Data_Analytics_Project_EDA_

March 24, 2025

1 Preparing the working data set

Add the 3 economic factors data sets :

1. GDP
2. Mortgage Rates
3. Unemployment rates

Download,load and preprocess the **Gross Domestic Porduct (GDP) / capita data**

[6]:
```
import pandas as pd

file_path='/content/GDP.csv'
GDP= pd.read_csv(file_path)

GDP= GDP[GDP['Country Name'] == 'Canada']

GDP= GDP.drop(columns=['Country Code', 'Indicator Name', 'Indicator Code',␣
↪'Country Name'])

# Transpose the DataFrame
GDP_transposed = GDP.T.reset_index()

# Rename the columns to 'Year' and 'GDP'
GDP_transposed.columns = ['Year', 'GDP']

#remove the first row
GDP_transposed = GDP_transposed.iloc[1:]
#remove the last row
GDP_transposed= GDP_transposed[:-1]

print(GDP_transposed.head())
```

```
   Year          GDP
1  1961  2246.083566
2  1962  2274.428471
3  1963  2380.317329
4  1964  2561.638491
5  1965  2777.183173
```

Download,load and preprocess the **Mortgage Rates data**

[7]:
```python
import pandas as pd

file_path='/content/Mortgage Rates.csv'
mortgage_rates= pd.read_csv(file_path)

# Drop unnecessary columns
mortgage_rates= mortgage_rates.drop(columns=['Conventional mortgage - 1-year',␣
↪'Conventional mortgage - 3-year', 'Prime rate'])

# Convert 'date' column to datetime
mortgage_rates['date'] = pd.to_datetime(mortgage_rates['date'])

# Extract the year from the 'date' column
mortgage_rates['Year'] = mortgage_rates['date'].dt.year

# Group data by year and calculate the mean value for each year
mortgage_rates = mortgage_rates.groupby('Year')['Conventional mortgage -␣
↪5-year'].mean()

# Rename the mortgage rate column
mortgage_rates = mortgage_rates.rename("Mortgage rate")

# Reset index to make 'Year' a regular column
mortgage_rates = mortgage_rates.reset_index()

print(mortgage_rates.head())
```

```
   Year  Mortgage rate
0  1975      11.377358
1  1976      11.817308
2  1977      10.298077
3  1978      10.490385
4  1979      12.052885
```

Download,load and preprocess the **unemployment rates data**

[8]:
```python
import pandas as pd

file_path='/content/Unemployment Rates.csv'
unemployment_rates= pd.read_csv(file_path)


# Filter unemployment_rates for Canada ONLY
canada_unemployment = unemployment_rates[unemployment_rates['GEO'] == 'Canada']

#Select only the desired columns
```

```
canada_unemployment = canada_unemployment[['REF_DATE', 'GEO', 'VALUE']]

#get only yearly unemployment rate values

#Turn RED_DATE to date time
canada_unemployment['REF_DATE'] = pd.
 ↪to_datetime(canada_unemployment['REF_DATE'])

# Extract the year from the 'REF_DATE' column
canada_unemployment['Year'] = canada_unemployment['REF_DATE'].dt.year

# Group data by year and calculate the mean value for each year
yearly_unemployment = canada_unemployment.groupby('Year')['VALUE'].mean()

yearly_unemployment = yearly_unemployment.rename("Unemployment rate")

# Reset the index to make 'Year' a regular column
yearly_unemployment = yearly_unemployment.reset_index()


print(yearly_unemployment.head())
```

```
   Year  Unemployment rate
0  1976           3.650382
1  1977           4.189545
2  1978           4.430369
3  1979           3.897901
4  1980           3.880271
```

Download,load, and preprocess the *target variable* - **New housing price index (NHPI) data**

[11]:
```
import pandas as pd

file_path='/content/NHPI.csv'
NHPI_data= pd.read_csv(file_path)



# Filter for Canada and Total (house and land)
NHPI_data = NHPI_data[(NHPI_data['GEO'] == 'Canada') & (NHPI_data['New housing␣
 ↪price indexes'] == 'Total (house and land)')]

# Keep only the 'REF_DATE' and 'VALUE' columns
NHPI_data = NHPI_data[['REF_DATE', 'VALUE']]

#get only yearly values

#Turn RED_DATE to date time
NHPI_data['REF_DATE'] = pd.to_datetime(NHPI_data['REF_DATE'])
```

```
# Extract the year from the 'REF_DATE' column
NHPI_data['Year'] = NHPI_data['REF_DATE'].dt.year

# Group data by year and calculate the mean value for each year
NHPI_data = NHPI_data.groupby('Year')['VALUE'].mean()

NHPI_data = NHPI_data.rename("NHPI")

# Reset the index to make 'Year' a regular column
NHPI_data = NHPI_data.reset_index()

print(NHPI_data.head())
```

```
   Year       NHPI
0  1981  40.008333
1  1982  39.158333
2  1983  37.875000
3  1984  38.016667
4  1985  38.475000
```

Combine all 3 data sets - aligned at the same year

[12]:
```
# Merge the dataframes
merged_data = pd.merge(NHPI_data, yearly_unemployment, on='Year', how='inner')
merged_data = pd.merge(merged_data, mortgage_rates, on='Year', how='inner')

# Convert 'Year' column to int before merging
GDP_transposed['Year'] = GDP_transposed['Year'].astype(int)
merged_data= pd.merge(merged_data, GDP_transposed, on='Year', how='inner')

print(merged_data.head())
```

```
   Year       NHPI  Unemployment rate  Mortgage rate          GDP
0  1981  40.008333           3.891040      18.350962  12379.03686
1  1982  39.158333           5.777962      18.149038  12527.31353
2  1983  37.875000           6.733969      13.283654  13477.10317
3  1984  38.016667           6.342140      13.596154  13930.47455
4  1985  38.475000           6.026463      12.168269  14170.12494
```

[84]:
```
# Check for missing values in the merged dataset
print(merged_data.isnull().sum())

# Check data types of each column
merged_data.dtypes
```

```
Year                 0
NHPI                 0
```

```
Unemployment rate    0
Mortgage rate        0
GDP                  0
dtype: int64
```

[84]:
```
Year                   int32
NHPI                 float64
Unemployment rate    float64
Mortgage rate        float64
GDP                  float64
dtype: object
```

[85]:
```
merged_data.info()
```

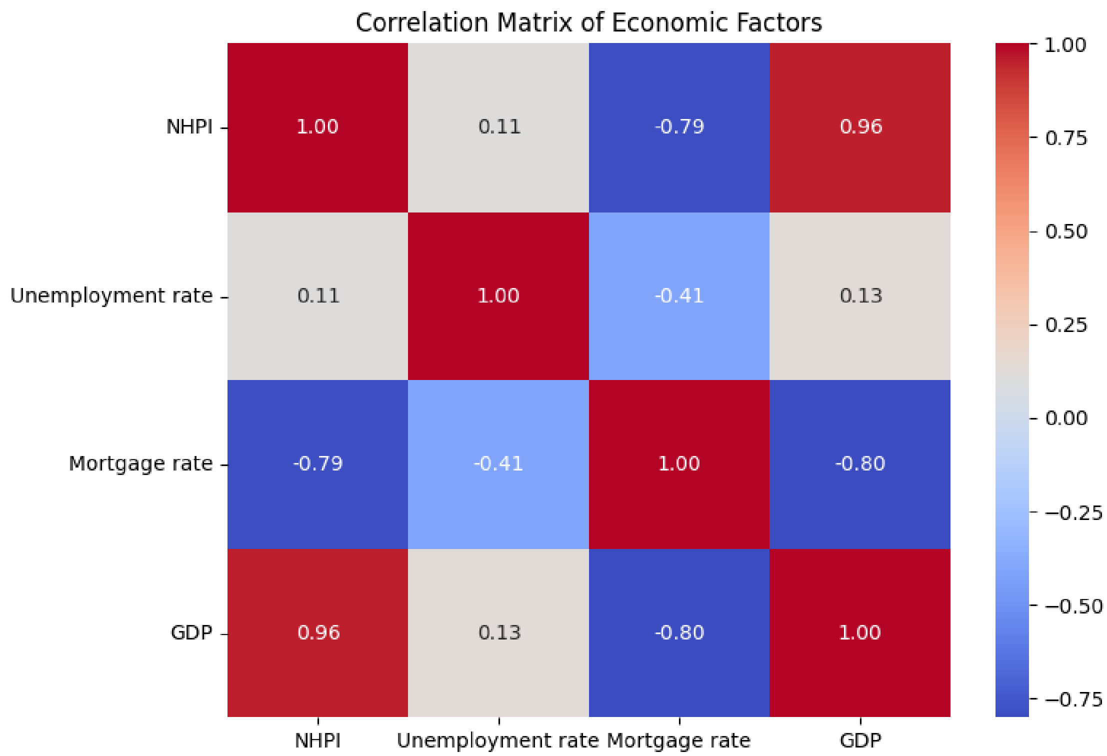
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 42 entries, 0 to 41
Data columns (total 5 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Year               42 non-null     int32
 1   NHPI               42 non-null     float64
 2   Unemployment rate  42 non-null     float64
 3   Mortgage rate      42 non-null     float64
 4   GDP                42 non-null     float64
dtypes: float64(4), int32(1)
memory usage: 1.6 KB
```

2 Exploratory Data Analysis

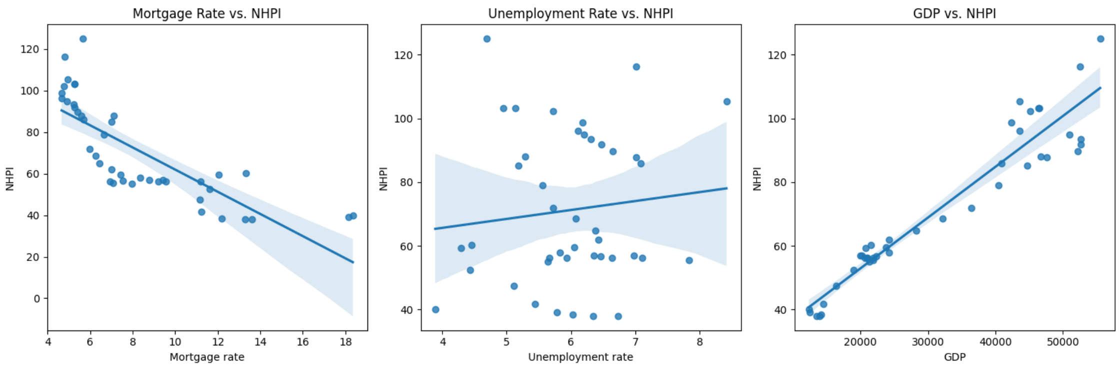
[16]:
```
import matplotlib.pyplot as plt
import seaborn as sns

# Calculate the correlation matrix
correlation_matrix = merged_data.drop(columns=['Year']).corr()

# Display the correlation matrix
print(correlation_matrix)

# Plotting the correlation matrix using a heatmap
plt.figure(figsize=(8, 6))
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt=".2f")
plt.title('Correlation Matrix of Economic Factors')
plt.show()
```

```
                       NHPI  Unemployment rate  Mortgage rate       GDP
NHPI               1.000000           0.110481      -0.793074  0.955736
Unemployment rate  0.110481           1.000000      -0.408373  0.134193
```

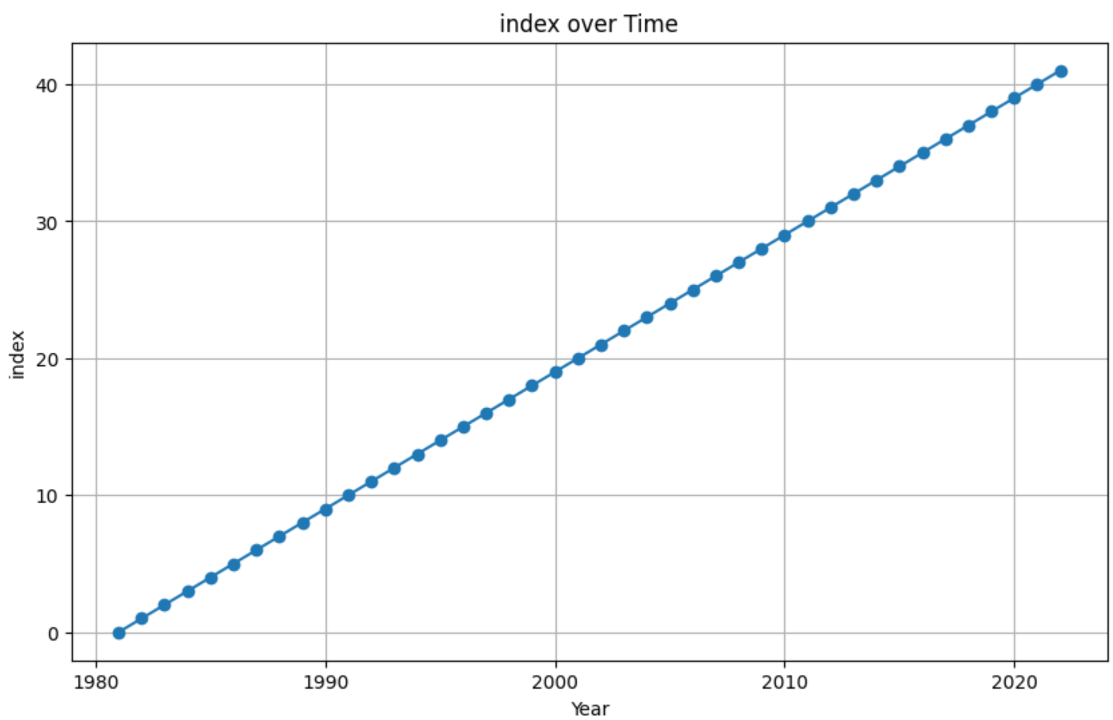
```
Mortgage rate      -0.793074          -0.408373       1.000000 -0.800903
GDP                 0.955736           0.134193      -0.800903  1.000000
```

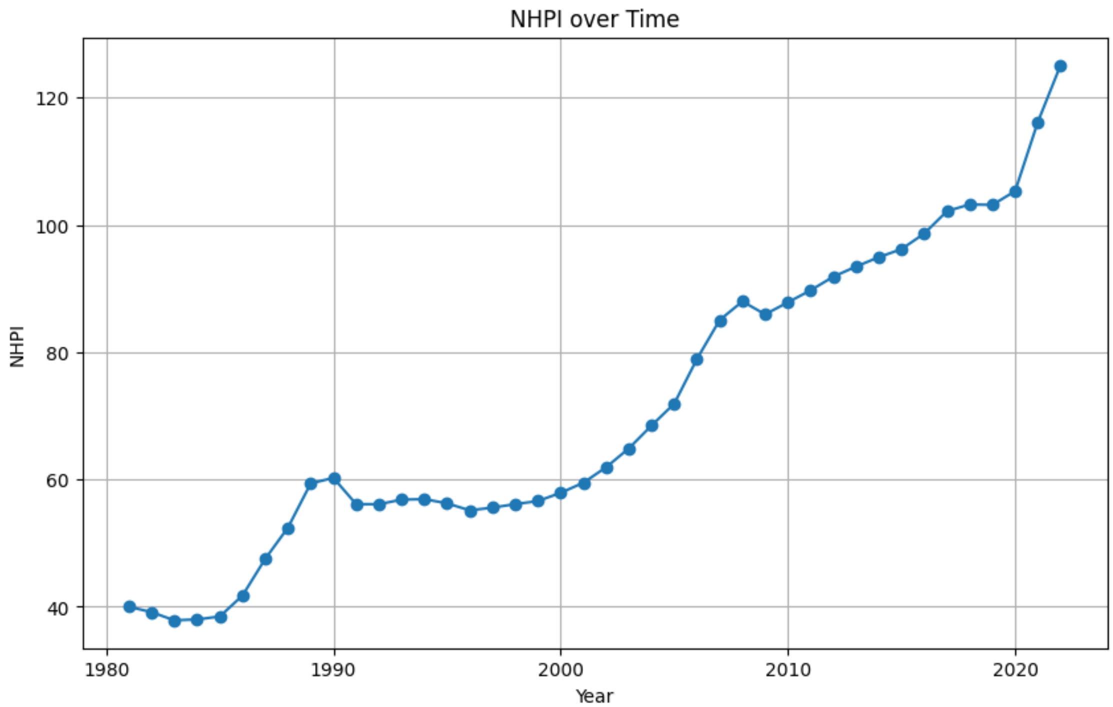



```
[17]: # Create scatter plots and regression lines
plt.figure(figsize=(15, 5))

# Mortgage Rate vs. NHPI
plt.subplot(1, 3, 1)
sns.regplot(x='Mortgage rate', y='NHPI', data=merged_data)
plt.title('Mortgage Rate vs. NHPI')

# Unemployment Rate vs. NHPI
plt.subplot(1, 3, 2)
sns.regplot(x='Unemployment rate', y='NHPI', data=merged_data)
plt.title('Unemployment Rate vs. NHPI')

# GDP vs. NHPI
plt.subplot(1, 3, 3)
sns.regplot(x='GDP', y='NHPI', data=merged_data)
plt.title('GDP vs. NHPI')

plt.tight_layout()
plt.show()
```

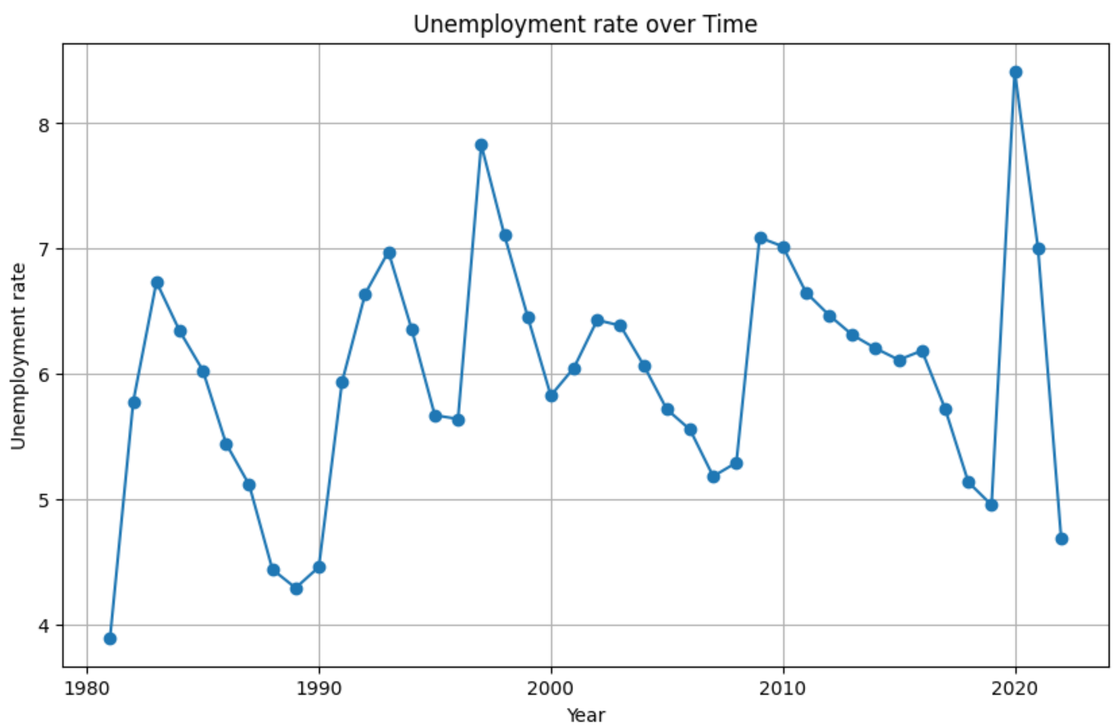


[19]:
```
for column in merged_data.columns:
  if column != 'Year':  # Skip the 'Year' column itself
    plt.figure(figsize=(10, 6))
    plt.plot(merged_data['Year'], merged_data[column], marker='o',␣
↪linestyle='-')
    plt.xlabel('Year')
    plt.ylabel(column)
    plt.title(f'{column} over Time')
    plt.grid(True)
    plt.show()
```

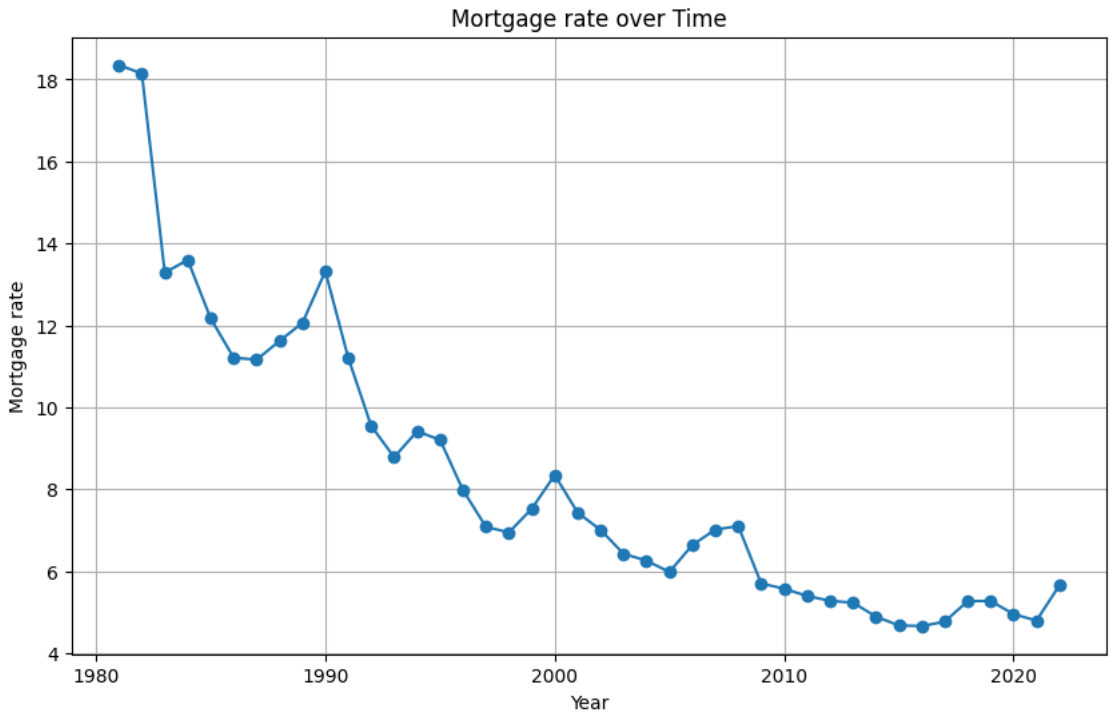


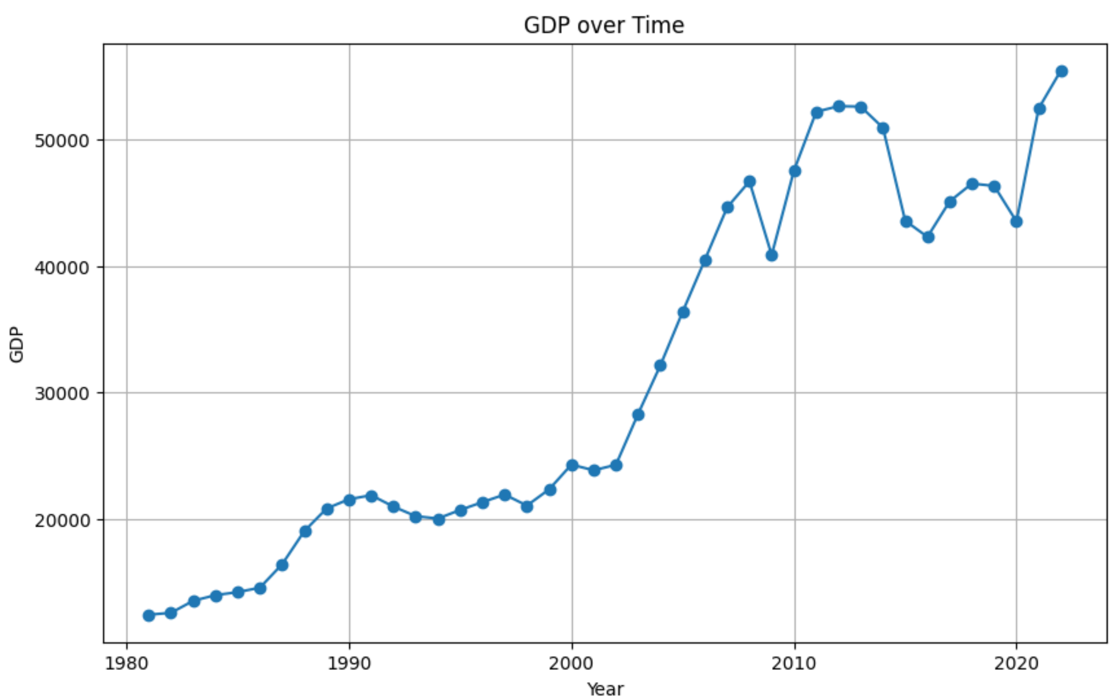


NHPI over Time
120
100
80
60
40
NHPI
1980
1990
2000
2010
2020
Year



Unemployment rate over Time
8
7
6
5
4
Unemployment rate
1980
1990
2000
2010
2020
Year


Mortgage rate over Time
Mortgage rate
Year
18
16
14
12
10
8
6
4
1980
1990
2000
2010
2020


GDP over Time
GDP
Year
50000
40000
30000
20000
1980
1990
2000
2010
2020

3 Model Comparison: Random Forest & ARIMAX

Random Forest

[92]:
```
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score

# Prepare the data for the model
X = merged_data.drop(columns=['NHPI'])  # Features (all columns except 'Year'␣
↪and 'NHPI')
y = merged_data['NHPI']  # Target variable ('NHPI')

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42) # 80% training and 20% test

# Initialize the Random Forest Regressor model
rf_model = RandomForestRegressor(n_estimators=100, random_state=42) # You can␣
↪adjust the number of estimators

# Train the model
rf_model.fit(X_train, y_train)

# Make predictions on the test set
y_pred = rf_model.predict(X_test)

# Evaluate the model
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse}")
print(f"R-squared: {r2}")
```

```
Mean Squared Error: 8.606138250000022
R-squared: 0.9784138674427942
```

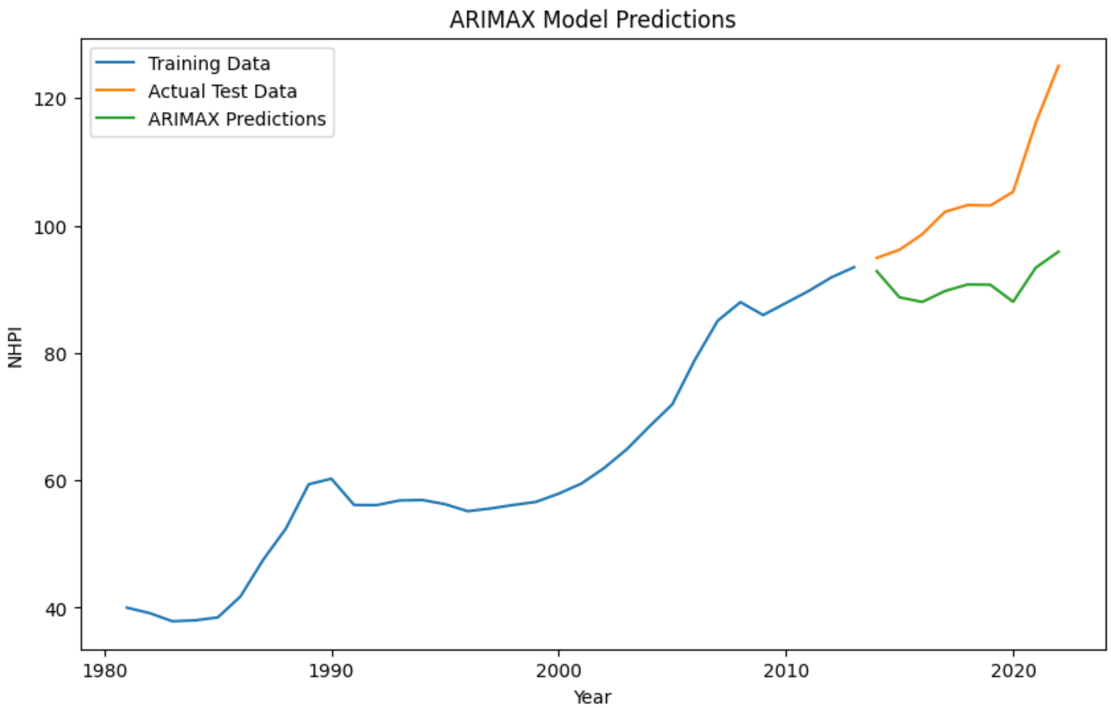
ARIMAX

[90]:
```
from statsmodels.tsa.statespace.sarimax import SARIMAX
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import mean_squared_error
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

# Prepare the data for ARIMAX
merged_data = merged_data.reset_index()  # Reset the index if previously set
merged_data = merged_data.set_index('Year')  # Set 'Year' as the index
```

```
# Define the exogenous variables
exog_vars = ['Unemployment rate', 'Mortgage rate', 'GDP']
exog = merged_data[exog_vars]

# Standardize exogenous variables
scaler = StandardScaler()
exog_scaled = scaler.fit_transform(exog)

# Split the data into training and testing sets
train_data = merged_data[:-9]  # Use data up to the last 9 observations for␣
↪training
test_data = merged_data[-9:]   # Use the last 9 observations for testing

exog_train_scaled = exog_scaled[:-9]
exog_test_scaled = exog_scaled[-9:]

# Fit the ARIMAX model with standardized exogenous variables
model = SARIMAX(train_data['NHPI'], exog=exog_train_scaled, order=(1, 1, 1),␣
↪seasonal_order=(0, 0, 0, 0))
model_fit = model.fit(disp=False)

# Make predictions on the test set
predictions = model_fit.predict(start=len(train_data), end=len(merged_data)-1,␣
↪exog=exog_test_scaled)

# Align predictions index with test_data index to fix x-axis misalignment
predictions.index = test_data.index

# Plot the results with correct alignment
plt.figure(figsize=(10, 6))
plt.plot(train_data['NHPI'], label='Training Data')
plt.plot(test_data['NHPI'], label='Actual Test Data')
plt.plot(predictions, label='ARIMAX Predictions')
plt.legend()
plt.title('ARIMAX Model Predictions')
plt.xlabel('Year')
plt.ylabel('NHPI')
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473:
ValueWarning: An unsupported index was provided. As a result, forecasts cannot
be generated. To use the model for forecasting, use one of the supported classes
of index.
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473:
ValueWarning: An unsupported index was provided. As a result, forecasts cannot
```

```
be generated. To use the model for forecasting, use one of the supported classes
of index.
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837:
ValueWarning: No supported index is available. Prediction results will be given
with an integer index beginning at `start`.
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837:
FutureWarning: No supported index is available. In the next version, calling
this method in a model without a supported index will result in an exception.
  return get_prediction_index(
```



Comparing the models

[94]:
```python
# Evaluate the ARIMAX model
arimax_mse = mean_squared_error(test_data['NHPI'], predictions)
arimax_r2 = r2_score(test_data['NHPI'], predictions)

print(f"\nARIMAX Model:")
print(f"Mean Squared Error: {arimax_mse}")
print(f"R-squared: {arimax_r2}")

print("\nModel Comparison:")
print(f"{'Model':<15} {'MSE':<10} {'R-squared':<10}")
print(f"{'Random Forest':<15} {mse:<10.2f} {r2:<10.2f}")
```

```
print(f"{'ARIMAX':<15} {arimax_mse:<10.2f} {arimax_r2:<10.2f}")
```

```
ARIMAX Model:
Mean Squared Error: 256.3470468285959
R-squared: -2.0239515583598346

Model Comparison:
Model          MSE        R-squared
Random Forest  8.61       0.98
ARIMAX         256.35     -2.02
```

4 Predicting NHPI for outyear

[89]:
```
# Merge the dataframes
merged_data = pd.merge(NHPI_data, yearly_unemployment, on='Year', how='inner')
merged_data = pd.merge(merged_data, mortgage_rates, on='Year', how='inner')

# Convert 'Year' column to int before merging
GDP_transposed['Year'] = GDP_transposed['Year'].astype(int)
merged_data= pd.merge(merged_data, GDP_transposed, on='Year', how='inner')

print(merged_data.tail())
```

```
    Year        NHPI  Unemployment rate  Mortgage rate          GDP
37  2018  103.225000           5.134042       5.265000  46539.17616
38  2019  103.158333           4.952130       5.270769  46352.86934
39  2020  105.308333           8.417576       4.949434  43537.83930
40  2021  116.175000           7.007870       4.790000  52496.84417
41  2022  125.108333           4.687379       5.651538  55509.39318
```

Since Random Forest had a better Accuracy (Lower MSE) and stronger Model Fit (Higher R^2) Random Forest model will be used to predict NHPI for the outyear 2023

[79]:
```
import pandas as pd
import numpy as np
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt

# Function to forecast features using Random Forest for a single year
def forecast_feature_rf_single_year(data, target_feature, forecast_year=2023):
    # Prepare dataset
    data = data.reset_index()  # Reset index to make 'Year' a column
    features = data.drop(columns=['Year', target_feature]).columns
    X = data[features]
    y = data[target_feature]
```

```
    # Train-test split
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=42)

    # Train Random Forest Regressor
    rf_model = RandomForestRegressor(n_estimators=200, random_state=42)
    rf_model.fit(X_train, y_train)

    # Create DataFrame for future prediction with initial values
    future_data = pd.DataFrame(index=[forecast_year], columns=data.columns)
    future_data['Year'] = forecast_year

    # Initialize future data with last known values from historical data
    for feature in features:
        future_data.loc[forecast_year, feature] = data.iloc[-1][feature]

    # Predict target feature for the forecast year
    future_data.loc[forecast_year, target_feature] = rf_model.
 ↪predict(future_data.loc[[forecast_year]][features])[0]

    return future_data[[target_feature]]

# Forecast exogenous variables for 2023
predicted_unemployment_2023 = forecast_feature_rf_single_year(merged_data,␣
 ↪'Unemployment rate')
predicted_mortgage_2023 = forecast_feature_rf_single_year(merged_data,␣
 ↪'Mortgage rate')
predicted_gdp_2023 = forecast_feature_rf_single_year(merged_data, 'GDP')

# Combine forecasted exogenous variables for 2023
future_exog_2023 = pd.concat([predicted_unemployment_2023,␣
 ↪predicted_mortgage_2023, predicted_gdp_2023], axis=1)
future_exog_2023['Year'] = future_exog_2023.index  # Add 'Year' column

# Prepare data for NHPI prediction for 2023
X_future_2023 = future_exog_2023[['Unemployment rate', 'Mortgage rate', 'GDP']]

# Predict NHPI for 2023 using the trained Random Forest model (rf_model from␣
 ↪previous code)
predicted_nhpi_2023 = rf_model.predict(X_future_2023)

# Create DataFrame for predicted NHPI for 2023
predicted_nhpi_df_2023 = pd.DataFrame({'Year': future_exog_2023['Year'],␣
 ↪'Predicted NHPI': predicted_nhpi_2023})
```

```
# Print the predicted NHPI for 2023
print(predicted_nhpi_df_2023)
```

```
      Year  Predicted NHPI
2023  2023       99.699458
```

[80]:
```
plt.figure(figsize=(10, 5))
plt.plot(merged_data['Year'], merged_data['NHPI'], label='Actual NHPI',␣
 ↪marker='o')
plt.plot(predicted_nhpi_df_2023['Year'], predicted_nhpi_df_2023['Predicted␣
 ↪NHPI'], label='Predicted NHPI (2023)', marker='s', color='red')
plt.xlabel("Year")
plt.ylabel("NHPI")
plt.title("NHPI Forecast for 2023 Using Random Forest")
plt.legend()
plt.grid()
plt.show()
```