2000	1	2.7	1.329	3481.0	348.0	41250.0	18010.0	37.6875	18.295

In [ ]: fig, (axes1, axes2) = plt.subplots(2,1, figsize=(16,12), sharex=True)  
# plt.tick\_params(axis='both', which='major', labelsize=22)  
plt.subplot(2,1,1)  
# plt.subplots\_adjust(wspace=.9, hspace=2)  
axes1.plot(df\_merge.Date, df\_merge.GallonsSold)  
axes1.set\_title('Gallons Sold Over Time', fontsize=22)  
axes1.set\_ylabel('Gallons (in Billions)', fontsize = 16)  
axes1.tick\_params(axis='both', which='both', labelsize=16)  
  
axes2.plot(df\_merge.Date, df\_merge.RegSales)  
axes2.set\_title('Sales Over Time', fontsize=22)  
axes2.set\_ylabel('Sales (in Billions)', fontsize = 16)  
axes2.tick\_params(axis='both', which='both', labelsize=16)  
axes2.tick\_params(axis='x', labelrotation=90)

## Gallons Sold Over Time



## Sales Over Time



The Gallons of Gas is declining slowly, in the recent price hike, the consumption of gallons of gas decreased.

## Machine Learning

### Data Pre Processing

```
In [ ]: # df_merge.to_csv('data/mldata.csv')
dffinal= pd.read_csv('data/mldata.csv', index_col= 0)
```

```
In [ ]: dffinal.head(2)
```

	Year	Month	InflationRate	GasPrice	Sales	NetIncome	Assets	Equity	Volume	AdjustedClos
<b>0</b>	2000	1	2.7	1.329	3481.0	348.0	41250.0	18010.0	37.6875	18.295
<b>1</b>	2000	2	3.2	1.415	3481.0	348.0	41250.0	18010.0	42.9618	16.476

```
In [ ]: dffinal.columns
```

```
Out[ ]: Index(['Year', 'Month', 'InflationRate', 'GasPrice', 'Sales', 'NetIncome',
   'Assets', 'Equity', 'Volume', 'AdjustedClose', 'Date',
   'AdjustedCloseChange', 'RegSales', 'GallonsSold', 'DateYM'],
  dtype='object')
```

## Feature Scaling

```
In [ ]: ##### MANUAL Train Test Split #####
# Since this is Time Series, we need split manually
# calculate train_size and test_size
train_size = int(len(dffinal)*0.8)
test_size = len(dffinal)-train_size

# split df
traindf, testdf = dffinal.iloc[0:train_size], dffinal.iloc[train_size:]

# columns needed
featureColumns = ['GasPrice', 'Equity', 'GallonsSold', 'Volume', 'InflationRate']
targetColumns = ['AdjustedClose']

# Since data has wide range, apply Standard Scale
# X Scaler
featureScaler = StandardScaler()
X_train = traindf[featureColumns] = featureScaler.fit_transform(traindf[featureColumns])
X_test = testdf[featureColumns] = featureScaler.transform(testdf[featureColumns].to_nu

# y Scaler
targetScaler = StandardScaler()
y_train = traindf[targetColumns] = targetScaler.fit_transform(traindf[targetColumns])
y_test = testdf[targetColumns] = targetScaler.transform(testdf[targetColumns])
```

```
In [ ]: # saving to pickle file
with open('output/featureScaler.pickle', 'wb') as handle1:
    pickle.dump(featureScaler, handle1, protocol=pickle.HIGHEST_PROTOCOL)

with open('output/targetScaler.pickle', 'wb') as handle2:
    pickle.dump(targetScaler, handle2, protocol=pickle.HIGHEST_PROTOCOL)
```

```
In [ ]: # Convert dimension for LSTM
Xt, yt = convSeq(traindf[featureColumns], traindf[targetColumns], 6)

Xv, yv = convSeq(testdf[featureColumns], testdf[targetColumns], 6)

print(X_train.shape)
print(Xt.shape)

(213, 5)
(207, 6, 5)
```

## Machine Learning

```
In [ ]: linear = LinearRegression()
ridge = Ridge()
randomForest = RandomForestRegressor()
xgb = XGBRegressor()
```

```
In [ ]: # mL
```

```

runML(linear,X_train,y_train,X_test,y_test)
runML(ridge,X_train,y_train,X_test,y_test)
runML(randomForest,X_train,y_train,X_test,y_test)
runML(xgb,X_train,y_train,X_test,y_test)

LinearRegression()
MAE score: 0.7940844727976012
MSE score: 0.8656600278614126

Ridge()
MAE score: 0.8103014998636389
MSE score: 0.8962780139211289

RandomForestRegressor()
MAE score: 0.8342168200717905
MSE score: 1.167616764866167

XGBRegressor(base_score=0.5, booster='gbtree', callbacks=None,
             colsample_bylevel=1, colsample_bynode=1, colsample_bytree=1,
             early_stopping_rounds=None, enable_categorical=False,
             eval_metric=None, gamma=0, gpu_id=-1, grow_policy='depthwise',
             importance_type=None, interaction_constraints='',
             learning_rate=0.300000012, max_bin=256, max_cat_to_onehot=4,
             max_delta_step=0, max_depth=6, max_leaves=0, min_child_weight=1,
             missing=nan, monotone_constraints='()', n_estimators=100, n_jobs=0,
             num_parallel_tree=1, predictor='auto', random_state=0, reg_alpha=0,
             reg_lambda=1, ...)
MAE score: 0.8587077470027596
MSE score: 1.2840163362590031

```

## Deep Learning

### ANN

```

In [ ]: # since ANN takes two dimension, we use X_train
# Features and optimizers
optimizer = 'rmsprop'

# Model
ann = Sequential()

# Hidden Layer 1
ann.add(Flatten(input_shape=(traindf[featureColumns].shape[1], 1)))
ann.add(Dense(16))
ann.add(LeakyReLU(alpha=0.05))

# Hidden Layer 2
ann.add(Dense(4))
ann.add(LeakyReLU(alpha=0.05))

# output layer
ann.add(Dense(1))

### compile the model using: optimizer = 'adam', loss = 'binary_crossentropy', metrics
ann.compile(loss='mse', optimizer=optimizer, metrics=['mse', 'mae'])

```

```
# model summary  
ann.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
<hr/>		
flatten (Flatten)	(None, 3)	0
dense (Dense)	(None, 16)	64
leaky_re_lu (LeakyReLU)	(None, 16)	0
dense_1 (Dense)	(None, 4)	68
leaky_re_lu_1 (LeakyReLU)	(None, 4)	0
dense_2 (Dense)	(None, 1)	5
<hr/>		
Total params: 137		
Trainable params: 137		
Non-trainable params: 0		

---

```
In [ ]: history = ann.fit(traindf[featureColumns], traindf[targetColumns], epochs=50, batch_si
```

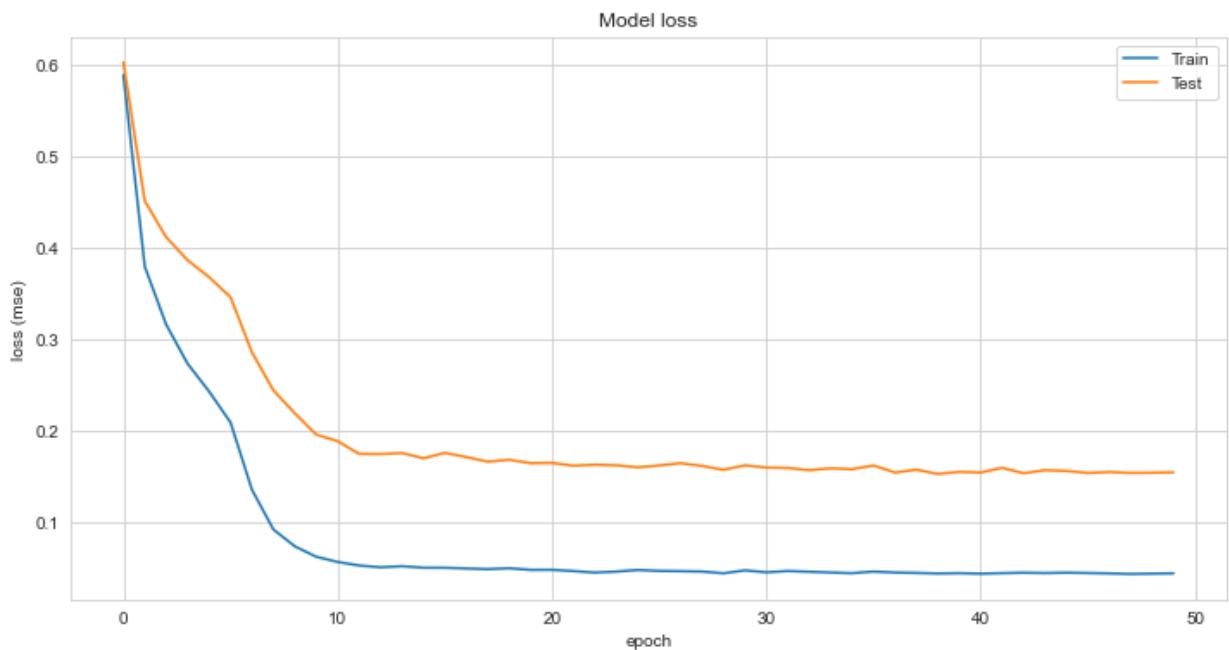
Epoch 1/50  
107/107 [=====] - 1s 3ms/step - loss: 0.5889 - mse: 0.5889 -  
mae: 0.6029 - val\_loss: 4.2499 - val\_mse: 4.2499 - val\_mae: 1.9328  
Epoch 2/50  
107/107 [=====] - 0s 1ms/step - loss: 0.3793 - mse: 0.3793 -  
mae: 0.4509 - val\_loss: 3.5887 - val\_mse: 3.5887 - val\_mae: 1.7282  
Epoch 3/50  
107/107 [=====] - 0s 1ms/step - loss: 0.3158 - mse: 0.3158 -  
mae: 0.4115 - val\_loss: 3.2739 - val\_mse: 3.2739 - val\_mae: 1.6353  
Epoch 4/50  
107/107 [=====] - 0s 1ms/step - loss: 0.2731 - mse: 0.2731 -  
mae: 0.3863 - val\_loss: 3.2231 - val\_mse: 3.2231 - val\_mae: 1.6424  
Epoch 5/50  
107/107 [=====] - 0s 2ms/step - loss: 0.2428 - mse: 0.2428 -  
mae: 0.3679 - val\_loss: 2.7911 - val\_mse: 2.7911 - val\_mae: 1.4978  
Epoch 6/50  
107/107 [=====] - 0s 1ms/step - loss: 0.2089 - mse: 0.2089 -  
mae: 0.3459 - val\_loss: 2.4485 - val\_mse: 2.4485 - val\_mae: 1.4100  
Epoch 7/50  
107/107 [=====] - 0s 1ms/step - loss: 0.1354 - mse: 0.1354 -  
mae: 0.2856 - val\_loss: 1.8600 - val\_mse: 1.8600 - val\_mae: 1.2267  
Epoch 8/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0919 - mse: 0.0919 -  
mae: 0.2440 - val\_loss: 1.6994 - val\_mse: 1.6994 - val\_mae: 1.1745  
Epoch 9/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0735 - mse: 0.0735 -  
mae: 0.2190 - val\_loss: 1.7085 - val\_mse: 1.7085 - val\_mae: 1.1893  
Epoch 10/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0621 - mse: 0.0621 -  
mae: 0.1956 - val\_loss: 1.5284 - val\_mse: 1.5284 - val\_mae: 1.1146  
Epoch 11/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0564 - mse: 0.0564 -  
mae: 0.1885 - val\_loss: 1.5182 - val\_mse: 1.5182 - val\_mae: 1.1190  
Epoch 12/50  
107/107 [=====] - 0s 2ms/step - loss: 0.0525 - mse: 0.0525 -  
mae: 0.1745 - val\_loss: 1.4908 - val\_mse: 1.4908 - val\_mae: 1.1044  
Epoch 13/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0506 - mse: 0.0506 -  
mae: 0.1744 - val\_loss: 1.6493 - val\_mse: 1.6493 - val\_mae: 1.1680  
Epoch 14/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0517 - mse: 0.0517 -  
mae: 0.1754 - val\_loss: 1.5501 - val\_mse: 1.5501 - val\_mae: 1.1319  
Epoch 15/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0501 - mse: 0.0501 -  
mae: 0.1697 - val\_loss: 1.4423 - val\_mse: 1.4423 - val\_mae: 1.0865  
Epoch 16/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0500 - mse: 0.0500 -  
mae: 0.1757 - val\_loss: 1.3389 - val\_mse: 1.3389 - val\_mae: 1.0461  
Epoch 17/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0493 - mse: 0.0493 -  
mae: 0.1711 - val\_loss: 1.4864 - val\_mse: 1.4864 - val\_mae: 1.1072  
Epoch 18/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0485 - mse: 0.0485 -  
mae: 0.1660 - val\_loss: 1.5620 - val\_mse: 1.5620 - val\_mae: 1.1370  
Epoch 19/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0495 - mse: 0.0495 -  
mae: 0.1681 - val\_loss: 1.4044 - val\_mse: 1.4044 - val\_mae: 1.0727  
Epoch 20/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0477 - mse: 0.0477 -  
mae: 0.1644 - val\_loss: 1.3542 - val\_mse: 1.3542 - val\_mae: 1.0505

Epoch 21/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0478 - mse: 0.0478 -  
mae: 0.1647 - val\_loss: 1.4882 - val\_mse: 1.4882 - val\_mae: 1.1061  
Epoch 22/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0464 - mse: 0.0464 -  
mae: 0.1616 - val\_loss: 1.5195 - val\_mse: 1.5195 - val\_mae: 1.1210  
Epoch 23/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0447 - mse: 0.0447 -  
mae: 0.1627 - val\_loss: 1.5392 - val\_mse: 1.5392 - val\_mae: 1.1324  
Epoch 24/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0458 - mse: 0.0458 -  
mae: 0.1620 - val\_loss: 1.4795 - val\_mse: 1.4795 - val\_mae: 1.1111  
Epoch 25/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0476 - mse: 0.0476 -  
mae: 0.1599 - val\_loss: 1.3286 - val\_mse: 1.3286 - val\_mae: 1.0361  
Epoch 26/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0466 - mse: 0.0466 -  
mae: 0.1619 - val\_loss: 1.2798 - val\_mse: 1.2798 - val\_mae: 1.0208  
Epoch 27/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0463 - mse: 0.0463 -  
mae: 0.1644 - val\_loss: 1.3441 - val\_mse: 1.3441 - val\_mae: 1.0447  
Epoch 28/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0459 - mse: 0.0459 -  
mae: 0.1613 - val\_loss: 1.3460 - val\_mse: 1.3460 - val\_mae: 1.0467  
Epoch 29/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0440 - mse: 0.0440 -  
mae: 0.1572 - val\_loss: 1.2290 - val\_mse: 1.2290 - val\_mae: 0.9923  
Epoch 30/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0472 - mse: 0.0472 -  
mae: 0.1620 - val\_loss: 1.2552 - val\_mse: 1.2552 - val\_mae: 1.0120  
Epoch 31/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0451 - mse: 0.0451 -  
mae: 0.1596 - val\_loss: 1.4233 - val\_mse: 1.4233 - val\_mae: 1.0807  
Epoch 32/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0465 - mse: 0.0465 -  
mae: 0.1592 - val\_loss: 1.2939 - val\_mse: 1.2939 - val\_mae: 1.0249  
Epoch 33/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0457 - mse: 0.0457 -  
mae: 0.1567 - val\_loss: 1.2935 - val\_mse: 1.2935 - val\_mae: 1.0282  
Epoch 34/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0448 - mse: 0.0448 -  
mae: 0.1588 - val\_loss: 1.2916 - val\_mse: 1.2916 - val\_mae: 1.0181  
Epoch 35/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0441 - mse: 0.0441 -  
mae: 0.1578 - val\_loss: 1.3041 - val\_mse: 1.3041 - val\_mae: 1.0275  
Epoch 36/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0459 - mse: 0.0459 -  
mae: 0.1619 - val\_loss: 1.1992 - val\_mse: 1.1992 - val\_mae: 0.9807  
Epoch 37/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0448 - mse: 0.0448 -  
mae: 0.1542 - val\_loss: 1.3608 - val\_mse: 1.3608 - val\_mae: 1.0526  
Epoch 38/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0444 - mse: 0.0444 -  
mae: 0.1573 - val\_loss: 1.2112 - val\_mse: 1.2112 - val\_mae: 0.9799  
Epoch 39/50  
107/107 [=====] - 0s 1ms/step - loss: 0.0437 - mse: 0.0437 -  
mae: 0.1527 - val\_loss: 1.4048 - val\_mse: 1.4048 - val\_mae: 1.0688  
Epoch 40/50  
107/107 [=====] - 0s 2ms/step - loss: 0.0441 - mse: 0.0441 -  
mae: 0.1548 - val\_loss: 1.1587 - val\_mse: 1.1587 - val\_mae: 0.9609

```
Epoch 41/50
107/107 [=====] - 0s 1ms/step - loss: 0.0436 - mse: 0.0436 -
mae: 0.1542 - val_loss: 1.2667 - val_mse: 1.2667 - val_mae: 1.0101
Epoch 42/50
107/107 [=====] - 0s 1ms/step - loss: 0.0441 - mse: 0.0441 -
mae: 0.1594 - val_loss: 1.1882 - val_mse: 1.1882 - val_mae: 0.9701
Epoch 43/50
107/107 [=====] - 0s 1ms/step - loss: 0.0446 - mse: 0.0446 -
mae: 0.1534 - val_loss: 1.3091 - val_mse: 1.3091 - val_mae: 1.0274
Epoch 44/50
107/107 [=====] - 0s 1ms/step - loss: 0.0442 - mse: 0.0442 -
mae: 0.1567 - val_loss: 1.3553 - val_mse: 1.3553 - val_mae: 1.0496
Epoch 45/50
107/107 [=====] - 0s 2ms/step - loss: 0.0447 - mse: 0.0447 -
mae: 0.1559 - val_loss: 1.2805 - val_mse: 1.2805 - val_mae: 1.0113
Epoch 46/50
107/107 [=====] - 0s 1ms/step - loss: 0.0443 - mse: 0.0443 -
mae: 0.1537 - val_loss: 1.2677 - val_mse: 1.2677 - val_mae: 1.0082
Epoch 47/50
107/107 [=====] - 0s 1ms/step - loss: 0.0438 - mse: 0.0438 -
mae: 0.1547 - val_loss: 1.1835 - val_mse: 1.1835 - val_mae: 0.9668
Epoch 48/50
107/107 [=====] - 0s 1ms/step - loss: 0.0433 - mse: 0.0433 -
mae: 0.1537 - val_loss: 1.1756 - val_mse: 1.1756 - val_mae: 0.9602
Epoch 49/50
107/107 [=====] - 0s 1ms/step - loss: 0.0436 - mse: 0.0436 -
mae: 0.1540 - val_loss: 1.4416 - val_mse: 1.4416 - val_mae: 1.0867
Epoch 50/50
107/107 [=====] - 0s 1ms/step - loss: 0.0439 - mse: 0.0439 -
mae: 0.1543 - val_loss: 1.1918 - val_mse: 1.1918 - val_mae: 0.9749
```

```
In [ ]: plt.figure(figsize=(12,6))
plt.plot(ann.history.history['loss'][:])
plt.plot(ann.history.history['mae'][:])
plt.title('Model loss')
plt.xlabel('epoch')
plt.ylabel('loss (mse)')
plt.legend(['Train', 'Test'], loc='upper right')
```

```
Out[ ]: <matplotlib.legend.Legend at 0x2c35d7e8a00>
```



```
In [ ]: # NN - this model takes in 3 dimension
inputs = Input(shape=(Xt.shape[1], Xt.shape[2]))
x = Flatten()(inputs)
x = Dense(16, activation=LeakyReLU(alpha=0.05))(x)
outputs = Dense(1)(x)
model = Model(inputs, outputs)

model.summary()

model.compile(optimizer=optimizer, loss="mse", metrics=['mse', "mae"])
history = model.fit(Xt, yt, epochs=50)
```

Model: "model"

Layer (type)	Output Shape	Param #
<hr/>		
input_1 (InputLayer)	[(None, 6, 3)]	0
flatten_1 (Flatten)	(None, 18)	0
dense_3 (Dense)	(None, 16)	304
dense_4 (Dense)	(None, 1)	17
<hr/>		
Total params: 321		
Trainable params: 321		
Non-trainable params: 0		

Epoch 1/50

7/7 [=====] - 0s 1ms/step - loss: 0.6585 - mse: 0.6585 - mae: 0.6286

Epoch 2/50

7/7 [=====] - 0s 1000us/step - loss: 0.3245 - mse: 0.3245 - mae: 0.4267

Epoch 3/50

7/7 [=====] - 0s 2ms/step - loss: 0.1996 - mse: 0.1996 - mae: 0.3349

Epoch 4/50

7/7 [=====] - 0s 1ms/step - loss: 0.1397 - mse: 0.1397 - mae: 0.2832

Epoch 5/50

7/7 [=====] - 0s 1ms/step - loss: 0.1119 - mse: 0.1119 - mae: 0.2604

Epoch 6/50

7/7 [=====] - 0s 1ms/step - loss: 0.1018 - mse: 0.1018 - mae: 0.2526

Epoch 7/50

7/7 [=====] - 0s 1ms/step - loss: 0.0965 - mse: 0.0965 - mae: 0.2463

Epoch 8/50

7/7 [=====] - 0s 2ms/step - loss: 0.0941 - mse: 0.0941 - mae: 0.2433

Epoch 9/50

7/7 [=====] - 0s 1ms/step - loss: 0.0907 - mse: 0.0907 - mae: 0.2357

Epoch 10/50

7/7 [=====] - 0s 1ms/step - loss: 0.0879 - mse: 0.0879 - mae: 0.2342

Epoch 11/50

7/7 [=====] - 0s 1ms/step - loss: 0.0853 - mse: 0.0853 - mae: 0.2301

Epoch 12/50

7/7 [=====] - 0s 1ms/step - loss: 0.0841 - mse: 0.0841 - mae: 0.2282

Epoch 13/50

7/7 [=====] - 0s 1ms/step - loss: 0.0813 - mse: 0.0813 - mae: 0.2269

Epoch 14/50

7/7 [=====] - 0s 999us/step - loss: 0.0782 - mse: 0.0782 - mae: 0.2181

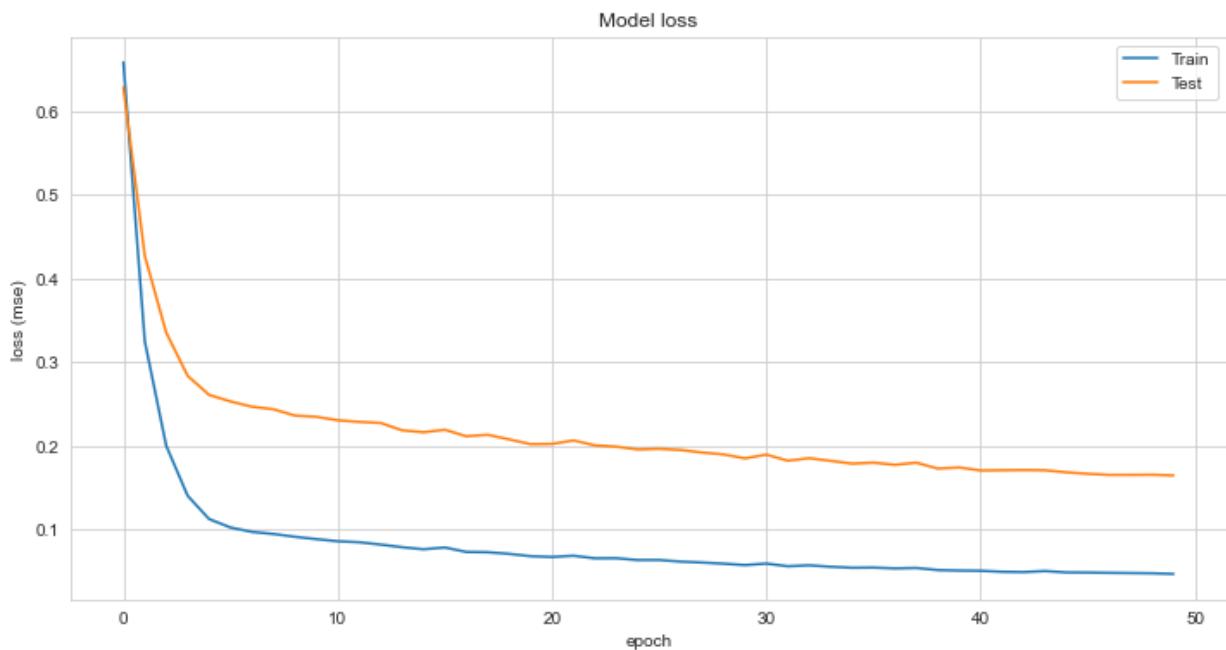
Epoch 15/50

7/7 [=====] - 0s 1ms/step - loss: 0.0757 - mse: 0.0757 - mae: 0.2157  
Epoch 16/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0779 - mse: 0.0779 - mae: 0.2187  
Epoch 17/50  
7/7 [=====] - 0s 999us/step - loss: 0.0725 - mse: 0.0725 - mae: 0.2110  
Epoch 18/50  
7/7 [=====] - 0s 999us/step - loss: 0.0722 - mse: 0.0722 - mae: 0.2127  
Epoch 19/50  
7/7 [=====] - 0s 999us/step - loss: 0.0702 - mse: 0.0702 - mae: 0.2072  
Epoch 20/50  
7/7 [=====] - 0s 2ms/step - loss: 0.0674 - mse: 0.0674 - mae: 0.2015  
Epoch 21/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0666 - mse: 0.0666 - mae: 0.2018  
Epoch 22/50  
7/7 [=====] - 0s 999us/step - loss: 0.0680 - mse: 0.0680 - mae: 0.2060  
Epoch 23/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0649 - mse: 0.0649 - mae: 0.2001  
Epoch 24/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0650 - mse: 0.0650 - mae: 0.1985  
Epoch 25/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0628 - mse: 0.0628 - mae: 0.1952  
Epoch 26/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0629 - mse: 0.0629 - mae: 0.1958  
Epoch 27/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0610 - mse: 0.0610 - mae: 0.1945  
Epoch 28/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0598 - mse: 0.0598 - mae: 0.1915  
Epoch 29/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0585 - mse: 0.0585 - mae: 0.1892  
Epoch 30/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0568 - mse: 0.0568 - mae: 0.1845  
Epoch 31/50  
7/7 [=====] - 0s 999us/step - loss: 0.0586 - mse: 0.0586 - mae: 0.1890  
Epoch 32/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0554 - mse: 0.0554 - mae: 0.1817  
Epoch 33/50  
7/7 [=====] - 0s 999us/step - loss: 0.0565 - mse: 0.0565 - mae: 0.1847  
Epoch 34/50  
7/7 [=====] - 0s 1ms/step - loss: 0.0548 - mse: 0.0548 - mae: 0.1815  
Epoch 35/50

```
7/7 [=====] - 0s 1ms/step - loss: 0.0536 - mse: 0.0536 - mae: 0.1782
Epoch 36/50
7/7 [=====] - 0s 999us/step - loss: 0.0538 - mse: 0.0538 - mae: 0.1794
Epoch 37/50
7/7 [=====] - 0s 999us/step - loss: 0.0528 - mse: 0.0528 - mae: 0.1768
Epoch 38/50
7/7 [=====] - 0s 999us/step - loss: 0.0534 - mse: 0.0534 - mae: 0.1793
Epoch 39/50
7/7 [=====] - 0s 2ms/step - loss: 0.0508 - mse: 0.0508 - mae: 0.1723
Epoch 40/50
7/7 [=====] - 0s 1ms/step - loss: 0.0503 - mse: 0.0503 - mae: 0.1736
Epoch 41/50
7/7 [=====] - 0s 1ms/step - loss: 0.0500 - mse: 0.0500 - mae: 0.1700
Epoch 42/50
7/7 [=====] - 0s 1ms/step - loss: 0.0488 - mse: 0.0488 - mae: 0.1702
Epoch 43/50
7/7 [=====] - 0s 1000us/step - loss: 0.0484 - mse: 0.0484 - mae: 0.1705
Epoch 44/50
7/7 [=====] - 0s 999us/step - loss: 0.0497 - mse: 0.0497 - mae: 0.1702
Epoch 45/50
7/7 [=====] - 0s 1000us/step - loss: 0.0480 - mse: 0.0480 - mae: 0.1678
Epoch 46/50
7/7 [=====] - 0s 1ms/step - loss: 0.0479 - mse: 0.0479 - mae: 0.1660
Epoch 47/50
7/7 [=====] - 0s 999us/step - loss: 0.0475 - mse: 0.0475 - mae: 0.1647
Epoch 48/50
7/7 [=====] - 0s 999us/step - loss: 0.0473 - mse: 0.0473 - mae: 0.1647
Epoch 49/50
7/7 [=====] - 0s 1ms/step - loss: 0.0470 - mse: 0.0470 - mae: 0.1649
Epoch 50/50
7/7 [=====] - 0s 1ms/step - loss: 0.0462 - mse: 0.0462 - mae: 0.1641
```

```
In [ ]: plt.figure(figsize=(12,6))
plt.plot(model.history.history['loss'][:])
plt.plot(model.history.history['mae'][:])
plt.title('Model loss')
plt.xlabel('epoch')
plt.ylabel('loss (mse)')
plt.legend(['Train', 'Test'], loc='upper right')
```

```
Out[ ]: <matplotlib.legend.Legend at 0x2c35a169210>
```



In [ ]:

## LSTM

```
In [ ]: optimizer = 'adam'

# Model
lstm = Sequential()

# # Hiddeen Layers
lstm.add(LSTM(units=16,activation = LeakyReLU(alpha=0.05), return_sequences = True, ir
lstm.add(LSTM(units=8,activation = LeakyReLU(alpha=0.05),input_shape= (Xt.shape[1], 16
lstm.add(Dense(units=3, activation = LeakyReLU(alpha=0.05)))
lstm.add(Dense(units=1, activation = LeakyReLU(alpha=0.05)))

checkpoint = ModelCheckpoint('output/lstm.h5', monitor='mse', save_best_only=True, ver
lstm.compile(optimizer=optimizer, loss='mse',metrics=[ 'mse', 'mae'])
lstm.summary()
history = lstm.fit(Xt, yt, epochs=50, batch_size=2,verbose=1, callbacks=checkpoint)
```

Model: "sequential\_11"

Layer (type)	Output Shape	Param #
<hr/>		
lstm_17 (LSTM)	(None, 6, 16)	1280
lstm_18 (LSTM)	(None, 8)	800
dense_30 (Dense)	(None, 3)	27
dense_31 (Dense)	(None, 1)	4
<hr/>		
Total params: 2,111		
Trainable params: 2,111		
Non-trainable params: 0		

Epoch 1/50

99/104 [=====>..] - ETA: 0s - loss: 0.7397 - mse: 0.7397 - mae: 0.7351

Epoch 1: mse improved from inf to 0.73403, saving model to output\lstm.h5

104/104 [=====] - 4s 5ms/step - loss: 0.7340 - mse: 0.7340 - mae: 0.7315

Epoch 2/50

100/104 [=====>..] - ETA: 0s - loss: 0.4982 - mse: 0.4982 - mae: 0.5571

Epoch 2: mse improved from 0.73403 to 0.49121, saving model to output\lstm.h5

104/104 [=====] - 0s 5ms/step - loss: 0.4912 - mse: 0.4912 - mae: 0.5482

Epoch 3/50

96/104 [=====>...] - ETA: 0s - loss: 0.4585 - mse: 0.4585 - mae: 0.5265

Epoch 3: mse improved from 0.49121 to 0.45987, saving model to output\lstm.h5

104/104 [=====] - 1s 5ms/step - loss: 0.4599 - mse: 0.4599 - mae: 0.5284

Epoch 4/50

96/104 [=====>...] - ETA: 0s - loss: 0.1698 - mse: 0.1698 - mae: 0.3142

Epoch 4: mse improved from 0.45987 to 0.16060, saving model to output\lstm.h5

104/104 [=====] - 1s 5ms/step - loss: 0.1606 - mse: 0.1606 - mae: 0.3043

Epoch 5/50

100/104 [=====>...] - ETA: 0s - loss: 0.0810 - mse: 0.0810 - mae: 0.2196

Epoch 5: mse improved from 0.16060 to 0.08058, saving model to output\lstm.h5

104/104 [=====] - 0s 5ms/step - loss: 0.0806 - mse: 0.0806 - mae: 0.2201

Epoch 6/50

99/104 [=====>...] - ETA: 0s - loss: 0.0715 - mse: 0.0715 - mae: 0.2046

Epoch 6: mse improved from 0.08058 to 0.07321, saving model to output\lstm.h5

104/104 [=====] - 1s 5ms/step - loss: 0.0732 - mse: 0.0732 - mae: 0.2068

Epoch 7/50

95/104 [=====>...] - ETA: 0s - loss: 0.0676 - mse: 0.0676 - mae: 0.1977

Epoch 7: mse improved from 0.07321 to 0.06890, saving model to output\lstm.h5

104/104 [=====] - 1s 6ms/step - loss: 0.0689 - mse: 0.0689 - mae: 0.2004

Epoch 8/50

```
98/104 [=====>..] - ETA: 0s - loss: 0.0703 - mse: 0.0703 - ma
e: 0.2032
Epoch 8: mse did not improve from 0.06890
104/104 [=====] - 1s 5ms/step - loss: 0.0690 - mse: 0.0690 -
mae: 0.2022
Epoch 9/50
104/104 [=====] - ETA: 0s - loss: 0.0623 - mse: 0.0623 - ma
e: 0.1926
Epoch 9: mse improved from 0.06890 to 0.06225, saving model to output\lstm.h5
104/104 [=====] - 1s 6ms/step - loss: 0.0623 - mse: 0.0623 -
mae: 0.1926
Epoch 10/50
97/104 [=====>..] - ETA: 0s - loss: 0.0613 - mse: 0.0613 - ma
e: 0.1919
Epoch 10: mse improved from 0.06225 to 0.06023, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0602 - mse: 0.0602 -
mae: 0.1901
Epoch 11/50
101/104 [=====>..] - ETA: 0s - loss: 0.0584 - mse: 0.0584 - ma
e: 0.1896
Epoch 11: mse improved from 0.06023 to 0.05758, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0576 - mse: 0.0576 -
mae: 0.1873
Epoch 12/50
100/104 [=====>..] - ETA: 0s - loss: 0.0570 - mse: 0.0570 - ma
e: 0.1829
Epoch 12: mse improved from 0.05758 to 0.05646, saving model to output\lstm.h5
104/104 [=====] - 0s 5ms/step - loss: 0.0565 - mse: 0.0565 -
mae: 0.1825
Epoch 13/50
103/104 [=====>..] - ETA: 0s - loss: 0.0551 - mse: 0.0551 - ma
e: 0.1819
Epoch 13: mse improved from 0.05646 to 0.05486, saving model to output\lstm.h5
104/104 [=====] - 0s 5ms/step - loss: 0.0549 - mse: 0.0549 -
mae: 0.1814
Epoch 14/50
97/104 [=====>..] - ETA: 0s - loss: 0.0554 - mse: 0.0554 - ma
e: 0.1799
Epoch 14: mse improved from 0.05486 to 0.05392, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0539 - mse: 0.0539 -
mae: 0.1783
Epoch 15/50
100/104 [=====>..] - ETA: 0s - loss: 0.0558 - mse: 0.0558 - ma
e: 0.1804
Epoch 15: mse did not improve from 0.05392
104/104 [=====] - 1s 5ms/step - loss: 0.0546 - mse: 0.0546 -
mae: 0.1782
Epoch 16/50
100/104 [=====>..] - ETA: 0s - loss: 0.0504 - mse: 0.0504 - ma
e: 0.1755
Epoch 16: mse improved from 0.05392 to 0.05069, saving model to output\lstm.h5
104/104 [=====] - 1s 6ms/step - loss: 0.0507 - mse: 0.0507 -
mae: 0.1767
Epoch 17/50
99/104 [=====>..] - ETA: 0s - loss: 0.0529 - mse: 0.0529 - ma
e: 0.1813
Epoch 17: mse did not improve from 0.05069
104/104 [=====] - 1s 5ms/step - loss: 0.0519 - mse: 0.0519 -
mae: 0.1791
Epoch 18/50
```

102/104 [=====>.] - ETA: 0s - loss: 0.0496 - mse: 0.0496 - mae: 0.1733  
Epoch 18: mse improved from 0.05069 to 0.04976, saving model to output\lstm.h5  
104/104 [=====] - 1s 5ms/step - loss: 0.0498 - mse: 0.0498 - mae: 0.1740  
Epoch 19/50  
96/104 [=====>...] - ETA: 0s - loss: 0.0479 - mse: 0.0479 - mae: 0.1701  
Epoch 19: mse improved from 0.04976 to 0.04626, saving model to output\lstm.h5  
104/104 [=====] - 1s 5ms/step - loss: 0.0463 - mse: 0.0463 - mae: 0.1670  
Epoch 20/50  
96/104 [=====>...] - ETA: 0s - loss: 0.0505 - mse: 0.0505 - mae: 0.1739  
Epoch 20: mse did not improve from 0.04626  
104/104 [=====] - 0s 4ms/step - loss: 0.0489 - mse: 0.0489 - mae: 0.1714  
Epoch 21/50  
95/104 [=====>...] - ETA: 0s - loss: 0.0481 - mse: 0.0481 - mae: 0.1701  
Epoch 21: mse improved from 0.04626 to 0.04567, saving model to output\lstm.h5  
104/104 [=====] - 1s 5ms/step - loss: 0.0457 - mse: 0.0457 - mae: 0.1649  
Epoch 22/50  
97/104 [=====>...] - ETA: 0s - loss: 0.0465 - mse: 0.0465 - mae: 0.1628  
Epoch 22: mse improved from 0.04567 to 0.04530, saving model to output\lstm.h5  
104/104 [=====] - 1s 5ms/step - loss: 0.0453 - mse: 0.0453 - mae: 0.1615  
Epoch 23/50  
96/104 [=====>...] - ETA: 0s - loss: 0.0425 - mse: 0.0425 - mae: 0.1550  
Epoch 23: mse improved from 0.04530 to 0.04337, saving model to output\lstm.h5  
104/104 [=====] - 1s 5ms/step - loss: 0.0434 - mse: 0.0434 - mae: 0.1583  
Epoch 24/50  
104/104 [=====] - ETA: 0s - loss: 0.0468 - mse: 0.0468 - mae: 0.1655  
Epoch 24: mse did not improve from 0.04337  
104/104 [=====] - 0s 5ms/step - loss: 0.0468 - mse: 0.0468 - mae: 0.1655  
Epoch 25/50  
103/104 [=====>.] - ETA: 0s - loss: 0.0429 - mse: 0.0429 - mae: 0.1601  
Epoch 25: mse improved from 0.04337 to 0.04269, saving model to output\lstm.h5  
104/104 [=====] - 1s 5ms/step - loss: 0.0427 - mse: 0.0427 - mae: 0.1596  
Epoch 26/50  
97/104 [=====>...] - ETA: 0s - loss: 0.0382 - mse: 0.0382 - mae: 0.1521  
Epoch 26: mse improved from 0.04269 to 0.03867, saving model to output\lstm.h5  
104/104 [=====] - 1s 6ms/step - loss: 0.0387 - mse: 0.0387 - mae: 0.1526  
Epoch 27/50  
96/104 [=====>...] - ETA: 0s - loss: 0.0415 - mse: 0.0415 - mae: 0.1545  
Epoch 27: mse did not improve from 0.03867  
104/104 [=====] - 0s 4ms/step - loss: 0.0410 - mse: 0.0410 - mae: 0.1552  
Epoch 28/50

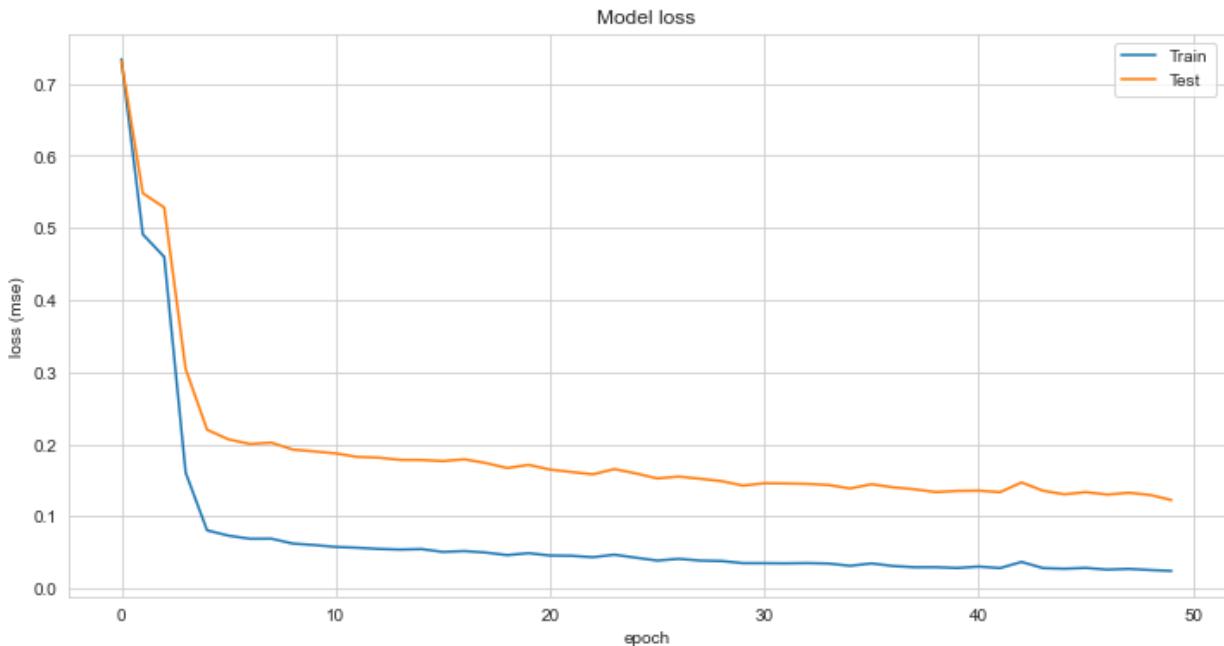
```
101/104 [=====>.] - ETA: 0s - loss: 0.0384 - mse: 0.0384 - mae: 0.1508
Epoch 28: mse did not improve from 0.03867
104/104 [=====] - 1s 5ms/step - loss: 0.0387 - mse: 0.0387 - mae: 0.1522
Epoch 29/50
94/104 [=====>...] - ETA: 0s - loss: 0.0379 - mse: 0.0379 - mae: 0.1479
Epoch 29: mse improved from 0.03867 to 0.03803, saving model to output\lstm.h5
104/104 [=====] - 1s 6ms/step - loss: 0.0380 - mse: 0.0380 - mae: 0.1489
Epoch 30/50
94/104 [=====>...] - ETA: 0s - loss: 0.0349 - mse: 0.0349 - mae: 0.1414
Epoch 30: mse improved from 0.03803 to 0.03509, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0351 - mse: 0.0351 - mae: 0.1427
Epoch 31/50
96/104 [=====>...] - ETA: 0s - loss: 0.0341 - mse: 0.0341 - mae: 0.1418
Epoch 31: mse improved from 0.03509 to 0.03504, saving model to output\lstm.h5
104/104 [=====] - 1s 6ms/step - loss: 0.0350 - mse: 0.0350 - mae: 0.1459
Epoch 32/50
96/104 [=====>...] - ETA: 0s - loss: 0.0329 - mse: 0.0329 - mae: 0.1430
Epoch 32: mse improved from 0.03504 to 0.03482, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0348 - mse: 0.0348 - mae: 0.1456
Epoch 33/50
95/104 [=====>...] - ETA: 0s - loss: 0.0352 - mse: 0.0352 - mae: 0.1449
Epoch 33: mse did not improve from 0.03482
104/104 [=====] - 0s 4ms/step - loss: 0.0352 - mse: 0.0352 - mae: 0.1450
Epoch 34/50
103/104 [=====>.] - ETA: 0s - loss: 0.0345 - mse: 0.0345 - mae: 0.1433
Epoch 34: mse improved from 0.03482 to 0.03453, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0345 - mse: 0.0345 - mae: 0.1434
Epoch 35/50
101/104 [=====>.] - ETA: 0s - loss: 0.0309 - mse: 0.0309 - mae: 0.1381
Epoch 35: mse improved from 0.03453 to 0.03140, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0314 - mse: 0.0314 - mae: 0.1387
Epoch 36/50
100/104 [=====>..] - ETA: 0s - loss: 0.0347 - mse: 0.0347 - mae: 0.1438
Epoch 36: mse did not improve from 0.03140
104/104 [=====] - 1s 7ms/step - loss: 0.0347 - mse: 0.0347 - mae: 0.1445
Epoch 37/50
98/104 [=====>..] - ETA: 0s - loss: 0.0304 - mse: 0.0304 - mae: 0.1382
Epoch 37: mse improved from 0.03140 to 0.03112, saving model to output\lstm.h5
104/104 [=====] - 1s 7ms/step - loss: 0.0311 - mse: 0.0311 - mae: 0.1403
Epoch 38/50
```

```
97/104 [=====>...] - ETA: 0s - loss: 0.0299 - mse: 0.0299 - mae: 0.1384
Epoch 38: mse improved from 0.03112 to 0.02943, saving model to output\lstm.h5
104/104 [=====] - 1s 7ms/step - loss: 0.0294 - mse: 0.0294 - mae: 0.1376
Epoch 39/50
101/104 [=====>.] - ETA: 0s - loss: 0.0289 - mse: 0.0289 - mae: 0.1316
Epoch 39: mse did not improve from 0.02943
104/104 [=====] - 1s 8ms/step - loss: 0.0295 - mse: 0.0295 - mae: 0.1337
Epoch 40/50
103/104 [=====>.] - ETA: 0s - loss: 0.0284 - mse: 0.0284 - mae: 0.1351
Epoch 40: mse improved from 0.02943 to 0.02835, saving model to output\lstm.h5
104/104 [=====] - 1s 6ms/step - loss: 0.0284 - mse: 0.0284 - mae: 0.1353
Epoch 41/50
103/104 [=====>.] - ETA: 0s - loss: 0.0300 - mse: 0.0300 - mae: 0.1346
Epoch 41: mse did not improve from 0.02835
104/104 [=====] - 1s 6ms/step - loss: 0.0304 - mse: 0.0304 - mae: 0.1356
Epoch 42/50
97/104 [=====>...] - ETA: 0s - loss: 0.0270 - mse: 0.0270 - mae: 0.1349
Epoch 42: mse improved from 0.02835 to 0.02826, saving model to output\lstm.h5
104/104 [=====] - 1s 6ms/step - loss: 0.0283 - mse: 0.0283 - mae: 0.1336
Epoch 43/50
93/104 [=====>....] - ETA: 0s - loss: 0.0389 - mse: 0.0389 - mae: 0.1507
Epoch 43: mse did not improve from 0.02826
104/104 [=====] - 0s 5ms/step - loss: 0.0368 - mse: 0.0368 - mae: 0.1470
Epoch 44/50
92/104 [=====>....] - ETA: 0s - loss: 0.0281 - mse: 0.0281 - mae: 0.1348
Epoch 44: mse improved from 0.02826 to 0.02825, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0283 - mse: 0.0283 - mae: 0.1356
Epoch 45/50
96/104 [=====>...] - ETA: 0s - loss: 0.0275 - mse: 0.0275 - mae: 0.1300
Epoch 45: mse improved from 0.02825 to 0.02739, saving model to output\lstm.h5
104/104 [=====] - 0s 5ms/step - loss: 0.0274 - mse: 0.0274 - mae: 0.1305
Epoch 46/50
96/104 [=====>...] - ETA: 0s - loss: 0.0292 - mse: 0.0292 - mae: 0.1357
Epoch 46: mse did not improve from 0.02739
104/104 [=====] - 0s 5ms/step - loss: 0.0285 - mse: 0.0285 - mae: 0.1336
Epoch 47/50
99/104 [=====>..] - ETA: 0s - loss: 0.0255 - mse: 0.0255 - mae: 0.1283
Epoch 47: mse improved from 0.02739 to 0.02615, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0261 - mse: 0.0261 - mae: 0.1302
Epoch 48/50
```

```
104/104 [=====] - ETA: 0s - loss: 0.0271 - mse: 0.0271 - mae: 0.1327
Epoch 48: mse did not improve from 0.02615
104/104 [=====] - 0s 5ms/step - loss: 0.0271 - mse: 0.0271 - mae: 0.1327
Epoch 49/50
98/104 [=====>..] - ETA: 0s - loss: 0.0253 - mse: 0.0253 - mae: 0.1285
Epoch 49: mse improved from 0.02615 to 0.02560, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0256 - mse: 0.0256 - mae: 0.1297
Epoch 50/50
95/104 [=====>...] - ETA: 0s - loss: 0.0239 - mse: 0.0239 - mae: 0.1218
Epoch 50: mse improved from 0.02560 to 0.02429, saving model to output\lstm.h5
104/104 [=====] - 1s 5ms/step - loss: 0.0243 - mse: 0.0243 - mae: 0.1226
```

```
In [ ]: plt.figure(figsize=(12,6))
plt.plot(lstm.history.history['loss'][:])
plt.plot(lstm.history.history['mae'][:])
plt.title('Model loss')
plt.xlabel('epoch')
plt.ylabel('loss (mse)')
plt.legend(['Train', 'Test'], loc='upper right')
```

```
Out[ ]: <matplotlib.legend.Legend at 0x1b1424922b0>
```



```
In [ ]: inputs = Input(shape=(Xt.shape[1], Xt.shape[2]))
x = LSTM(16)(inputs)
outputs = Dense(1)(x)
model = Model(inputs, outputs)

model.compile(optimizer="rmsprop", loss="mse", metrics=['mse', "mae"])
history = model.fit(Xt, yt, epochs=50)
```

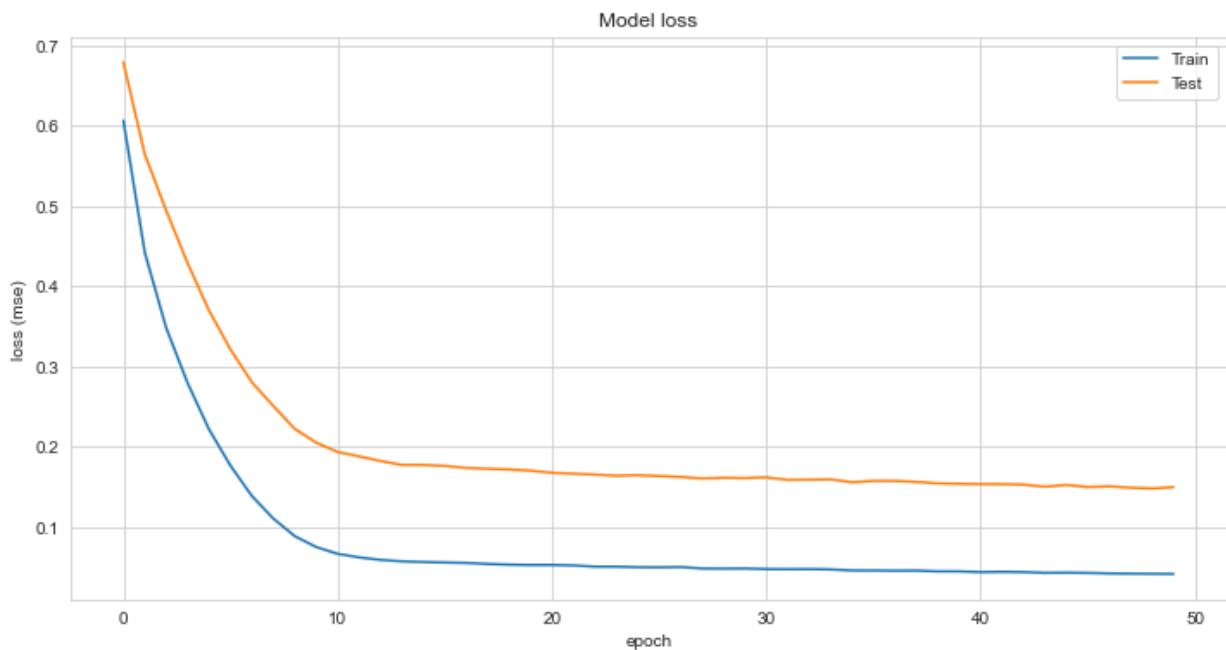
Epoch 1/50  
7/7 [=====] - 2s 4ms/step - loss: 0.6062 - mse: 0.6062 - ma  
e: 0.6789  
Epoch 2/50  
7/7 [=====] - 0s 3ms/step - loss: 0.4419 - mse: 0.4419 - ma  
e: 0.5642  
Epoch 3/50  
7/7 [=====] - 0s 4ms/step - loss: 0.3479 - mse: 0.3479 - ma  
e: 0.4940  
Epoch 4/50  
7/7 [=====] - 0s 3ms/step - loss: 0.2792 - mse: 0.2792 - ma  
e: 0.4285  
Epoch 5/50  
7/7 [=====] - 0s 4ms/step - loss: 0.2216 - mse: 0.2216 - ma  
e: 0.3695  
Epoch 6/50  
7/7 [=====] - 0s 3ms/step - loss: 0.1764 - mse: 0.1764 - ma  
e: 0.3212  
Epoch 7/50  
7/7 [=====] - 0s 3ms/step - loss: 0.1387 - mse: 0.1387 - ma  
e: 0.2803  
Epoch 8/50  
7/7 [=====] - 0s 4ms/step - loss: 0.1106 - mse: 0.1106 - ma  
e: 0.2507  
Epoch 9/50  
7/7 [=====] - 0s 4ms/step - loss: 0.0887 - mse: 0.0887 - ma  
e: 0.2223  
Epoch 10/50  
7/7 [=====] - 0s 4ms/step - loss: 0.0753 - mse: 0.0753 - ma  
e: 0.2052  
Epoch 11/50  
7/7 [=====] - 0s 4ms/step - loss: 0.0667 - mse: 0.0667 - ma  
e: 0.1936  
Epoch 12/50  
7/7 [=====] - 0s 4ms/step - loss: 0.0624 - mse: 0.0624 - ma  
e: 0.1880  
Epoch 13/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0592 - mse: 0.0592 - ma  
e: 0.1824  
Epoch 14/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0574 - mse: 0.0574 - ma  
e: 0.1774  
Epoch 15/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0566 - mse: 0.0566 - ma  
e: 0.1774  
Epoch 16/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0559 - mse: 0.0559 - ma  
e: 0.1762  
Epoch 17/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0555 - mse: 0.0555 - ma  
e: 0.1737  
Epoch 18/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0542 - mse: 0.0542 - ma  
e: 0.1727  
Epoch 19/50  
7/7 [=====] - 0s 4ms/step - loss: 0.0533 - mse: 0.0533 - ma  
e: 0.1717  
Epoch 20/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0529 - mse: 0.0529 - ma  
e: 0.1703

Epoch 21/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0529 - mse: 0.0529 - ma  
e: 0.1677  
Epoch 22/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0523 - mse: 0.0523 - ma  
e: 0.1665  
Epoch 23/50  
7/7 [=====] - 0s 9ms/step - loss: 0.0509 - mse: 0.0509 - ma  
e: 0.1654  
Epoch 24/50  
7/7 [=====] - 0s 5ms/step - loss: 0.0508 - mse: 0.0508 - ma  
e: 0.1641  
Epoch 25/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0501 - mse: 0.0501 - ma  
e: 0.1647  
Epoch 26/50  
7/7 [=====] - 0s 5ms/step - loss: 0.0500 - mse: 0.0500 - ma  
e: 0.1636  
Epoch 27/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0503 - mse: 0.0503 - ma  
e: 0.1625  
Epoch 28/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0485 - mse: 0.0485 - ma  
e: 0.1606  
Epoch 29/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0484 - mse: 0.0484 - ma  
e: 0.1615  
Epoch 30/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0486 - mse: 0.0486 - ma  
e: 0.1611  
Epoch 31/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0478 - mse: 0.0478 - ma  
e: 0.1620  
Epoch 32/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0477 - mse: 0.0477 - ma  
e: 0.1588  
Epoch 33/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0478 - mse: 0.0478 - ma  
e: 0.1591  
Epoch 34/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0473 - mse: 0.0473 - ma  
e: 0.1595  
Epoch 35/50  
7/7 [=====] - 0s 5ms/step - loss: 0.0461 - mse: 0.0461 - ma  
e: 0.1558  
Epoch 36/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0460 - mse: 0.0460 - ma  
e: 0.1576  
Epoch 37/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0458 - mse: 0.0458 - ma  
e: 0.1575  
Epoch 38/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0459 - mse: 0.0459 - ma  
e: 0.1563  
Epoch 39/50  
7/7 [=====] - 0s 6ms/step - loss: 0.0450 - mse: 0.0450 - ma  
e: 0.1545  
Epoch 40/50  
7/7 [=====] - 0s 3ms/step - loss: 0.0450 - mse: 0.0450 - ma  
e: 0.1540

```
Epoch 41/50
7/7 [=====] - 0s 3ms/step - loss: 0.0441 - mse: 0.0441 - mae: 0.1535
Epoch 42/50
7/7 [=====] - 0s 3ms/step - loss: 0.0444 - mse: 0.0444 - mae: 0.1535
Epoch 43/50
7/7 [=====] - 0s 4ms/step - loss: 0.0440 - mse: 0.0440 - mae: 0.1530
Epoch 44/50
7/7 [=====] - 0s 3ms/step - loss: 0.0431 - mse: 0.0431 - mae: 0.1503
Epoch 45/50
7/7 [=====] - 0s 5ms/step - loss: 0.0433 - mse: 0.0433 - mae: 0.1526
Epoch 46/50
7/7 [=====] - 0s 3ms/step - loss: 0.0430 - mse: 0.0430 - mae: 0.1499
Epoch 47/50
7/7 [=====] - 0s 3ms/step - loss: 0.0424 - mse: 0.0424 - mae: 0.1508
Epoch 48/50
7/7 [=====] - 0s 4ms/step - loss: 0.0421 - mse: 0.0421 - mae: 0.1491
Epoch 49/50
7/7 [=====] - 0s 3ms/step - loss: 0.0419 - mse: 0.0419 - mae: 0.1481
Epoch 50/50
7/7 [=====] - 0s 3ms/step - loss: 0.0418 - mse: 0.0418 - mae: 0.1499
```

```
In [ ]: plt.figure(figsize=(12,6))
plt.plot(model.history.history['loss'][::])
plt.plot(model.history.history['mae'][::])
plt.title('Model loss')
plt.xlabel('epoch')
plt.ylabel('loss (mse)')
plt.legend(['Train', 'Test'], loc='upper right')
```

```
Out[ ]: <matplotlib.legend.Legend at 0x1b133ce3070>
```



## RNN Bidirectional LSTM

```
In [ ]: optimizer = SGD(learning_rate=0.001)
biLSTM = Sequential()
# biLSTM.add(Bidirectional(LSTM(units=64, dropout=0.5, recurrent_dropout=0.5), input_shape=(Xt.shape[1], Xt.shape[2])))
biLSTM.add(Bidirectional(LSTM(units=64), input_shape=(Xt.shape[1], Xt.shape[2])))
biLSTM.add(Dense(units=32, activation='swish'))
biLSTM.add(Dense(units=16, activation='swish'))
biLSTM.add(Dense(units=8, activation='swish'))
biLSTM.add(Dense(units=1, activation='swish'))

biLSTM.compile(optimizer=optimizer, loss='mse', metrics=['mse', 'mae'])

biLSTM.summary()

# Tensor Board
log_dir = "logs/fit/" + dt.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = tensorflow.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=0)

history = biLSTM.fit(Xt, yt, epochs=50, batch_size=2, verbose=1, callbacks=[tensorboard_callback])
```

Model: "sequential\_3"

Layer (type)	Output Shape	Param #
bidirectional_3 (Bidirectional)	(None, 128)	35840
dense_12 (Dense)	(None, 32)	4128
dense_13 (Dense)	(None, 16)	528
dense_14 (Dense)	(None, 8)	136
dense_15 (Dense)	(None, 1)	9

---

Total params: 40,641  
 Trainable params: 40,641  
 Non-trainable params: 0

Epoch 1/50  
 104/104 [=====] - 4s 5ms/step - loss: 1.0222 - mse: 1.0222 - mae: 0.8880  
 Epoch 2/50  
 104/104 [=====] - 1s 5ms/step - loss: 1.0061 - mse: 1.0061 - mae: 0.8813  
 Epoch 3/50  
 104/104 [=====] - 1s 6ms/step - loss: 0.9907 - mse: 0.9907 - mae: 0.8746  
 Epoch 4/50  
 104/104 [=====] - 1s 5ms/step - loss: 0.9756 - mse: 0.9756 - mae: 0.8682  
 Epoch 5/50  
 104/104 [=====] - 1s 5ms/step - loss: 0.9604 - mse: 0.9604 - mae: 0.8620  
 Epoch 6/50  
 104/104 [=====] - 1s 5ms/step - loss: 0.9445 - mse: 0.9445 - mae: 0.8551  
 Epoch 7/50  
 104/104 [=====] - 1s 5ms/step - loss: 0.9278 - mse: 0.9278 - mae: 0.8487  
 Epoch 8/50  
 104/104 [=====] - 0s 4ms/step - loss: 0.9100 - mse: 0.9100 - mae: 0.8409  
 Epoch 9/50  
 104/104 [=====] - 0s 5ms/step - loss: 0.8902 - mse: 0.8902 - mae: 0.8330  
 Epoch 10/50  
 104/104 [=====] - 0s 4ms/step - loss: 0.8685 - mse: 0.8685 - mae: 0.8235  
 Epoch 11/50  
 104/104 [=====] - 0s 4ms/step - loss: 0.8439 - mse: 0.8439 - mae: 0.8136  
 Epoch 12/50  
 104/104 [=====] - 0s 4ms/step - loss: 0.8159 - mse: 0.8159 - mae: 0.8014  
 Epoch 13/50  
 104/104 [=====] - 0s 4ms/step - loss: 0.7842 - mse: 0.7842 - mae: 0.7870  
 Epoch 14/50

104/104 [=====] - 0s 4ms/step - loss: 0.7477 - mse: 0.7477 -  
mae: 0.7687  
Epoch 15/50  
104/104 [=====] - 0s 4ms/step - loss: 0.7065 - mse: 0.7065 -  
mae: 0.7495  
Epoch 16/50  
104/104 [=====] - 0s 4ms/step - loss: 0.6602 - mse: 0.6602 -  
mae: 0.7249  
Epoch 17/50  
104/104 [=====] - 0s 4ms/step - loss: 0.6090 - mse: 0.6090 -  
mae: 0.6952  
Epoch 18/50  
104/104 [=====] - 0s 4ms/step - loss: 0.5551 - mse: 0.5551 -  
mae: 0.6629  
Epoch 19/50  
104/104 [=====] - 0s 4ms/step - loss: 0.5013 - mse: 0.5013 -  
mae: 0.6276  
Epoch 20/50  
104/104 [=====] - 0s 4ms/step - loss: 0.4513 - mse: 0.4513 -  
mae: 0.5888  
Epoch 21/50  
104/104 [=====] - 0s 5ms/step - loss: 0.4087 - mse: 0.4087 -  
mae: 0.5543  
Epoch 22/50  
104/104 [=====] - 0s 5ms/step - loss: 0.3755 - mse: 0.3755 -  
mae: 0.5234  
Epoch 23/50  
104/104 [=====] - 0s 4ms/step - loss: 0.3521 - mse: 0.3521 -  
mae: 0.5020  
Epoch 24/50  
104/104 [=====] - 0s 5ms/step - loss: 0.3360 - mse: 0.3360 -  
mae: 0.4842  
Epoch 25/50  
104/104 [=====] - 0s 4ms/step - loss: 0.3249 - mse: 0.3249 -  
mae: 0.4725  
Epoch 26/50  
104/104 [=====] - 0s 4ms/step - loss: 0.3168 - mse: 0.3168 -  
mae: 0.4639  
Epoch 27/50  
104/104 [=====] - 0s 4ms/step - loss: 0.3107 - mse: 0.3107 -  
mae: 0.4555  
Epoch 28/50  
104/104 [=====] - 0s 4ms/step - loss: 0.3061 - mse: 0.3061 -  
mae: 0.4494  
Epoch 29/50  
104/104 [=====] - 0s 4ms/step - loss: 0.3023 - mse: 0.3023 -  
mae: 0.4448  
Epoch 30/50  
104/104 [=====] - 0s 4ms/step - loss: 0.2992 - mse: 0.2992 -  
mae: 0.4409  
Epoch 31/50  
104/104 [=====] - 0s 5ms/step - loss: 0.2965 - mse: 0.2965 -  
mae: 0.4378  
Epoch 32/50  
104/104 [=====] - 0s 5ms/step - loss: 0.2943 - mse: 0.2943 -  
mae: 0.4353  
Epoch 33/50  
104/104 [=====] - 0s 4ms/step - loss: 0.2923 - mse: 0.2923 -  
mae: 0.4328  
Epoch 34/50

```

104/104 [=====] - 0s 4ms/step - loss: 0.2906 - mse: 0.2906 -
mae: 0.4299
Epoch 35/50
104/104 [=====] - 0s 4ms/step - loss: 0.2891 - mse: 0.2891 -
mae: 0.4285
Epoch 36/50
104/104 [=====] - 0s 4ms/step - loss: 0.2877 - mse: 0.2877 -
mae: 0.4265
Epoch 37/50
104/104 [=====] - 0s 5ms/step - loss: 0.2864 - mse: 0.2864 -
mae: 0.4252
Epoch 38/50
104/104 [=====] - 0s 4ms/step - loss: 0.2854 - mse: 0.2854 -
mae: 0.4238
Epoch 39/50
104/104 [=====] - 0s 4ms/step - loss: 0.2844 - mse: 0.2844 -
mae: 0.4225
Epoch 40/50
104/104 [=====] - 0s 5ms/step - loss: 0.2833 - mse: 0.2833 -
mae: 0.4206
Epoch 41/50
104/104 [=====] - 0s 4ms/step - loss: 0.2824 - mse: 0.2824 -
mae: 0.4196
Epoch 42/50
104/104 [=====] - 1s 5ms/step - loss: 0.2815 - mse: 0.2815 -
mae: 0.4188
Epoch 43/50
104/104 [=====] - 0s 4ms/step - loss: 0.2808 - mse: 0.2808 -
mae: 0.4175
Epoch 44/50
104/104 [=====] - 0s 4ms/step - loss: 0.2801 - mse: 0.2801 -
mae: 0.4162
Epoch 45/50
104/104 [=====] - 0s 4ms/step - loss: 0.2795 - mse: 0.2795 -
mae: 0.4153
Epoch 46/50
104/104 [=====] - 0s 4ms/step - loss: 0.2788 - mse: 0.2788 -
mae: 0.4143
Epoch 47/50
104/104 [=====] - 0s 4ms/step - loss: 0.2782 - mse: 0.2782 -
mae: 0.4130
Epoch 48/50
104/104 [=====] - 0s 4ms/step - loss: 0.2776 - mse: 0.2776 -
mae: 0.4123
Epoch 49/50
104/104 [=====] - 0s 4ms/step - loss: 0.2770 - mse: 0.2770 -
mae: 0.4113
Epoch 50/50
104/104 [=====] - 0s 4ms/step - loss: 0.2766 - mse: 0.2766 -
mae: 0.4105

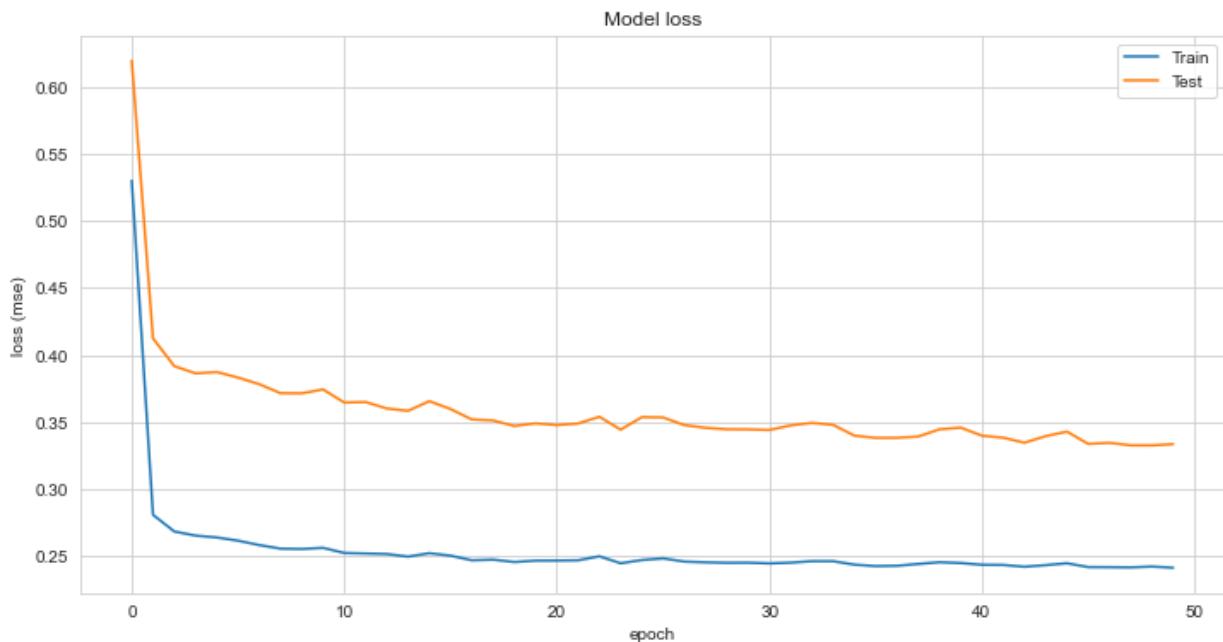
```

```

In [ ]: plt.figure(figsize=(12,6))
plt.plot(bilstm.history.history['loss'][::])
plt.plot(bilstm.history.history['mae'][::])
plt.title('Model loss')
plt.xlabel('epoch')
plt.ylabel('loss (mse)')
plt.legend(['Train', 'Test'], loc='upper right')

```

```
Out[ ]: <matplotlib.legend.Legend at 0x26c9810b400>
```



## TensorBoard

```
In [ ]: %load_ext tensorboard
tensorboard --logdir logs/fit
```

## Hyper Parameters Tuning

```
In [ ]:
def create_model():
    activation = 'relu'
    neurons = 32
    optimizer = 'adam'
    model = Sequential()
    model.add(Bidirectional(LSTM(units=neurons), input_dim = 5, input_shape=(Xt.shape[1], Xt.shape[2])))
    model.add(Dense(units=neurons/2, activation=activation))
    model.add(Dense(units=neurons/4, activation=activation))
    model.add(Dense(units=3, activation=activation))
    model.add(Dense(units=1, activation=activation))
    model.compile(optimizer=optimizer, loss='mse', metrics=['mse', 'mae'])
    return model

# history = biLSTM.fit(Xt, yt, epochs=50, batch_size=2, verbose=1)
keras_model = KerasClassifier(build_fn=create_model, verbose=1)
```

```
In [ ]: a = create_model()
a.fit(Xt,yt,epochs =20,batch_size=2)
```

Epoch 1/20  
104/104 [=====] - 22s 4ms/step - loss: 0.6828 - mse: 0.6828 - mae: 0.6808  
Epoch 2/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4576 - mse: 0.4576 - mae: 0.5060  
Epoch 3/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4503 - mse: 0.4503 - mae: 0.4942  
Epoch 4/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4482 - mse: 0.4482 - mae: 0.4918  
Epoch 5/20  
104/104 [=====] - 0s 4ms/step - loss: 0.4468 - mse: 0.4468 - mae: 0.4887  
Epoch 6/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4454 - mse: 0.4454 - mae: 0.4868  
Epoch 7/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4470 - mse: 0.4470 - mae: 0.4892  
Epoch 8/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4466 - mse: 0.4466 - mae: 0.4912  
Epoch 9/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4440 - mse: 0.4440 - mae: 0.4846  
Epoch 10/20  
104/104 [=====] - 0s 4ms/step - loss: 0.4445 - mse: 0.4445 - mae: 0.4841  
Epoch 11/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4443 - mse: 0.4443 - mae: 0.4830  
Epoch 12/20  
104/104 [=====] - 0s 4ms/step - loss: 0.4442 - mse: 0.4442 - mae: 0.4846  
Epoch 13/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4419 - mse: 0.4419 - mae: 0.4789  
Epoch 14/20  
104/104 [=====] - 0s 4ms/step - loss: 0.4416 - mse: 0.4416 - mae: 0.4772  
Epoch 15/20  
104/104 [=====] - 0s 4ms/step - loss: 0.4412 - mse: 0.4412 - mae: 0.4764  
Epoch 16/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4422 - mse: 0.4422 - mae: 0.4788  
Epoch 17/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4420 - mse: 0.4420 - mae: 0.4813  
Epoch 18/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4412 - mse: 0.4412 - mae: 0.4780  
Epoch 19/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4421 - mse: 0.4421 - mae: 0.4806  
Epoch 20/20  
104/104 [=====] - 0s 3ms/step - loss: 0.4410 - mse: 0.4410 - mae: 0.4763

```
Out[ ]: <keras.callbacks.History at 0x2078dfd1c40>
```

## Batch Size and Epochs

```
In [ ]: # parameters List
batch_size = [2, 4, 8, 16]
epochs = [30]
# optimizer = ['SGD', 'GD', 'Adam']
# activation = [LeakyReLU(alpha=0.05), 'selu', 'elu', 'swish']
# neurons = [16,32,64,128]

# convert to disctionary to search
param_grid = dict(batch_size=batch_size, epochs=epochs)
```

```
In [ ]: grid = GridSearchCV(estimator=keras_model, param_grid=param_grid, n_jobs=1)
grid_result = grid.fit(Xt, yt)

# summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))
```

Epoch 1/30  
83/83 [=====] - 4s 3ms/step - loss: 8704.3389 - mse: 8704.33  
89 - mae: 80.5521  
Epoch 2/30  
83/83 [=====] - 0s 4ms/step - loss: 4021.0781 - mse: 4021.07  
81 - mae: 49.9577  
Epoch 3/30  
83/83 [=====] - 0s 3ms/step - loss: 828.1892 - mse: 828.1892  
- mae: 22.6985  
Epoch 4/30  
83/83 [=====] - 0s 3ms/step - loss: 276.9172 - mse: 276.9172  
- mae: 13.1895  
Epoch 5/30  
83/83 [=====] - 0s 3ms/step - loss: 199.3811 - mse: 199.3811  
- mae: 11.4453  
Epoch 6/30  
83/83 [=====] - 0s 4ms/step - loss: 169.4635 - mse: 169.4635  
- mae: 10.3989  
Epoch 7/30  
83/83 [=====] - 0s 4ms/step - loss: 135.8060 - mse: 135.8060  
- mae: 9.1280  
Epoch 8/30  
83/83 [=====] - 0s 3ms/step - loss: 122.5607 - mse: 122.5607  
- mae: 8.7114  
Epoch 9/30  
35/83 [=====>.....] - ETA: 0s - loss: 114.4602 - mse: 114.4602 - mae: 8.6727

```

-----
KeyboardInterrupt                                     Traceback (most recent call last)
c:\Users\Gumo\Desktop\Git\Class\CIS62_ProjectLSTM\index.ipynb Cell 165' in <module>
    <a href='vscode-notebook-cell:/c%3A/Users/Gumo/Desktop/Git/Class/CIS62_ProjectLSTM/index.ipynb#ch0000162?line=0'>1</a> grid = GridSearchCV(estimator=keras_model, param_grid=param_grid, n_jobs=1)
----> <a href='vscode-notebook-cell:/c%3A/Users/Gumo/Desktop/Git/Class/CIS62_ProjectLSTM/index.ipynb#ch0000162?line=1'>2</a> grid_result = grid.fit(Xt, yt)
     <a href='vscode-notebook-cell:/c%3A/Users/Gumo/Desktop/Git/Class/CIS62_ProjectLSTM/index.ipynb#ch0000162?line=3'>4</a> # summarize results
     <a href='vscode-notebook-cell:/c%3A/Users/Gumo/Desktop/Git/Class/CIS62_ProjectLSTM/index.ipynb#ch0000162?line=4'>5</a> print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\sklearn\model_selection\_search.py:891, in BaseSearchCV.fit(self, X, y, groups, **fit_params)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=884'>885</a>     results = self._format_results(
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=885'>886</a>         all_candidate_params, n_splits, all_out, all_more_results
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=886'>887</a>     )
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=888'>889</a>     return results
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=890'>891</a> self._run_search(evaluate_candidates)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=892'>893</a> # multimetric is determined here because in the case of a callable
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=893'>894</a> # self.scoring the return type is only known after calling
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=894'>895</a> first_test_score = all_out[0]["test_scores"]

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\sklearn\model_selection\_search.py:1392, in GridSearchCV._run_search(self, evaluate_candidates)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=1389'>1390</a> def _run_search(self, evaluate_candidates):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=1390'>1391</a>     """Search all candidates in parameter_grid"""
-> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=1391'>1392</a>     evaluate_candidates(ParameterGrid(self.param_grid))

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\sklearn\model_selection\_search.py:838, in BaseSearchCV.fit.<locals>.evaluate_candidates(candidate_params, cv, more_results)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=829'>830</a> if self.verbose > 0:
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=830'>831</a>     print(
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn\model_selection\_search.py?line=831'>832</a>         "Fitting {0} folds for each of {1} candidates,"
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env\lib\site-packages\sklearn
```

```

n/model_selection/_search.py?line=832'>833</a>           " totalling {2} fits".format(
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=833'>834</a>           n_splits, n_candidates, n_
candidates * n_splits
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=834'>835</a>           )
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=835'>836</a>           )
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=837'>838</a> out = parallel(
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=838'>839</a>           delayed(_fit_and_score)(
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=839'>840</a>           clone(base_estimator),
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=840'>841</a>           X,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=841'>842</a>           y,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=842'>843</a>           train=train,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=843'>844</a>           test=test,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=844'>845</a>           parameters=parameters,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=845'>846</a>           split_progress=(split_idx, n_s
plits),
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=846'>847</a>           candidate_progress=(cand_idx,
n_candidates),
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=847'>848</a>           **fit_and_score_kwargs,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=848'>849</a>           )
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=849'>850</a>           for (cand_idx, parameters), (split
_idx, (train, test)) in product(
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=850'>851</a>           enumerate(candidate_params), e
numerate(cv.split(X, y, groups))
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=851'>852</a>           )
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=852'>853</a>           )
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=853'>854</a>           if len(out) < 1:
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=855'>856</a>           raise ValueError(
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=856'>857</a>           "No fits were performed. "
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=857'>858</a>           "Was the CV iterator empty? "
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=858'>859</a>           "Were there no candidates?"
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_search.py?line=859'>860</a>           )

```

File c:\Users\Gumo\Desktop\Git\desktop\_env\lib\site-packages\joblib\parallel.py:1043,  
in Parallel.\_\_call\_\_(self, iterable)  
<a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop\_env/lib/site-packages/joblib/

```

parallel.py?line=1033'>1034</a>    try:
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1034'>1035</a>        # Only set self._iterating to True if at least a
batch
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1035'>1036</a>        # was dispatched. In particular this covers the e
dge
    (...)

    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1039'>1040</a>        # was very quick and its callback already dispalc
hed all the
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1040'>1041</a>        # remaining jobs.
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1041'>1042</a>        self._iterating = False
-> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1042'>1043</a>        if self.dispatch_one_batch(iterator):
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1043'>1044</a>        self._iterating = self._original_iterator is
not None
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/
parallel.py?line=1045'>1046</a>        while self.dispatch_one_batch(iterator):

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\joblib\parallel.py:861,
in Parallel.dispatch_one_batch(self, iterator)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=858'>859</a>        return False
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=859'>860</a> else:
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=860'>861</a>        self._dispatch(tasks)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=861'>862</a>        return True

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\joblib\parallel.py:779,
in Parallel._dispatch(self, batch)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=776'>777</a> with self._lock:
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=777'>778</a>        job_idx = len(self._jobs)
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=778'>779</a>        job = self._backend.apply_async(batch, callback=c
b)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=779'>780</a>        # A job can complete so quickly than its callback
is
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=780'>781</a>        # called before we get here, causing self._jobs t
o
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=781'>782</a>        # grow. To ensure correct results ordering, .inse
rt is
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=782'>783</a>        # used (rather than .append) in the following lin
e
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/jobli
b/parallel.py?line=783'>784</a>        self._jobs.insert(job_idx, job)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\joblib\_parallel_backend
s.py:208, in SequentialBackend.apply_async(self, func, callback)

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<a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=205'>206</a> def apply_async(self, func, callback=None):
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=206'>207</a>     """Schedule a func to be run"""
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=207'>208</a>     result = ImmediateResult(func)
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=208'>209</a>     if callback:
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=209'>210</a>         callback(result)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\joblib\_parallel_backend_s.py:572, in ImmediateResult.__init__(self, batch)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=568'>569</a> def __init__(self, batch):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=569'>570</a>     # Don't delay the application, to avoid keeping the input
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=570'>571</a>         # arguments in memory
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/_parallel_backends.py?line=571'>572</a>     self.results = batch()

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\joblib\parallel.py:262,
in BatchedCalls.__call__(self)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=257'>258</a> def __call__(self):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=258'>259</a>     # Set the default nested backend to self._backend but do not set the
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=259'>260</a>         # change the default number of processes to -1
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=260'>261</a>             with parallel_backend(self._backend, n_jobs=self._n_jobs):
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=261'>262</a>                 return [func(*args, **kwargs)
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=262'>263</a>                         for func, args, kwargs in self.items]

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\joblib\parallel.py:262,
in <listcomp>(.0)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=257'>258</a> def __call__(self):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=258'>259</a>     # Set the default nested backend to self._backend but do not set the
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=259'>260</a>         # change the default number of processes to -1
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=260'>261</a>             with parallel_backend(self._backend, n_jobs=self._n_jobs):
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=261'>262</a>                 return [func(*args, **kwargs)
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/joblib/parallel.py?line=262'>263</a>                         for func, args, kwargs in self.items]

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\sklearn\utils\fixes.py:2
16, in _FuncWrapper.__call__(self, *args, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear

```

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n/utils/fixes.py?line=213'>214</a> def __call__(self, *args, **kwargs):
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/utils/fixes.py?line=214'>215</a>     with config_context(**self.config):
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/utils/fixes.py?line=215'>216</a>         return self.function(*args, **kwargs)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\sklearn\model_selection
\_validation.py:680, in _fit_and_score(estimator, X, y, scorer, train, test, verbose,
parameters, fit_params, return_train_score, return_parameters, return_n_test_samples,
return_times, return_estimator, split_progress, candidate_progress, error_score)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_validation.py?line=677'>678</a>         estimator.fit(X_train, **f
it_params)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_validation.py?line=678'>679</a>     else:
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_validation.py?line=679'>680</a>         estimator.fit(X_train, y_t
rain, **fit_params)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_validation.py?line=681'>682</a> except Exception:
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_validation.py?line=682'>683</a>     # Note fit time as time until
error
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/sklear
n/model_selection/_validation.py?line=683'>684</a>     fit_time = time.time() - start
_time

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\keras\wrappers\scikit_le
arn.py:236, in KerasClassifier.fit(self, x, y, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=233'>234</a>     raise ValueError('Invalid shape for y: '
+ str(y.shape))
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=234'>235</a>     self.n_classes_ = len(self.classes_)
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=235'>236</a>     return super(KerasClassifier, self).fit(x,
y, **kwargs)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\keras\wrappers\scikit_le
arn.py:164, in BaseWrapper.fit(self, x, y, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=160'>161</a>     fit_args = copy.deepcopy(self.filter_sk_pa
rameters(Sequential.fit))
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=161'>162</a>     fit_args.update(kwargs)
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=163'>164</a>     history = self.model.fit(x, y, **fit_args)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/
wrappers/scikit_learn.py?line=165'>166</a>     return history

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\keras\utils\traceback_ut
ils.py:64, in filter_traceback.<locals>.error_handler(*args, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/ker
a/s/utils/traceback_utils.py?line=61'>62</a>     filtered_tb = None
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/ker
a/s/utils/traceback_utils.py?line=62'>63</a>     try:
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/ker
a/s/utils/traceback_utils.py?line=63'>64</a>         return fn(*args, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/ker
a/s/utils/traceback_utils.py?line=64'>65</a>     except Exception as e: # pylint: disable=

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```

broad-except
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/utils/traceback_utils.py?line=65'>66</a>    filtered_tb = _process_traceback_frames
(e.__traceback__)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\keras\engine\training.py:1384, in Model.fit(self, x, y, batch_size, epochs, verbose, callbacks, validation_split, validation_data, shuffle, class_weight, sample_weight, initial_epoch, steps_per_epoch, validation_steps, validation_batch_size, validation_freq, max_queue_size, workers, use_multiprocessing)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1376'>1377</a>    with tf.profiler.experimental.Trace(
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1377'>1378</a>        'train',
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1378'>1379</a>        epoch_num=epoch,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1379'>1380</a>        step_num=step,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1380'>1381</a>        batch_size=batch_size,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1381'>1382</a>        _r=1):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1382'>1383</a>    callbacks.on_train_batch_begin(step)
-> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1383'>1384</a>    tmp_logs = self.train_function(iterator)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1384'>1385</a>    if data_handler.should_sync:
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/keras/engine/training.py?line=1385'>1386</a>        context.async_wait()

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\util\traceback_utils.py:150, in filter_traceback.<locals>.error_handler(*args, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/util/traceback_utils.py?line=147'>148</a>    filtered_tb = None
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/util/traceback_utils.py?line=148'>149</a>    try:
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/util/traceback_utils.py?line=149'>150</a>    return fn(*args, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/util/traceback_utils.py?line=150'>151</a>    except Exception as e:
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/util/traceback_utils.py?line=151'>152</a>        filtered_tb = _process_traceback_frames(e.__traceback__)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\eager\def_function.py:915, in Function.__call__(self, *args, **kwds)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/eager/def_function.py?line=911'>912</a>    compiler = "xla" if self._jit_compile else "nonXla"
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/eager/def_function.py?line=912'>914</a>    with OptionalXlaContext(self._jit_compile):
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/eager/def_function.py?line=914'>915</a>    result = self._call(*args, **kwds)
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorflow/python/eager/def_function.py?line=916'>917</a>    new_tracing_count = self.experimental_get_tracing_count()
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
```

```

flow/python/eager/def_function.py?line=917'>918</a> without_tracing = (tracing_count
== new_tracing_count)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\eager
\def_function.py:947, in Function._call(self, *args, **kwds)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=943'>944</a>    self._lock.release()
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=944'>945</a>    # In this case we have created
variables on the first call, so we run the
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=945'>946</a>    # defunned version which is gua
ranteed to never create variables.
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=946'>947</a>    return self._stateless_fn(*arg
s, **kwds) # pylint: disable=not-callable
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=947'>948</a> elif self._stateful_fn is not Non
e:
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=948'>949</a>    # Release the lock early so tha
t multiple threads can perform the call
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=949'>950</a>    # in parallel.
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensor
flow/python/eager/def_function.py?line=950'>951</a>    self._lock.release()

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\eager
\function.py:2956, in Function.__call__(self, *args, **kwargs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=2952'>2953</a> with self._lock:
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=2953'>2954</a>    (graph_function,
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=2954'>2955</a>    filtered_flat_args) = self._maybe
_define_function(args, kwargs)
-> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=2955'>2956</a> return graph_function._call_flat(
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=2956'>2957</a>    filtered_flat_args, captured_inp
uts=graph_function.captured_inputs)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\eager
\function.py:1853, in ConcreteFunction._call_flat(self, args, captured_inputs, cancel
ation_manager)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1848'>1849</a> possible_gradient_type = gradients_u
til.PossibleTapeGradientTypes(args)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1849'>1850</a> if (possible_gradient_type == gradie
nts_util.POSSIBLE_GRADIENT_TYPES_NONE
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1850'>1851</a>        and executing_eagerly):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1851'>1852</a>    # No tape is watching; skip to run
ning the function.
-> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1852'>1853</a>    return self._build_call_outputs(se
lf._inference_function.call(
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1853'>1854</a>

```

```

low/python/eager/function.py?line=1853'>1854</a>           ctx, args, cancellation_manager
r=cancellation_manager))
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1854'>1855</a> forward_backward = self._select_forw
ard_and_backward_functions(
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1855'>1856</a> args,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1856'>1857</a> possible_gradient_type,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1857'>1858</a> executing_eagerly)
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=1858'>1859</a> forward_function, args_with_tangents
= forward_backward.forward()

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\eager
\function.py:499, in _EagerDefinedFunction.call(self, ctx, args, cancellation_manager)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=496'>497</a> with _InterpolateFunctionError(self):
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=497'>498</a> if cancellation_manager is None:
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=498'>499</a> outputs = execute.execute(
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=499'>500</a> str(self.signature.name),
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=500'>501</a> num_outputs=self._num_output
s,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=501'>502</a> inputs=args,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=502'>503</a> attrs=attrs,
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=503'>504</a> ctx=ctx)
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=504'>505</a> else:
            <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=505'>506</a> outputs = execute.execute_with_ca
ncellation(
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=506'>507</a> str(self.signature.name),
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=507'>508</a> num_outputs=self._num_output
s,
                (...))
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=510'>511</a> ctx=ctx,
                <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/function.py?line=511'>512</a> cancellation_manager=cancella
tion_manager)

File c:\Users\Gumo\Desktop\Git\desktop_env\lib\site-packages\tensorflow\python\eager
\execute.py:54, in quick_execute(op_name, num_outputs, inputs, attrs, ctx, name)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/execute.py?line=51'>52</a> try:
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/execute.py?line=52'>53</a> ctx.ensure_initialized()
--> <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tensorf
low/python/eager/execute.py?line=53'>54</a> tensors = pywrap_tfe.TFE_Py_Execute(c

```

```

tx._handle, device_name, op_name,
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tenso
rflow/python/eager/execute.py?line=54'>55</a> i
nputs, attrs, num_outputs)
    <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tenso
rflow/python/eager/execute.py?line=55'>56</a> except core._NotOkStatusException as e:
        <a href='file:///c%3A/Users/Gumo/Desktop/Git/desktop_env/lib/site-packages/tenso
rflow/python/eager/execute.py?line=56'>57</a> if name is not None:

```

### KeyboardInterrupt:

```
In [ ]: grid_result.best_estimator_
grid_result.error_score
```

```
Out[ ]: nan
```

## Optimizer

```

In [ ]: # # parameters list
# batch_size = [2, 4, 8, 16, 32]
# epochs = [10, 50]
# optimizer = ['SGD', 'GD', 'Adam']
# activation = [LeakyReLU(alpha=0.05), 'selu', 'elu', 'swish']
# neurons = [16,32,64,128]

# # convert to disctionary to search
# param_grid = dict(optimizer=optimizer)
# grid = GridSearchCV(estimator=keras_model, param_grid=param_grid, n_jobs=1, cv=3)
# grid_result = grid.fit(Xt, yt)

# # summarize results
# print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
# means = grid_result.cv_results_['mean_test_score']
# stds = grid_result.cv_results_['std_test_score']
# params = grid_result.cv_results_['params']
# for mean, stdev, param in zip(means, stds, params):
#     print("%f (%f) with: %r" % (mean, stdev, param))

```

## Activation Funciton

```

In [ ]: # # parameters list
# batch_size = [2, 4, 8, 16, 32]
# epochs = [10, 50]
# optimizer = ['SGD', 'GD', 'Adam']
# activation = [LeakyReLU(alpha=0.05), 'selu', 'elu', 'swish']
# neurons = [16,32,64,128]

# # convert to disctionary to search
# param_grid = dict(activation=activation)
# grid = GridSearchCV(estimator=keras_model, param_grid=param_grid, n_jobs=1, cv=3)
# grid_result = grid.fit(Xt, yt)

# # summarize results
# print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
# means = grid_result.cv_results_['mean_test_score']
# stds = grid_result.cv_results_['std_test_score']
# params = grid_result.cv_results_['params']

```

```
# for mean, stdev, param in zip(means, stds, params):
#     print("%f (%f) with: %r" % (mean, stdev, param))
```

## Neurons

```
In [ ]: # # parameters list
# batch_size = [2, 4, 8, 16, 32]
# epochs = [10, 50]
# optimizer = ['SGD', 'GD', 'Adam']
# activation = [LeakyReLU(alpha=0.05), 'selu', 'elu', 'swish']
# neurons = [16,32,64,128]

# # convert to disctionary to search
# param_grid = dict(neurons=neurons)
# grid = GridSearchCV(estimator=keras_model, param_grid=param_grid, n_jobs=1, cv=3)
# grid_result = grid.fit(Xt, yt)

# # summarize results
# print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
# means = grid_result.cv_results_['mean_test_score']
# stds = grid_result.cv_results_['std_test_score']
# params = grid_result.cv_results_['params']
# for mean, stdev, param in zip(means, stds, params):
#     print("%f (%f) with: %r" % (mean, stdev, param))
```

```
In [ ]: def create_model(learn_rate=0.01):
    # create model
    model = Sequential()
    model.add(Bidirectional(LSTM(units=24), input_shape=(Xt.shape[1], Xt.shape[2])))
    model.add(Dense(12, activation='relu'))
    model.add(Dense(1, activation='sigmoid'))
    # Compile model
    optimizer = SGD(learning_rate=learn_rate)
    model.compile(loss='binary_crossentropy', optimizer=optimizer, metrics=['mae', 'mse'])
    return model
model = KerasClassifier(build_fn=create_model, epochs=20, batch_size=16, verbose=0)

# define the grid search parameters
batch_size = [2, 4, 8, 16, 32]
epochs = [10, 50]
optimizer = ['SGD', 'GD', 'Adam']
activation = [LeakyReLU(alpha=0.05), 'selu', 'elu', 'swish']
neurons = [16,32,64,128]
param_grid = dict(batch_size=batch_size, epochs=epochs)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=1, cv=3)
grid_result = grid.fit(Xt, yt)

# summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
```

```
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))
```

WARNING:tensorflow:5 out of the last 15 calls to <function Model.make\_test\_function.<locals>.test\_function at 0x00000207CE4C0EE0> triggered tf.function retracing. Tracing is expensive and the excessive number of tracings could be due to (1) creating @tf.function repeatedly in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.function has experimental\_relax\_shapes=True option that relaxes argument shapes that can avoid unnecessary retracing. For (3), please refer to [https://www.tensorflow.org/guide/function#controlling\\_retracing](https://www.tensorflow.org/guide/function#controlling_retracing) and [https://www.tensorflow.org/api\\_docs/python/tf/function](https://www.tensorflow.org/api_docs/python/tf/function) for more details.

WARNING:tensorflow:5 out of the last 13 calls to <function Model.make\_test\_function.<locals>.test\_function at 0x00000207DB53F790> triggered tf.function retracing. Tracing is expensive and the excessive number of tracings could be due to (1) creating @tf.function repeatedly in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.function has experimental\_relax\_shapes=True option that relaxes argument shapes that can avoid unnecessary retracing. For (3), please refer to [https://www.tensorflow.org/guide/function#controlling\\_retracing](https://www.tensorflow.org/guide/function#controlling_retracing) and [https://www.tensorflow.org/api\\_docs/python/tf/function](https://www.tensorflow.org/api_docs/python/tf/function) for more details.

```
Best: nan using {'batch_size': 2, 'epochs': 10}
nan (nan) with: {'batch_size': 2, 'epochs': 10}
nan (nan) with: {'batch_size': 2, 'epochs': 50}
nan (nan) with: {'batch_size': 4, 'epochs': 10}
nan (nan) with: {'batch_size': 4, 'epochs': 50}
nan (nan) with: {'batch_size': 8, 'epochs': 10}
nan (nan) with: {'batch_size': 8, 'epochs': 50}
nan (nan) with: {'batch_size': 16, 'epochs': 10}
nan (nan) with: {'batch_size': 16, 'epochs': 50}
nan (nan) with: {'batch_size': 32, 'epochs': 10}
nan (nan) with: {'batch_size': 32, 'epochs': 50}
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

## Predict

In [ ]:

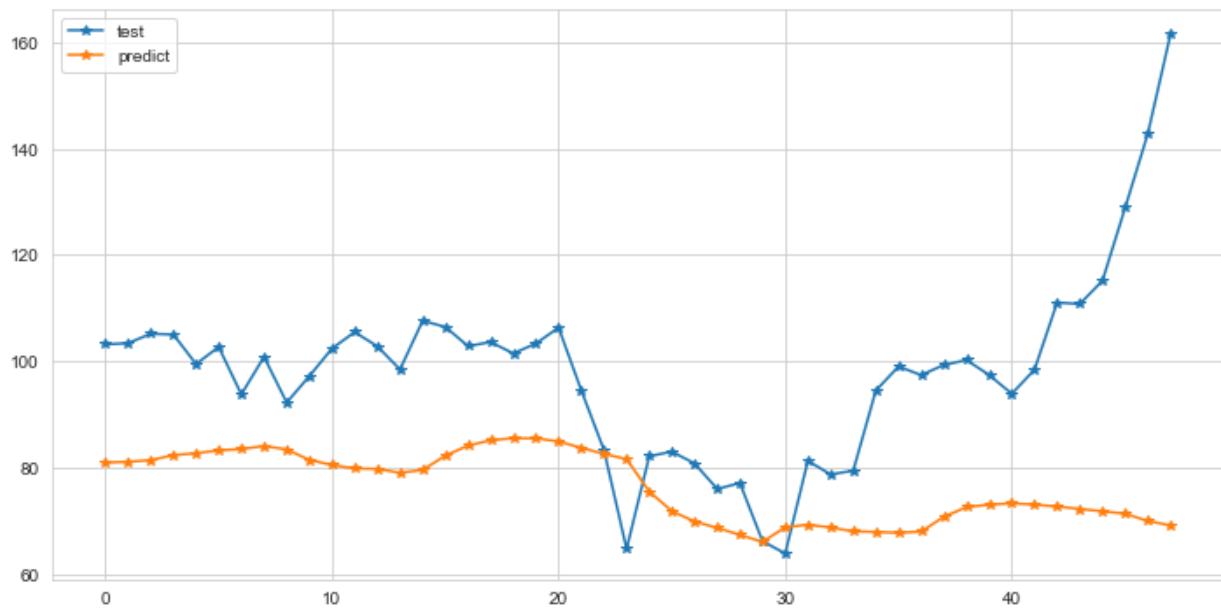
```
# y_predict using Bidirectional LSTM model
y_predict = bilSTM.predict(Xv)
yt_inverse = targetScaler.inverse_transform(yt.reshape(-1,1))
yv_inverse = targetScaler.inverse_transform(yv.reshape(-1,1))
y_predict_inv = targetScaler.inverse_transform(y_predict)
```

In [ ]:

```
plt.figure(figsize=(12,6))
plt.plot(yv_inverse.flatten(), marker = '*', label='test')
plt.plot(y_predict_inv.flatten(), marker = '*', label='predict')
plt.legend()
```

Out[ ]:

```
<matplotlib.legend.Legend at 0x26ca2c79a50>
```



## Conclusion

1. Alpha Vantage is one of the best python module to pull stock-related data.
2. pd.melt is great tool to split dataframes into a list/column view
3. The Sales of Chevron has never reached back to 2008 level (Since Great Recession).
4. Stock market percent change is way more volatile than inflation
5. Gas Price and Sales has strong positive correlation, also Gas Price has positive correlation to all other columns.
6. Recent Gas Price surge has increased Sales dramatically, however gallons of gas sold declined. Sales increase due to price change and not gallons sold.
7. Since it is time series, we should not shuffle/randomize the data for machine learning.
8. Data pre-processing for machine learning will be energy and time consuming, converting data to the right scale and reshape to correct dimension without interrupting data itself.
9. Model engineering requires high level of topic understanding, data understanding, and math.

## References

- Mr. Paul obtaining certain Chevron public data from FactSet (Paid Service, easier to pull certain public data)
- Alpha Vantage API  
certain Chevron (CVX) Data
- Inflation Data  
<https://www.usinflationcalculator.com/inflation/current-inflation-rates/#:~:text=The%20annual%20inflation%20rate%20for,at%208%3A30%20a.m.%20ET.>
- Gas Prices  
<https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?>

n=pet&s=emm\_epm0\_pte\_nus\_dpg&f=m