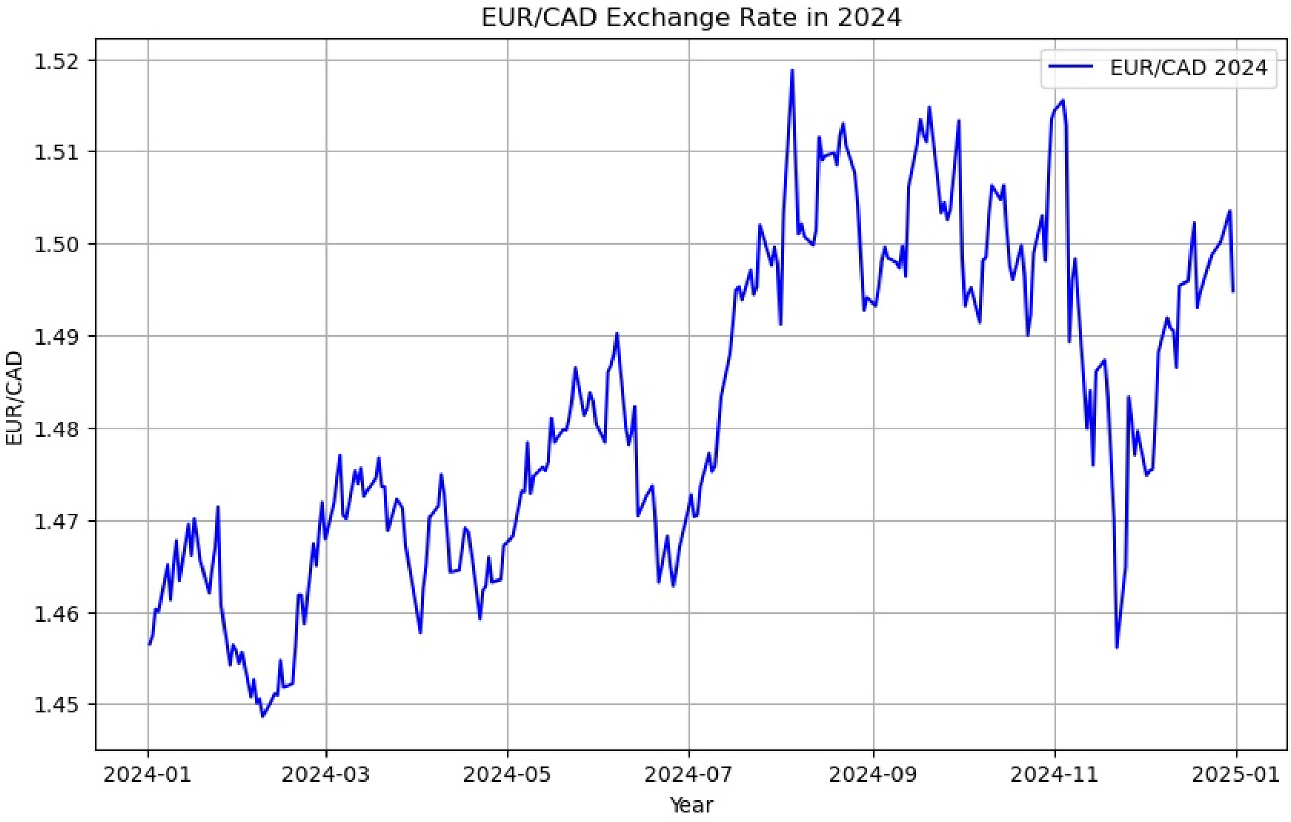
Goal 3: Simulated currency forecast for exchange rate EUR/CAD for 2025, assuming we work with only the data until the end of 2024 and did not know the actual data: Forecasting with SARIMAX, afterwards comparison with actual data for January, February, March and April 25

In [1]:

```
#Import neccessary libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import zipfile
import io
import requests
from statsmodels.tsa.statespace.sarimax import SARIMAX
import warnings

# Suppress warnings
warnings.filterwarnings("ignore")

# Downloading and preparing data:
# URL of the historical data from ECB
url = 'https://www.ecb.europa.eu/stats/eurofxref/eurofxref-hist.zip'

# Sending a GET request to the URL to fetch the zip file
response = requests.get(url)

# Unzipping the file in memory
with zipfile.ZipFile(io.BytesIO(response.content)) as z:

    # Opening the CSV file inside the zip file
    with z.open('eurofxref-hist.csv') as f:

        # Reading the CSV data into a pandas DataFrame
        df = pd.read_csv(f)

# Renaming the first column to 'Date' for clarity and converting the 'Date' column to datetime format
df.rename(columns={df.columns[0]: 'Date'}, inplace=True)
df['Date'] = pd.to_datetime(df['Date'], format='%Y-%m-%d')

# Setting the 'Date' column as the index of the DataFrame
df.set_index('Date', inplace=True)

# Filtering the data to keep only the EUR/CAD exchange rates and sorting the DataFrame by the date
df = df[['CAD']]
df = df.sort_index()

# Filtering data for the year 2024
df_train = df.loc['2024-01-01':'2024-12-31']

# Interpolating missing data based on the time index (linear interpolation)
df_train['CAD'] = df_train['CAD'].interpolate(method='time')

# Displaying the DataFrame for 2024
print("Exchange rate for EUR/CAD in 2024: ")
print(df_train)

# Adding a plot
# Creating a figure with specified size
plt.figure(figsize=(10, 6))

# Plotting the CAD/Euro exchange rate for the year 2024
plt.plot(df_train.index, df_train['CAD'], label='EUR/CAD 2024', color='blue')

# Adding a title to the plot
plt.title('EUR/CAD Exchange Rate in 2024')

# Adding labels to the x-axis and y-axis
plt.xlabel('Year')
plt.ylabel('EUR/CAD')

# Displaying gridlines
plt.grid(True)

# Adding a legend to the plot
plt.legend()

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

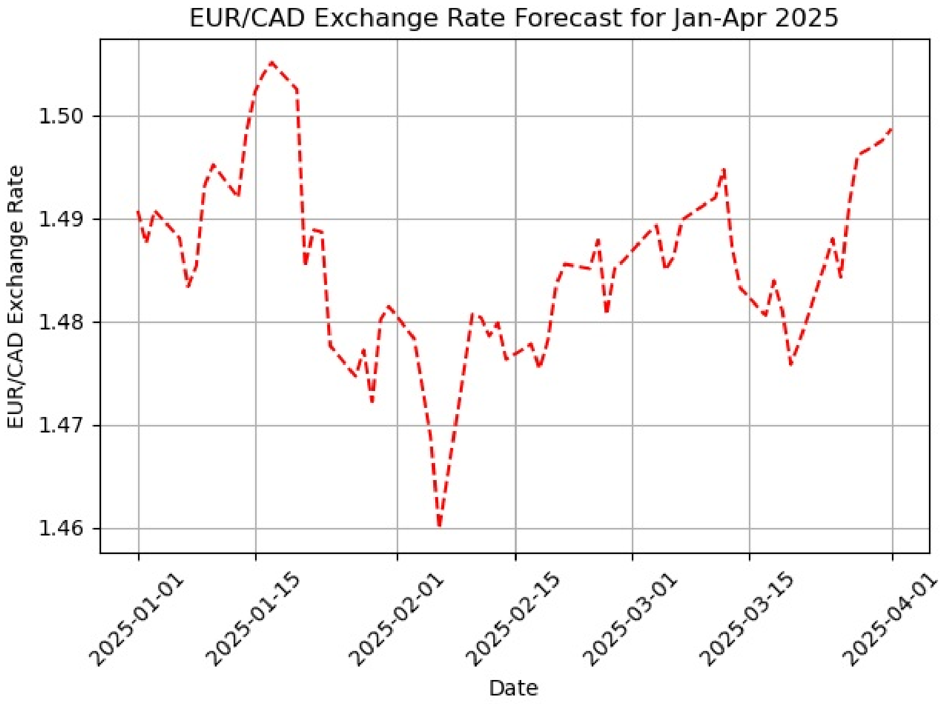
```
Exchange rate for EUR/CAD in 2024:
               CAD
Date              
2024-01-02  1.4565
2024-01-03  1.4574
2024-01-04  1.4603
2024-01-05  1.4600
2024-01-08  1.4651
...            ...
2024-12-23  1.4978
2024-12-24  1.4988
2024-12-27  1.5002
2024-12-30  1.5035
2024-12-31  1.4948

[256 rows x 1 columns]
```



In [2]:

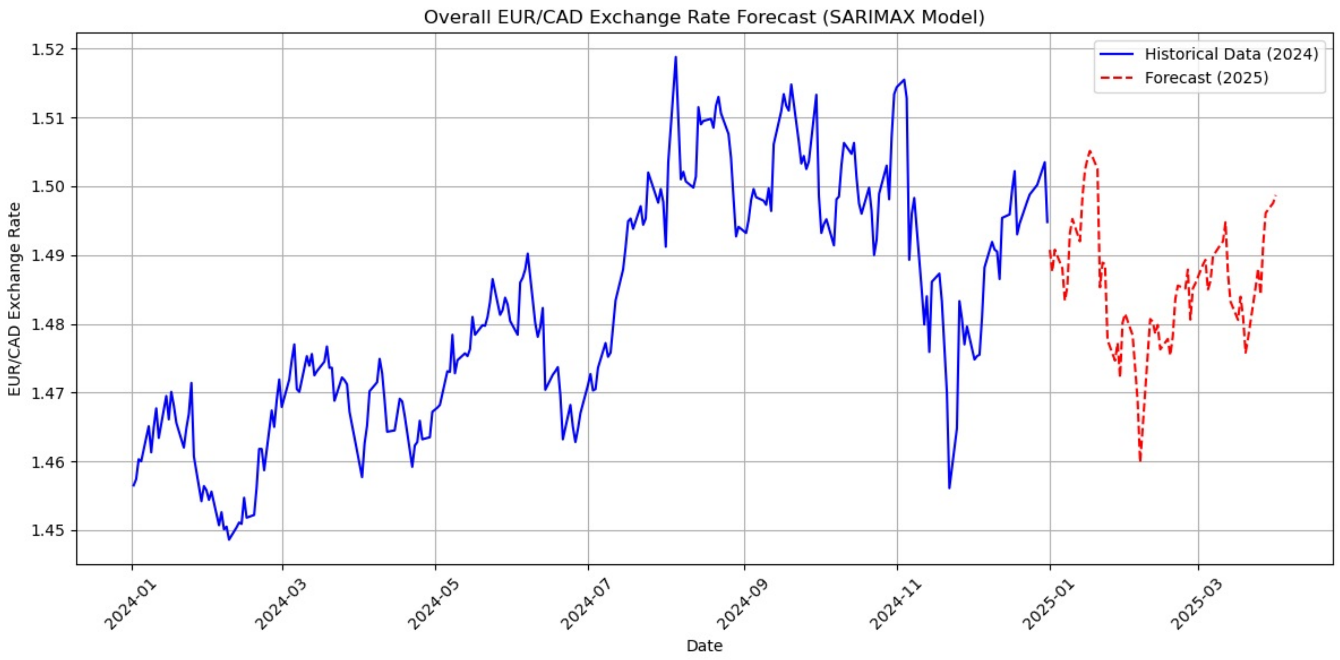
```
# Fit SARIMAX model
# Define (p, d, q) and (P, D, Q, 52) (52 for the seasonal component, assuming weekly seasonality)
p, d, q = 1, 1, 1  # Example values for the model
P, D, Q = 1, 1, 1  # Seasonal values

# Create the model
model = SARIMAX(df_train['CAD'],
                order=(p, d, q),
                seasonal_order=(P, D, Q, 52),  # Seasonal periods (52 for weekly)
                enforce_stationarity=False,
                enforce_invertibility=False)

# Fit the model
fitted = model.fit(disp=0)

# Forecast for 65 periods (business days)
n_periods = 65
predictions = fitted.predict(len(df_train), len(df_train) + n_periods - 1)

# Generate forecast data (future timestamps)
future_dates = pd.date_range(start=df_train.index[-1] + pd.Timedelta(days=1), periods=n_periods, freq='B')

# Forecast in tabular form
forecast_df = pd.DataFrame({
    'Date': future_dates,
    'Forecast_EUR_CAD': predictions
})
print("\nForecast for EUR/CAD (Jan–Apr 2025):")
print(forecast_df)

# Plot the forecasted values
plt.plot(forecast_df['Date'], forecast_df['Forecast_EUR_CAD'], label='Forecast (Jan–Apr 2025)', color='red', li
plt.xticks(rotation=45)
plt.title('EUR/CAD Exchange Rate Forecast for Jan-Apr 2025')
plt.xlabel('Date')
plt.ylabel('EUR/CAD Exchange Rate')
plt.grid(True)
plt.tight_layout()
plt.show()
```

```
Forecast for EUR/CAD (Jan–Apr 2025):
          Date  Forecast_EUR_CAD
256 2025-01-01          1.490744
257 2025-01-02          1.487582
258 2025-01-03          1.490770
259 2025-01-06          1.488066
260 2025-01-07          1.483382
..         ...               ...
316 2025-03-26          1.484267
317 2025-03-27          1.491499
318 2025-03-28          1.496106
319 2025-03-31          1.497574
320 2025-04-01          1.498716

[65 rows x 2 columns]
```



In [3]:

```python
# Plot of historical data and forecast
plt.figure(figsize=(12, 6))
plt.plot(df_train.index, df_train['CAD'], label='Historical Data (2024)', color='blue')
plt.plot(future_dates, predictions, label='Forecast (2025)', color='red', linestyle='--')
plt.title('Overall EUR/CAD Exchange Rate Forecast (SARIMAX Model)')
plt.xlabel('Date')
plt.ylabel('EUR/CAD Exchange Rate')
plt.legend()
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```



In [4]:

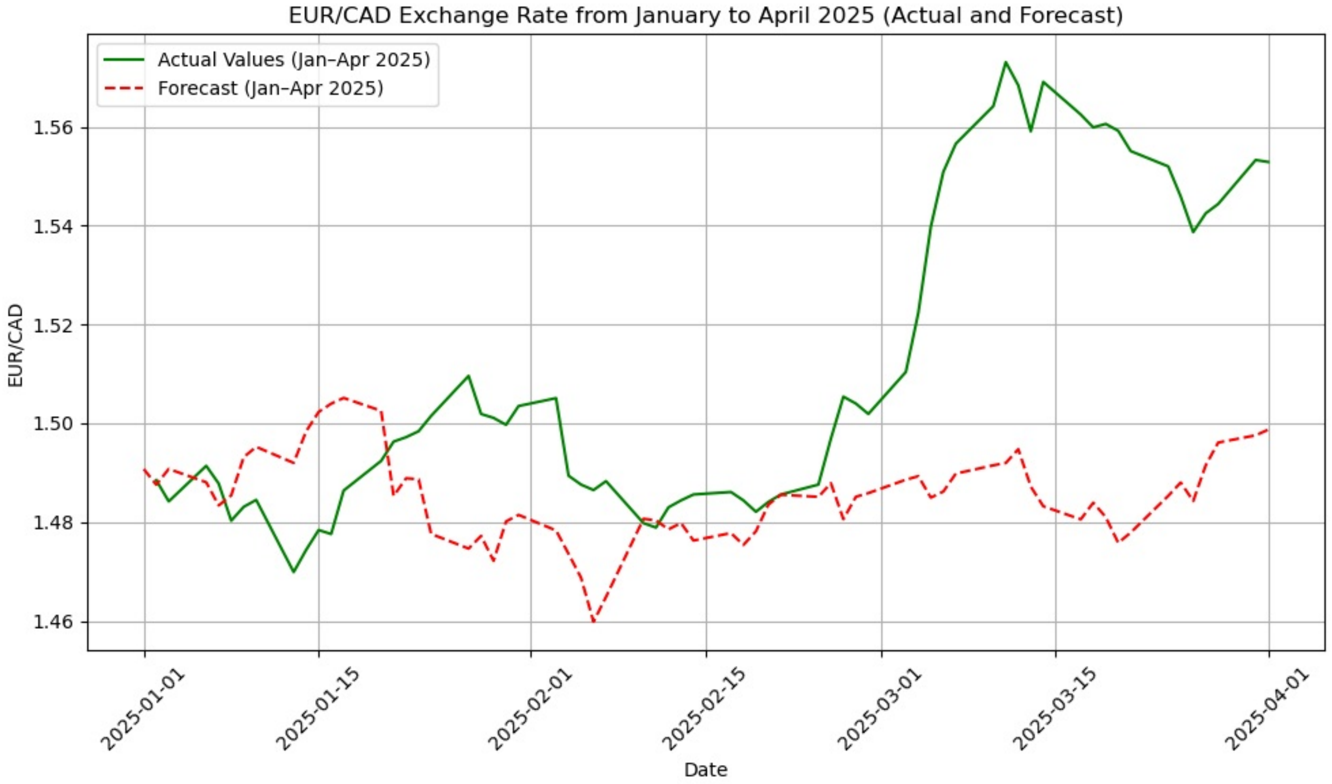
```
# Comparison: Getting actual data for Jan-Apr 2025
# Filter data for January to April 2025
df_2025_filtered = df.loc['2025-01-01':'2025-04-01']
df_2025_filtered['CAD'] = df_2025_filtered['CAD'].interpolate(method='time')

# Display the filtered data
print("\nEUR/CAD Exchange Rates from 1st Jan 2025 to 30th Apr 2025:")
print(df_2025_filtered)
```

```
EUR/CAD Exchange Rates from 1st Jan 2025 to 30th Apr 2025:
               CAD
Date
2025-01-02  1.4885
2025-01-03  1.4842
2025-01-06  1.4914
2025-01-07  1.4878
2025-01-08  1.4803
...            ...
2025-03-26  1.5387
2025-03-27  1.5425
2025-03-28  1.5444
2025-03-31  1.5533
2025-04-01  1.5529

[64 rows x 1 columns]
```

In [5]:

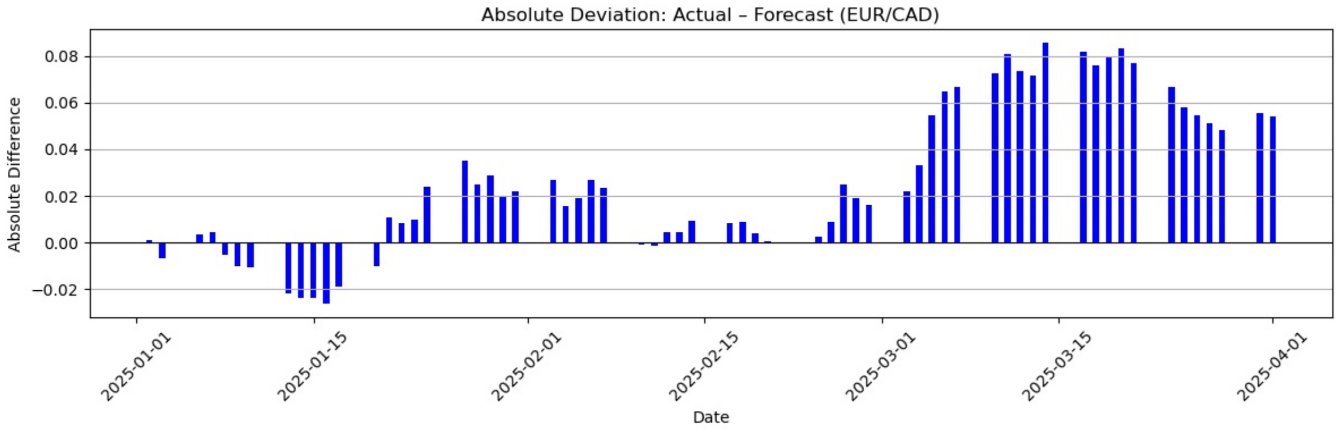
```
# Merge forecast with actuals
comparison_df = pd.merge(
    df_2025_filtered[['CAD']],
    forecast_df.set_index('Date'),
    left_index=True,
    right_index=True,
    how='inner'
)

# Calculate the absolute and relative differences
comparison_df['Abs_Diff'] = comparison_df['CAD'] - comparison_df['Forecast_EUR_CAD']
comparison_df['Rel_Diff (%)'] = 100 * comparison_df['Abs_Diff'] / comparison_df['CAD']

# Print the comparison table
print("\nComparison of Actual vs Forecasted EUR/CAD Exchange Rate (Jan–Apr 2025):")
print(comparison_df[['CAD', 'Forecast_EUR_CAD', 'Abs_Diff', 'Rel_Diff (%)']].round(4))

# Plot of actual vs forecast
plt.figure(figsize=(10, 6))

plt.plot(df_2025_filtered.index, df_2025_filtered['CAD'], label='Actual Values (Jan–Apr 2025)', color='green')
plt.plot(forecast_df['Date'], forecast_df['Forecast_EUR_CAD'], label='Forecast (Jan–Apr 2025)', color='red', li

plt.title('EUR/CAD Exchange Rate from January to April 2025 (Actual and Forecast)')
plt.xlabel('Date')
plt.ylabel('EUR/CAD')
plt.grid(True)
plt.legend()
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```

```
Comparison of Actual vs Forecasted EUR/CAD Exchange Rate (Jan–Apr 2025):
               CAD  Forecast_EUR_CAD  Abs_Diff  Rel_Diff (%)
Date
2025-01-02  1.4885            1.4876    0.0009        0.0617
2025-01-03  1.4842            1.4908   -0.0066       -0.4426
2025-01-06  1.4914            1.4881    0.0033        0.2235
2025-01-07  1.4878            1.4834    0.0044        0.2969
2025-01-08  1.4803            1.4854   -0.0051       -0.3453
...            ...               ...       ...           ...
2025-03-26  1.5387            1.4843    0.0544        3.5376
2025-03-27  1.5425            1.4915    0.0510        3.3064
2025-03-28  1.5444            1.4961    0.0483        3.1270
2025-03-31  1.5533            1.4976    0.0557        3.5876
2025-04-01  1.5529            1.4987    0.0542        3.4892

[64 rows x 4 columns]
```



In [6]:

```
# Plotting deviation as bar chart
plt.figure(figsize=(12, 4))
plt.bar(comparison_df.index, comparison_df['Abs_Diff'], width=0.5, color='blue')
plt.axhline(0, color='black', linewidth=0.8)
plt.title('Absolute Deviation: Actual – Forecast (EUR/CAD)')
plt.xlabel('Date')
plt.ylabel('Absolute Difference')
plt.grid(True, axis='y')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



In [7]:

```
# Model summary
print("These are the SARIMAX results:")
print(fitted.summary())
```

```
These are the SARIMAX results:
                                     SARIMAX Results                                      
==========================================================================================
Dep. Variable:                                CAD   No. Observations:                  256
Model:             SARIMAX(1, 1, 1)x(1, 1, 1, 52)   Log Likelihood               -3050.916
Date:                            Thu, 15 May 2025   AIC                           6111.832
Time:                                    10:45:19   BIC                           6126.852
Sample:                                         0   HQIC                          6117.935
                                            - 256                                         
Covariance Type:                              opg                                         
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1          0.3956         -0       -inf      0.000       0.396       0.396
ma.L1         -0.5359         -0        inf      0.000      -0.536      -0.536
ar.S.L52      -0.3060   3.42e-34  -8.94e+32      0.000      -0.306      -0.306
ma.S.L52   -4.063e+12   2.91e-30   -1.4e+42      0.000   -4.06e+12   -4.06e+12
sigma2       5.88e-09   9.84e-10      5.977      0.000    3.95e-09    7.81e-09
===================================================================================
Ljung-Box (L1) (Q):                   0.38   Jarque-Bera (JB):                 8.56
Prob(Q):                              0.54   Prob(JB):                         0.01
Heteroskedasticity (H):               1.78   Skew:                            -0.46
Prob(H) (two-sided):                  0.04   Kurtosis:                         3.73
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
[2] Covariance matrix is singular or near-singular, with condition number    inf. Standard errors may be unstab
le.
```

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