Task 2 Data Exploration with python

a) Perform Exploratory data analysis

In [2]:

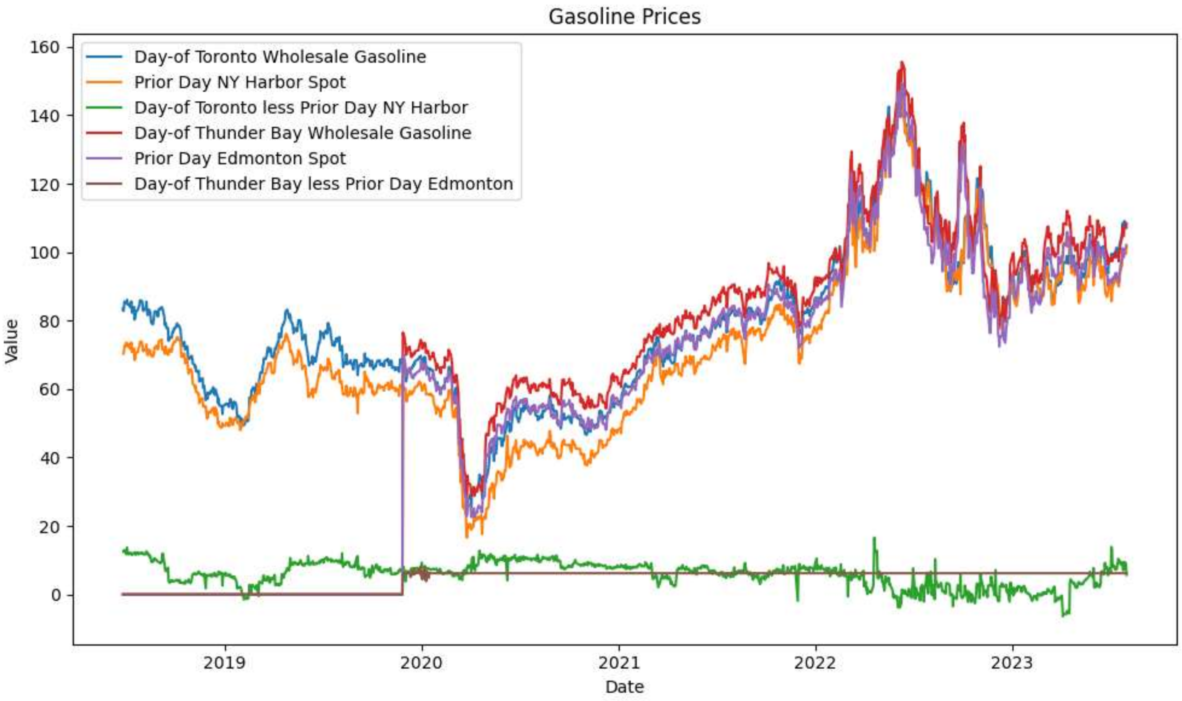
```
import pandas as pd
import matplotlib.pyplot as plt

df = pd.read_csv("wholesalegasolineprices.csv")

# Overview of the dataset
print(df.head())
print(df.info())
print(df.describe())
```

```
        Date  Day-of Toronto Wholesale Gasoline  Prior Day NY Harbor Spot  \
0  6/25/2018                               83.5                       NaN   
1  6/26/2018                               82.8                      70.3   
2  6/27/2018                               83.4                      70.9   
3  6/28/2018                               85.6                      72.6   
4  6/29/2018                               85.3                      72.6   

   Day-of Toronto less Prior Day NY Harbor  \
0                                      NaN   
1                                     12.5   
2                                     12.5   
3                                     13.0   
4                                     12.7   

   Day-of Thunder Bay Wholesale Gasoline  Prior Day Edmonton Spot  \
0                                    0.0                      NaN   
1                                    0.0                      0.0   
2                                    0.0                      0.0   
3                                    0.0                      0.0   
4                                    0.0                      0.0   

   Day-of Thunder Bay less Prior Day Edmonton  
0                                         NaN  
1                                         0.0  
2                                         0.0  
3                                         0.0  
4                                         0.0  
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1297 entries, 0 to 1296
Data columns (total 7 columns):
 #   Column                                      Non-Null Count  Dtype  
---  ------                                      --------------  -----  
 0   Date                                        1297 non-null   object 
 1   Day-of Toronto Wholesale Gasoline           1297 non-null   float64
 2   Prior Day NY Harbor Spot                    1296 non-null   float64
 3   Day-of Toronto less Prior Day NY Harbor     1296 non-null   float64
 4   Day-of Thunder Bay Wholesale Gasoline       1297 non-null   float64
 5   Prior Day Edmonton Spot                     1296 non-null   float64
 6   Day-of Thunder Bay less Prior Day Edmonton  1296 non-null   float64
dtypes: float64(6), object(1)
memory usage: 65.9+ KB
None
       Day-of Toronto Wholesale Gasoline  Prior Day NY Harbor Spot  \
count                        1297.000000               1296.000000   
mean                           77.759445                 71.744753   
std                            22.199763                 24.134664   
min                            23.300000                 16.600000   
25%                            62.700000                 56.600000   
50%                            76.300000                 68.900000   
75%                            91.100000                 88.900000   
max                           146.700000                149.700000   

       Day-of Toronto less Prior Day NY Harbor  \
count                              1296.000000   
mean                                  6.010262   
std                                   3.578425   
min                                  -6.400000   
```

```
25%                                   3.600000
50%                                   6.600000
75%                                   8.400000
max                                  16.600000

       Day-of Thunder Bay Wholesale Gasoline  Prior Day Edmonton Spot  \
count                            1297.000000              1296.000000
mean                               61.429453                57.056019
std                                44.157387                41.688146
min                                 0.000000                 0.000000
25%                                 0.000000                 0.000000
50%                                70.600000                64.450000
75%                                95.300000                89.150000
max                               155.600000               149.400000

       Day-of Thunder Bay less Prior Day Edmonton
count                                 1296.000000
mean                                     4.423765
std                                      2.805891
min                                      0.000000
25%                                      0.000000
50%                                      6.200000
75%                                      6.200000
max                                      8.200000
```

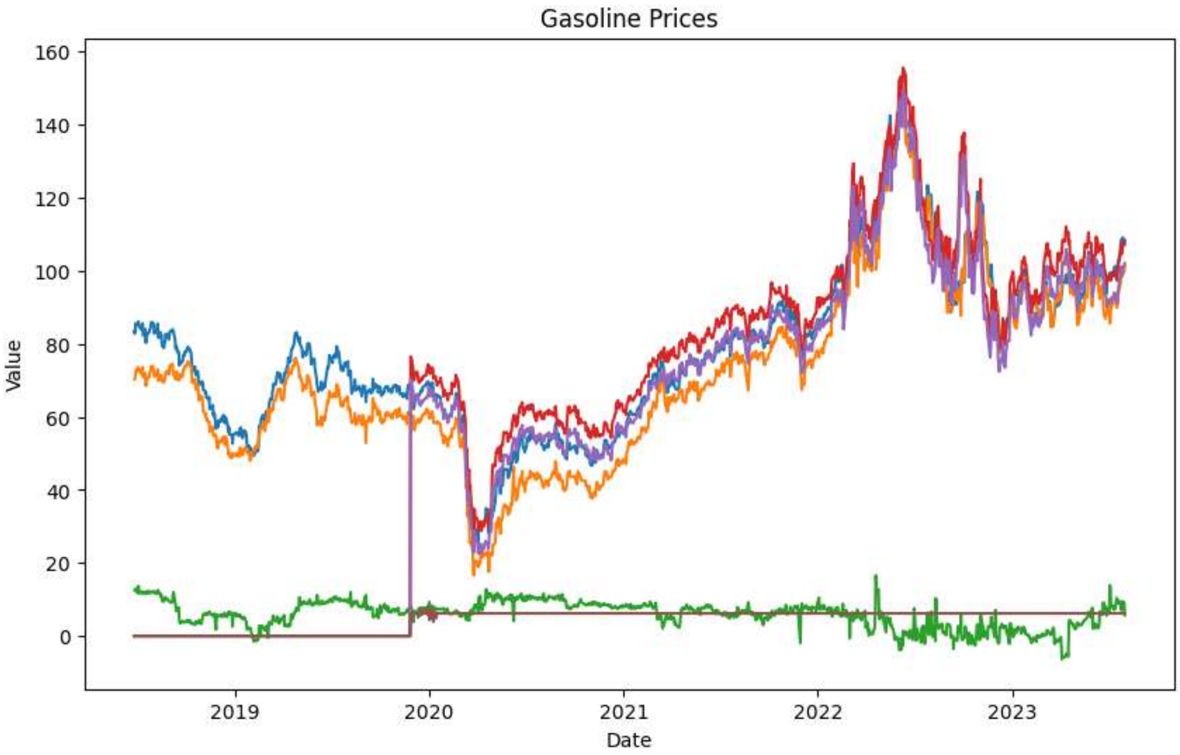
In [3]:

```
# Convert the 'Date' column to datetime format
df['Date'] = pd.to_datetime(df['Date'])

# Plot each column as a separate line chart
plt.figure(figsize=(10, 6))
plt.plot(df['Date'], df['Day-of Toronto Wholesale Gasoline'], label='Day-of Tor
plt.plot(df['Date'], df['Prior Day NY Harbor Spot'], label='Prior Day NY Harbor
plt.plot(df['Date'], df['Day-of Toronto less Prior Day NY Harbor'], label='Day
plt.plot(df['Date'], df['Day-of Thunder Bay Wholesale Gasoline'], label='Day-of
plt.plot(df['Date'], df['Prior Day Edmonton Spot'], label='Prior Day Edmonton S
plt.plot(df['Date'], df['Day-of Thunder Bay less Prior Day Edmonton'], label='D

# Set labels and title
plt.xlabel('Date')
plt.ylabel('Value')
plt.title('Gasoline Prices')
plt.legend()

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



b) Generate summary stats

```
In [4]:  # Generate summary statistics
         summary_stats = df.describe()

         # Identify data types
         data_types = df.dtypes

         # Visualize data distribution
         plt.figure(figsize=(10, 6))
         for column in df.columns[1:]:
             plt.plot(df['Date'], df[column], label=column)
         plt.xlabel('Date')
         plt.ylabel('Value')
         plt.title('Gasoline Prices')
         plt.show()

         print("Summary Statistics:")
         print(summary_stats)
         print("\nData Types:")
         print(data_types)
```



```
Summary Statistics:
       Day-of Toronto Wholesale Gasoline  Prior Day NY Harbor Spot  \
count                        1297.000000               1296.000000   
mean                           77.759445                 71.744753   
std                            22.199763                 24.134664   
min                            23.300000                 16.600000   
25%                            62.700000                 56.600000   
50%                            76.300000                 68.900000   
75%                            91.100000                 88.900000   
max                           146.700000                149.700000   

       Day-of Toronto less Prior Day NY Harbor  \
count                              1296.000000   
mean                                  6.010262   
std                                   3.578425   
min                                  -6.400000   
25%                                   3.600000   
50%                                   6.600000   
75%                                   8.400000   
max                                  16.600000   

       Day-of Thunder Bay Wholesale Gasoline  Prior Day Edmonton Spot  \
count                            1297.000000              1296.000000   
mean                               61.429453                57.056019   
std                                44.157387                41.688146   
min                                 0.000000                 0.000000   
25%                                 0.000000                 0.000000   
50%                                70.600000                64.450000   
75%                                95.300000                89.150000   
max                               155.600000               149.400000   

       Day-of Thunder Bay less Prior Day Edmonton  
count                                 1296.000000  
mean                                     4.423765  
std                                      2.805891  
min                                      0.000000  
25%                                      0.000000  
50%                                      6.200000  
75%                                      6.200000  
max                                      8.200000  

Data Types:
Date                                          datetime64[ns]
Day-of Toronto Wholesale Gasoline                    float64
Prior Day NY Harbor Spot                             float64
Day-of Toronto less Prior Day NY Harbor              float64
Day-of Thunder Bay Wholesale Gasoline                float64
Prior Day Edmonton Spot                              float64
Day-of Thunder Bay less Prior Day Edmonton           float64
dtype: object
```

Task 3 Data preprocessing with python

a) Preprocess

In [5]:
```
'''
plt.figure(figsize=(10, 6))
for i, column in enumerate(df.columns[1:], 1):
    plt.subplot(2, 3, i)
    plt.bar(df['Date'], df[column])
    plt.xlabel('Date')
    plt.ylabel(column)

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

Out[5]:
```
"\nplt.figure(figsize=(10, 6))\nfor i, column in enumerate(df.columns[1:],
1):\n    plt.subplot(2, 3, i)\n    plt.bar(df['Date'], df[column])\n    plt.x
label('Date')\n    plt.ylabel(column)\n\nplt.tight_layout()\nplt.show()\n"
```

b) Handle Missing values, Outliers, and Perform

In [6]:
```

# Convert the 'Date' column to datetime format
df['Date'] = pd.to_datetime(df['Date'])

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

df = df.fillna(0)

threshold = df.quantile(0.99)
df = df.clip(upper=threshold, axis=1)

df['Diff_Toronto_and_NY'] = df['Day-of Toronto Wholesale Gasoline'] - df['Prio
df['Diff_Toronto_and_ThunderBay'] = df['Day-of Toronto less Prior Day NY Harbo
df['Diff_Edmonton_and_ThunderBay'] = df['Day-of Thunder Bay less Prior Day Edm
```

In [7]:

```
df.head(10)
```

Out[7]:

	Day-of Toronto Wholesale Gasoline	Prior Day NY Harbor Spot	Day-of Toronto less Prior Day NY Harbor	Day-of Thunder Bay Wholesale Gasoline	Prior Day Edmonton Spot	Day-of Thunder Bay less Prior Day Edmonton	Diff_Toronto_and_NY	Diff_
Date								
2018-06-25	83.5	0.0	0.000	0.0	0.0	0.0	83.5	
2018-06-26	82.8	70.3	12.404	0.0	0.0	0.0	12.5	
2018-06-27	83.4	70.9	12.404	0.0	0.0	0.0	12.5	
2018-06-28	85.6	72.6	12.404	0.0	0.0	0.0	13.0	
2018-06-29	85.3	72.6	12.404	0.0	0.0	0.0	12.7	
2018-07-02	85.3	73.6	11.700	0.0	0.0	0.0	11.7	
2018-07-03	86.1	72.4	12.404	0.0	0.0	0.0	13.7	
2018-07-04	84.7	72.7	12.000	0.0	0.0	0.0	12.0	
2018-07-05	84.7	72.6	12.100	0.0	0.0	0.0	12.1	
2018-07-06	84.8	73.1	11.700	0.0	0.0	0.0	11.7	

Task 4 Implement Machine learning models with python

a) Two machine learning models

In [8]:

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score


# Split the data into features (X) and target (y)
X = df.drop(columns=['Day-of Toronto Wholesale Gasoline'])
y = df['Day-of Toronto Wholesale Gasoline']

# 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, rando

# Model 1: Linear Regression
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)
lr_predictions = lr_model.predict(X_test)

# Model 2: Random Forest Regression
rf_model = RandomForestRegressor(n_estimators=100, random_state=42)
rf_model.fit(X_train, y_train)
rf_predictions = rf_model.predict(X_test)

# Evaluate Model Performance
lr_mse = mean_squared_error(y_test, lr_predictions)
lr_r2 = r2_score(y_test, lr_predictions)

rf_mse = mean_squared_error(y_test, rf_predictions)
rf_r2 = r2_score(y_test, rf_predictions)

# Compare the performance of the models
print("Linear Regression:")
print(f"Mean Squared Error: {lr_mse:.2f}")
print(f"R-squared: {lr_r2:.2f}")

print("\nRandom Forest Regression:")
print(f"Mean Squared Error: {rf_mse:.2f}")
print(f"R-squared: {rf_r2:.2f}")
```

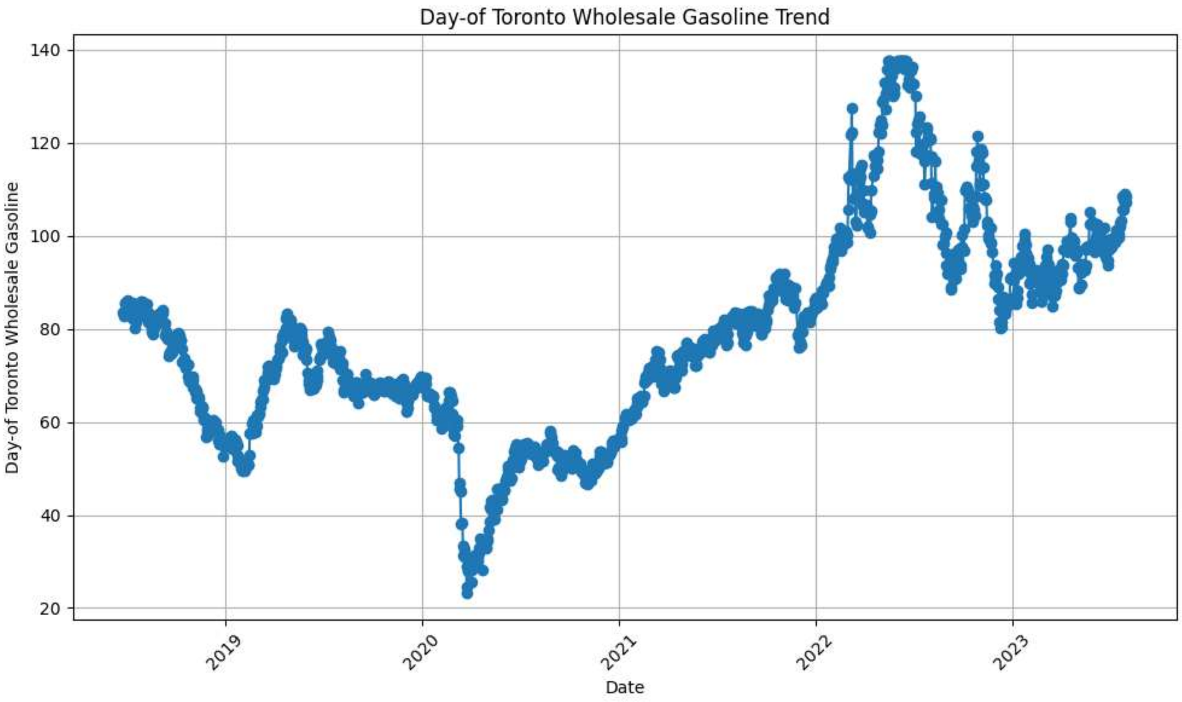
```
Linear Regression:
Mean Squared Error: 0.00
R-squared: 1.00

Random Forest Regression:
Mean Squared Error: 1.17
R-squared: 1.00
```

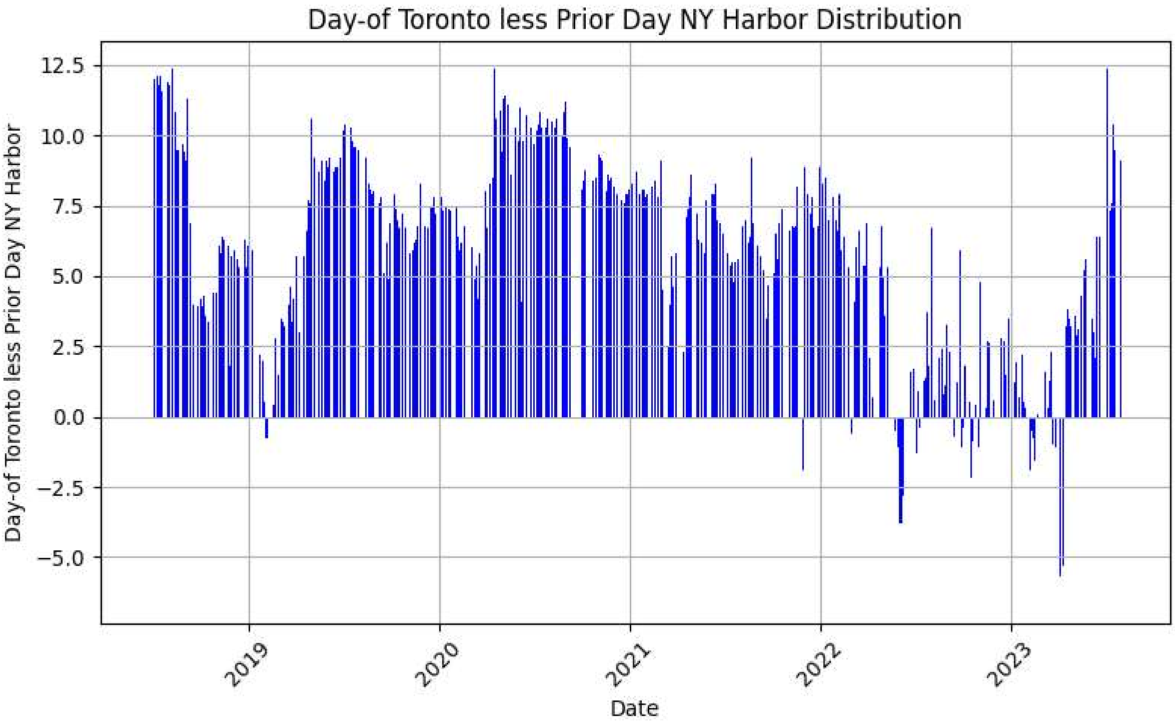
In [9]:

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import confusion_matrix, classification_report

X = df.drop(columns=['Day-of Toronto Wholesale Gasoline'])
y = df['Day-of Toronto Wholesale Gasoline']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, rando

model = LogisticRegression()
model.fit(X_train, y_train)
y_pred = model.predict(X_test)

cm = confusion_matrix(y_test, y_pred)
print("Confusion Matrix:")
print(cm)

cr = classification_report(y_test, y_pred)
print("\nClassification Report:")
print(cr)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
Cell In[9], line 12
      9 X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=
0.2, random_state=42)
     11 model = LogisticRegression()
---> 12 model.fit(X_train, y_train)
     13 y_pred = model.predict(X_test)
     15 cm = confusion_matrix(y_test, y_pred)

File /lib/python3.11/site-packages/sklearn/linear_model/_logistic.py:1204, in
LogisticRegression.fit(self, X, y, sample_weight)
   1194     _dtype = [np.float64, np.float32]
   1196 X, y = self._validate_data(
   1197     X,
   1198     y,
   (...)
   1202     accept_large_sparse=solver not in ["liblinear", "sag", "saga"],
   1203 )
-> 1204 check_classification_targets(y)
   1205 self.classes_ = np.unique(y)
   1207 multi_class = _check_multi_class(self.multi_class, solver, len(self.c
lasses_))

File /lib/python3.11/site-packages/sklearn/utils/multiclass.py:218, in check_
classification_targets(y)
    210 y_type = type_of_target(y, input_name="y")
    211 if y_type not in [
    212     "binary",
    213     "multiclass",
   (...)
    216     "multilabel-sequences",
    217 ]:
--> 218     raise ValueError("Unknown label type: %r" % y_type)

ValueError: Unknown label type: 'continuous'
```

In [10]:
```
import pandas as pd
import matplotlib.pyplot as plt

# Line Plot: Day-of Toronto Wholesale Gasoline
plt.figure(figsize=(10, 6))
plt.plot(df.index, df['Day-of Toronto Wholesale Gasoline'], marker='o', linest
plt.xlabel('Date')
plt.ylabel('Day-of Toronto Wholesale Gasoline')
plt.title('Day-of Toronto Wholesale Gasoline Trend')
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()

# Bar Chart: Day-of Toronto less Prior Day NY Harbor
plt.figure(figsize=(8, 5))
plt.bar(df.index, df['Day-of Toronto less Prior Day NY Harbor'], color='blue')
plt.xlabel('Date')
plt.ylabel('Day-of Toronto less Prior Day NY Harbor')
plt.title('Day-of Toronto less Prior Day NY Harbor Distribution')
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```




Day-of Toronto less Prior Day NY Harbor Distribution
Day-of Toronto less Prior Day NY Harbor
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
2019
2020
2021
2022
2023
Date

b) Evaluate two models

In [11]:

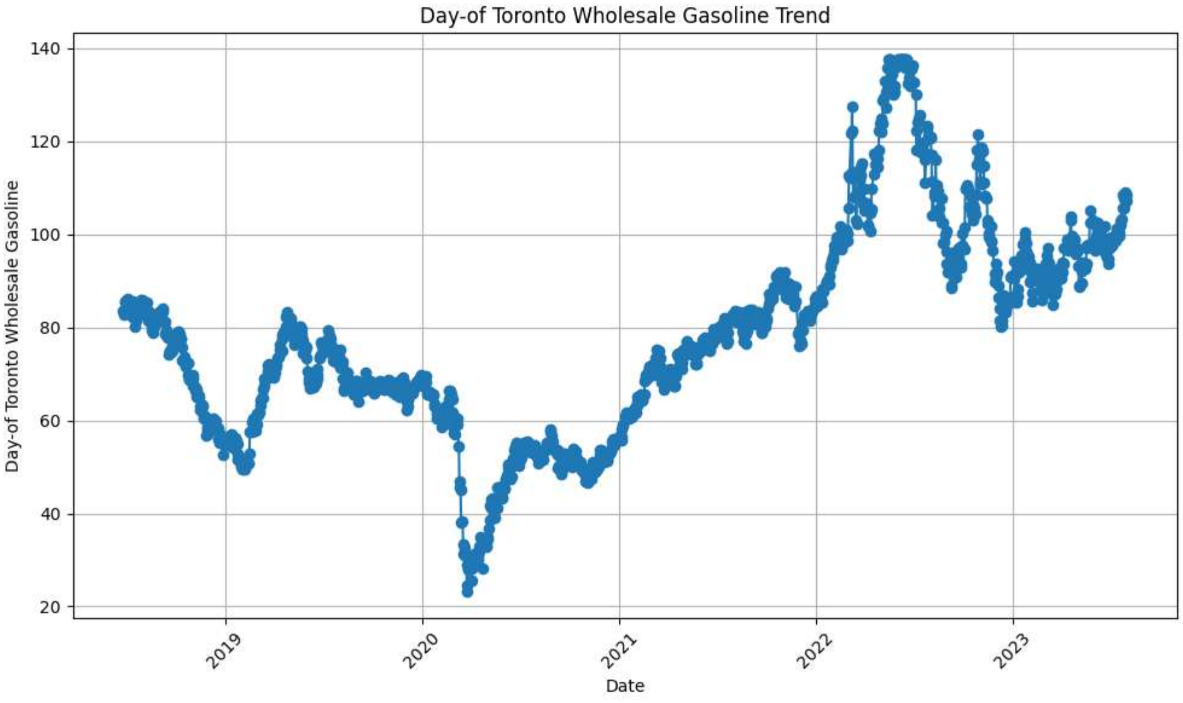
```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score

# Preprocessing (if necessary)

# Split the data into features (X) and target (y)
X = df.drop(columns=['Day-of Toronto Wholesale Gasoline'])
y = df['Day-of Toronto Wholesale Gasoline']

# 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, rando

# Model 1: Linear Regression
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)
lr_predictions = lr_model.predict(X_test)

# Model 2: Random Forest Regression
rf_model = RandomForestRegressor(n_estimators=100, random_state=42)
rf_model.fit(X_train, y_train)
rf_predictions = rf_model.predict(X_test)

# Evaluate Model Performance
lr_mse = mean_squared_error(y_test, lr_predictions)
lr_r2 = r2_score(y_test, lr_predictions)

rf_mse = mean_squared_error(y_test, rf_predictions)
rf_r2 = r2_score(y_test, rf_predictions)

# Compare the performance of the models
print("Linear Regression:")
print(f"Mean Squared Error: {lr_mse:.2f}")
print(f"R-squared: {lr_r2:.2f}")

print("\nRandom Forest Regression:")
print(f"Mean Squared Error: {rf_mse:.2f}")
print(f"R-squared: {rf_r2:.2f}")
```

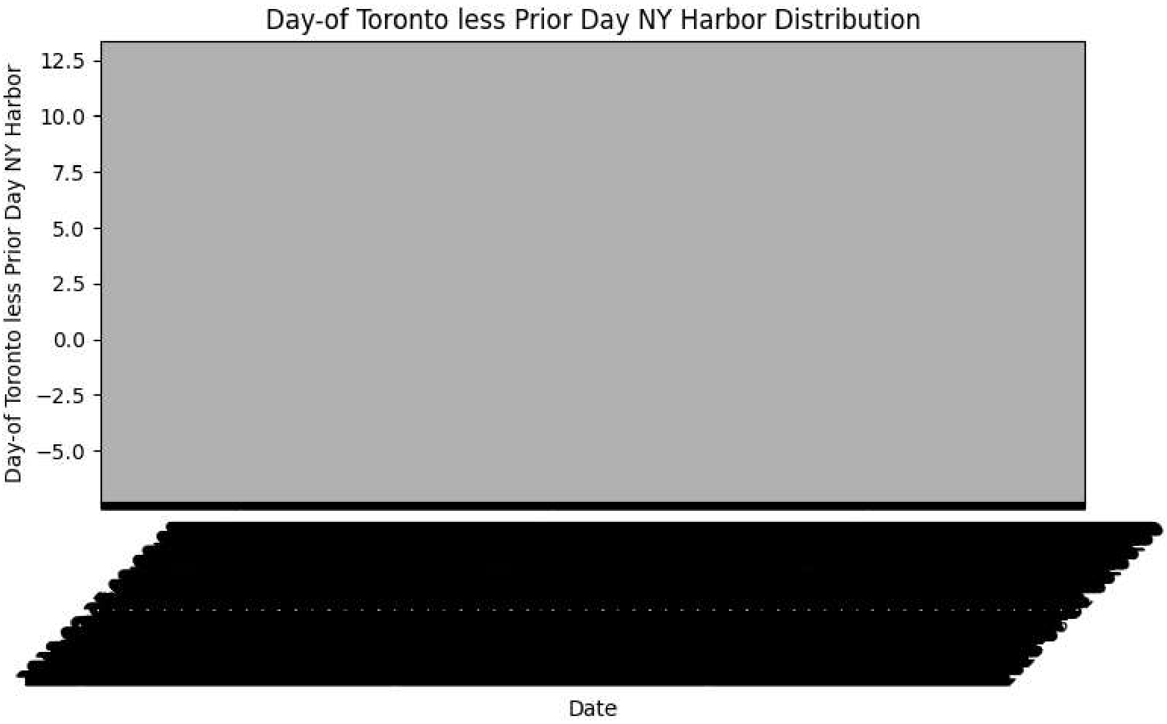
```
Linear Regression:
Mean Squared Error: 0.00
R-squared: 1.00

Random Forest Regression:
Mean Squared Error: 1.17
R-squared: 1.00
```

Task 5 Data Visualization

5.1 Create Meaningfull plots

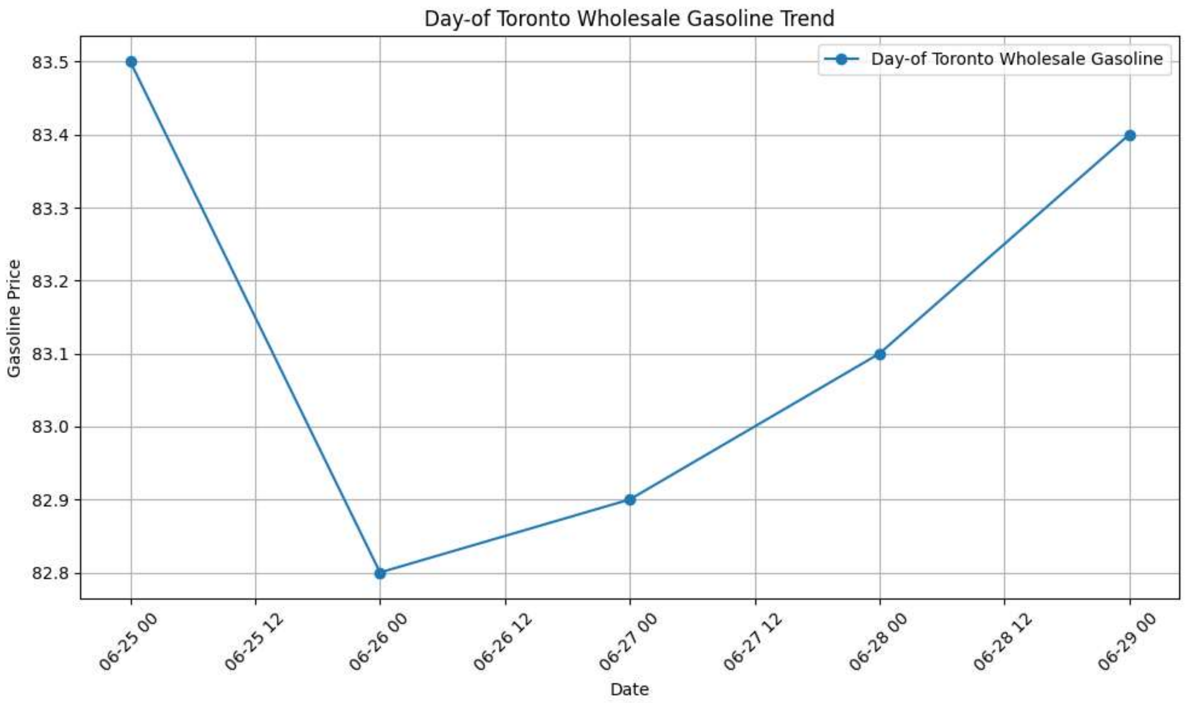
In [15]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Line Plot: Day-of Toronto Wholesale Gasoline
plt.figure(figsize=(10, 6))
plt.plot(df.index, df['Day-of Toronto Wholesale Gasoline'], marker='o', linesty
plt.xlabel('Date')
plt.ylabel('Day-of Toronto Wholesale Gasoline')
plt.title('Day-of Toronto Wholesale Gasoline Trend')
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()

# Bar Chart: Day-of Toronto less Prior Day NY Harbor
plt.figure(figsize=(8, 5))
sns.barplot(x=df.index, y=df['Day-of Toronto less Prior Day NY Harbor'], color
plt.xlabel('Date')
plt.ylabel('Day-of Toronto less Prior Day NY Harbor')
plt.title('Day-of Toronto less Prior Day NY Harbor Distribution')
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```

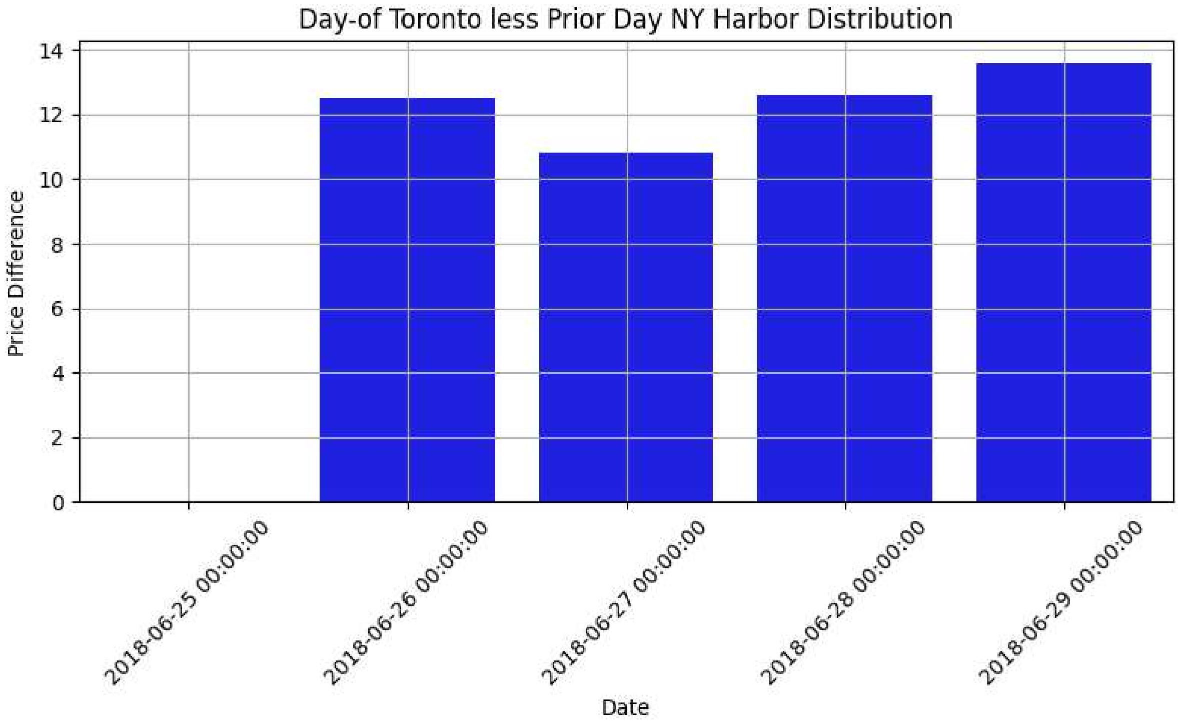



Day-of Toronto less Prior Day NY Harbor Distribution
Day-of Toronto less Prior Day NY Harbor
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
Date

In [17]:

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Sample data
data = {
    'Date': ['6/25/2018', '6/26/2018', '6/27/2018', '6/28/2018', '6/29/2018'],
    'Day-of Toronto Wholesale Gasoline': [83.5, 82.8, 82.9, 83.1, 83.4],
    'Prior Day NY Harbor Spot': [0, 70.3, 72.1, 70.5, 69.8],
    'Day-of Toronto less Prior Day NY Harbor': [0, 12.5, 10.8, 12.6, 13.6],
    'Day-of Thunder Bay Wholesale Gasoline': [0, 0, 0, 0, 0],
    'Prior Day Edmonton Spot': [0, 0, 0, 0, 0],
    'Day-of Thunder Bay less Prior Day Edmonton': [0, 0, 0, 0, 0]
}

# Create DataFrame from the data
df = pd.DataFrame(data)

# Convert the 'Date' column to datetime format
df['Date'] = pd.to_datetime(df['Date'])

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

# Line Plot: Day-of Toronto Wholesale Gasoline
plt.figure(figsize=(10, 6))
plt.plot(df.index, df['Day-of Toronto Wholesale Gasoline'], marker='o', linesty
plt.xlabel('Date')
plt.ylabel('Gasoline Price')
plt.title('Day-of Toronto Wholesale Gasoline Trend')
plt.xticks(rotation=45)
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()

# Bar Chart: Day-of Toronto less Prior Day NY Harbor
plt.figure(figsize=(8, 5))
sns.barplot(x=df.index, y=df['Day-of Toronto less Prior Day NY Harbor'], color
plt.xlabel('Date')
plt.ylabel('Price Difference')
plt.title('Day-of Toronto less Prior Day NY Harbor Distribution')
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```


Day-of Toronto Wholesale Gasoline Trend
Day-of Toronto Wholesale Gasoline
Gasoline Price
83.5
83.4
83.3
83.2
83.1
83.0
82.9
82.8
06-25 00
06-25 12
06-26 00
06-26 12
06-27 00
06-27 12
06-28 00
06-28 12
06-29 00
Date


Day-of Toronto less Prior Day NY Harbor Distribution
Price Difference
14
12
10
8
6
4
2
0
2018-06-25 00:00:00
2018-06-26 00:00:00
2018-06-27 00:00:00
2018-06-28 00:00:00
2018-06-29 00:00:00
Date

```
In [ ]:
```

```
In [ ]:
```