Predicting the Quarterly Gross Profit for Walmart

In [1]:
```
# Importing Packages
import itertools
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import statsmodels.api as sm
import matplotlib
import itertools
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import statsmodels.api as sm
import matplotlib
import sklearn.preprocessing
from sklearn.metrics import r2_score
import keras

from keras.layers import Dense,Dropout,SimpleRNN,GRU, Bidirectional,LSTM
from tensorflow.keras.optimizers import SGD
from keras.models import Sequential
from sklearn.preprocessing import MinMaxScaler, StandardScaler

plt.style.use('fivethirtyeight')
matplotlib.rcParams['axes.labelsize'] = 14
matplotlib.rcParams['xtick.labelsize'] = 12
matplotlib.rcParams['ytick.labelsize'] = 12
matplotlib.rcParams['text.color'] = 'k'
```

In [7]:
```
# Reading the Data
df=pd.read_excel('Walmart Quarterly Gross Profit.xlsx')
df.head()
```

Out[7]:

	Date	Quartely Gross Profit
0	2009-01-31	26797
1	2009-04-30	23854
2	2009-07-31	25820
3	2009-10-31	25458
4	2010-01-31	28847

In [8]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 56 entries, 0 to 55
Data columns (total 2 columns):
 #   Column                 Non-Null Count  Dtype         
---  ------                 --------------  -----         
 0   Date                   56 non-null     datetime64[ns]
 1   Quartely Gross Profit  56 non-null     int64         
dtypes: datetime64[ns](1), int64(1)
memory usage: 1.0 KB
```

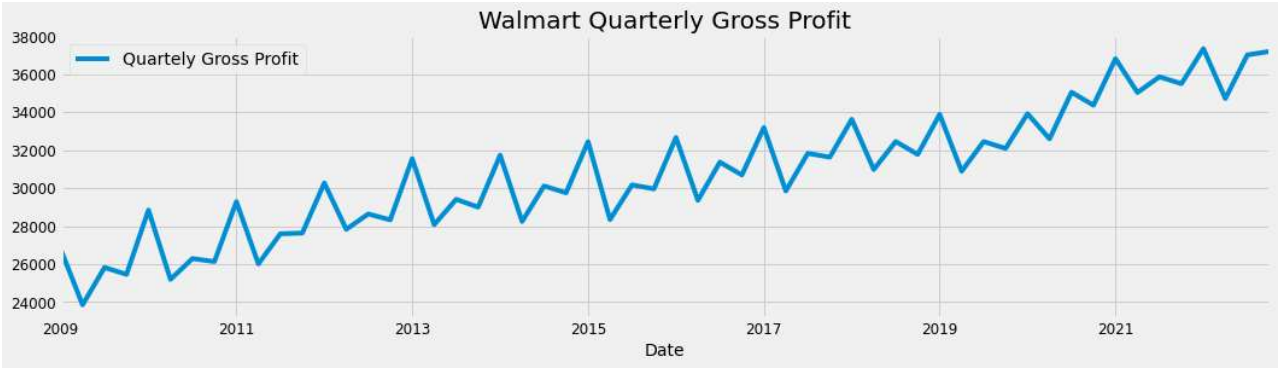
In [9]:
```
# Setting Date as Index
df = df.set_index('Date')
df.head()
```

Out[9]:

	Quartely Gross Profit
Date	
2009-01-31	26797
2009-04-30	23854
2009-07-31	25820
2009-10-31	25458
2010-01-31	28847

In [10]:

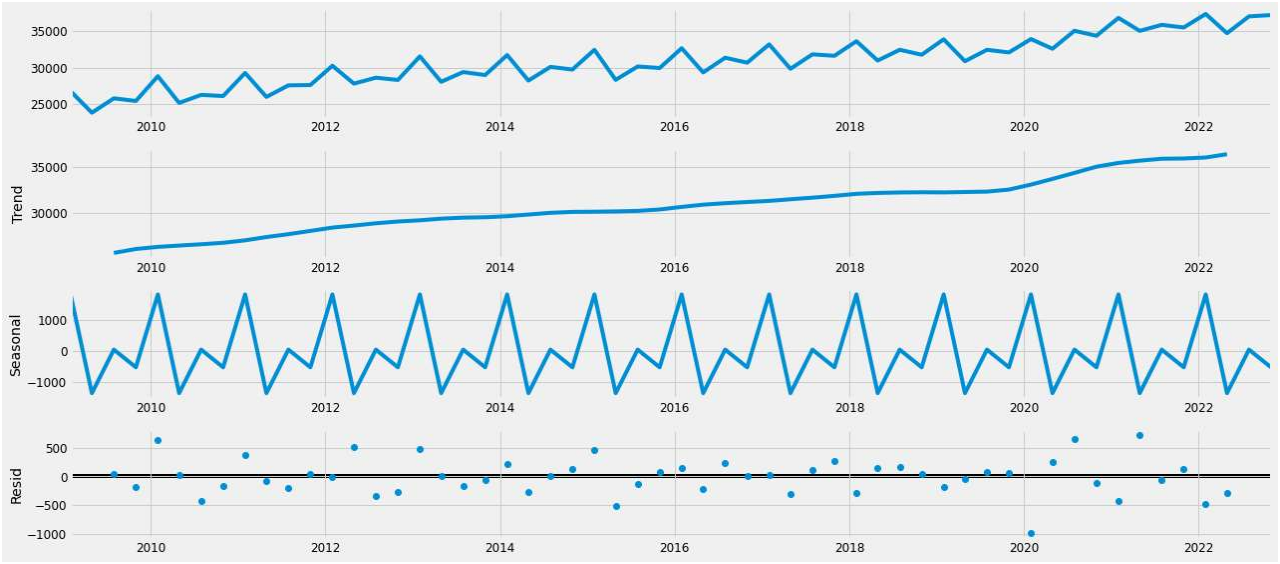
```
# Plotting the data
df.plot(figsize=(16,4),legend=True)
plt.title('Walmart Quarterly Gross Profit')
plt.show()
```



In [11]:

```
# Decomposition the data
from pylab import rcParams
rcParams['figure.figsize'] = 18, 8

decomposition = sm.tsa.seasonal_decompose(df, model = 'additive')
fig = decomposition.plot()
plt.show()
```



In [13]:
```
1 !pip install pmdarima
```

```
Looking in indexes: https://pypi.org/simple, (https://pypi.org/simple,) https://us-python.pkg.dev/colab-wheels/public/simple/ (https://us-python.pkg.dev/colab-wheels/public/simple/)
Collecting pmdarima
  Downloading pmdarima-2.0.2-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_28_x86_64.whl (1.9 MB)
     |████████████████████████████████| 1.9 MB 4.3 MB/s
Requirement already satisfied: urllib3 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (1.24.3)
Collecting statsmodels>=0.13.2
  Downloading statsmodels-0.13.5-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (9.9 MB)
     |████████████████████████████████| 9.9 MB 52.4 MB/s
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (1.0.2)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (1.7.3)
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (1.3.5)
Requirement already satisfied: numpy>=1.21.2 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (1.21.6)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (0.29.32)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (1.2.0)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/python3.8/dist-packages (from pmdarima) (57.4.0)
Requirement already satisfied: pytz>=2017.3 in /usr/local/lib/python3.8/dist-packages (from pandas>=0.19->pmdarima) (2022.6)
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.8/dist-packages (from pandas>=0.19->pmdarima) (2.8.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.8/dist-packages (from python-dateutil>=2.7.3->pandas>=0.19->pmdarima) (1.15.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.8/dist-packages (from scikit-learn>=0.22->pmdarima) (3.1.0)
Requirement already satisfied: patsy>=0.5.2 in /usr/local/lib/python3.8/dist-packages (from statsmodels>=0.13.2->pmdarima) (0.5.3)
Requirement already satisfied: packaging>=21.3 in /usr/local/lib/python3.8/dist-packages (from statsmodels>=0.13.2->pmdarima) (21.3)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python3.8/dist-packages (from packaging>=21.3->statsmodels>=0.13.2->pmdarima) (3.0.9)
Installing collected packages: statsmodels, pmdarima
  Attempting uninstall: statsmodels
    Found existing installation: statsmodels 0.12.2
    Uninstalling statsmodels-0.12.2:
      Successfully uninstalled statsmodels-0.12.2
Successfully installed pmdarima-2.0.2 statsmodels-0.13.5
```

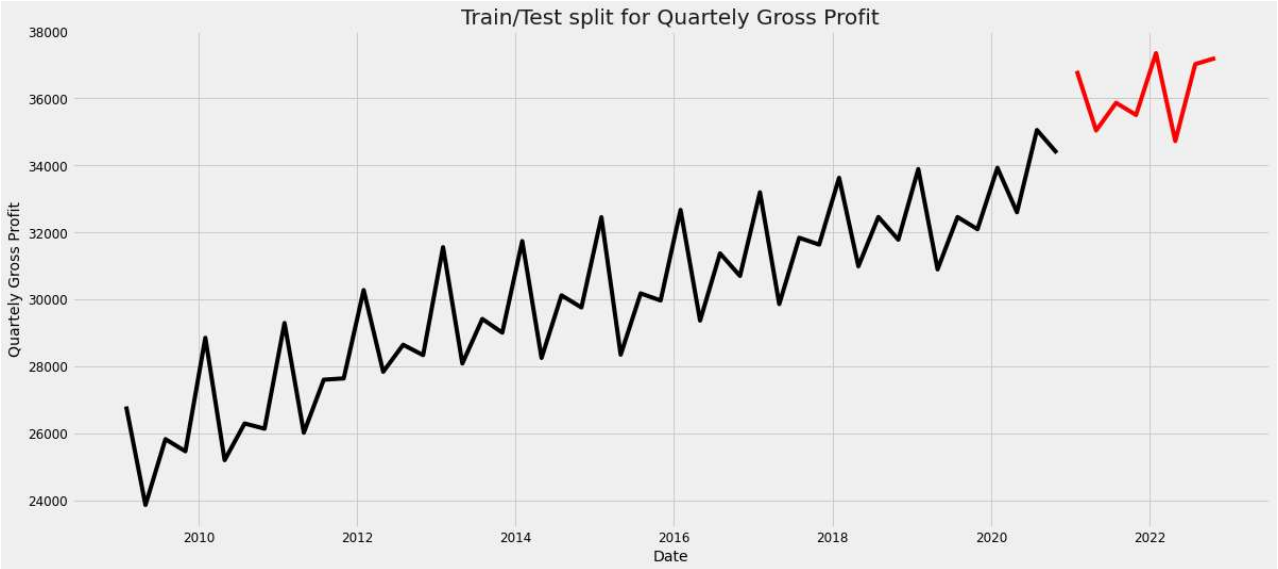
In [18]:

```
# Dividing the data into training and testing
# Ploting the data
import seaborn as sns
df['Date'] = df.index
train = df[df['Date'] < pd.to_datetime("2020-12", format='%Y-%m')]
train['train'] = train['Quartely Gross Profit']
del train['Date']
del train['Quartely Gross Profit']
test = df[df['Date'] >= pd.to_datetime("2020-12", format='%Y-%m')]
del test['Date']
test['test'] = test['Quartely Gross Profit']
del test['Quartely Gross Profit']
plt.plot(train, color = "black")
plt.plot(test, color = "red")
plt.title("Train/Test split for Quartely Gross Profit")
plt.ylabel("Quartely Gross Profit")
plt.xlabel('Date')
sns.set()
plt.show()
```

```
<ipython-input-18-53ca2ab34e47>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)
  train['train'] = train['Quartely Gross Profit']
<ipython-input-18-53ca2ab34e47>:11: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)
  test['test'] = test['Quartely Gross Profit']
```

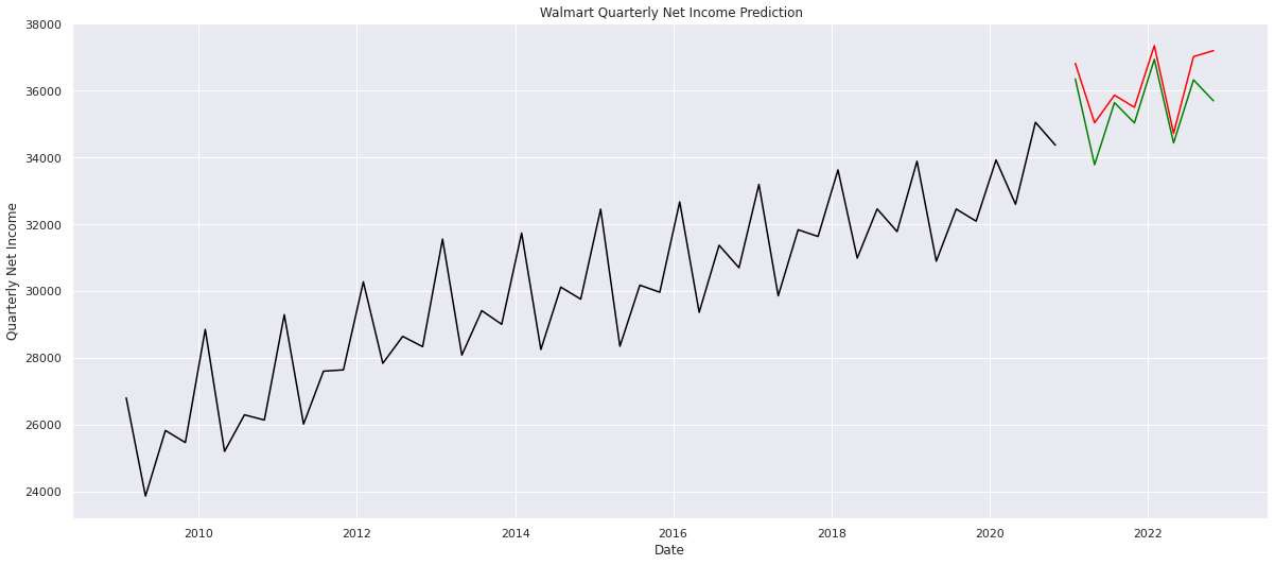


In [19]:
```
# Applying ARIMA Model
from pmdarima.arima import auto_arima
model = auto_arima(train, trace=True, error_action='ignore', suppress_warnings=True)
model.fit(train)
forecast = model.predict(n_periods=len(test))
forecast = pd.DataFrame(forecast,index = test.index,columns=['Prediction'])
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=804.349, Time=0.32 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=862.330, Time=0.03 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=844.558, Time=0.04 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=846.847, Time=0.09 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=860.584, Time=0.02 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.29 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=805.513, Time=0.23 sec
 ARIMA(3,1,2)(0,0,0)[0] intercept   : AIC=792.556, Time=0.15 sec
 ARIMA(3,1,1)(0,0,0)[0] intercept   : AIC=790.184, Time=0.15 sec
 ARIMA(3,1,0)(0,0,0)[0] intercept   : AIC=838.276, Time=0.16 sec
 ARIMA(4,1,1)(0,0,0)[0] intercept   : AIC=776.234, Time=0.13 sec
 ARIMA(4,1,0)(0,0,0)[0] intercept   : AIC=778.402, Time=0.32 sec
 ARIMA(5,1,1)(0,0,0)[0] intercept   : AIC=771.630, Time=0.37 sec
 ARIMA(5,1,0)(0,0,0)[0] intercept   : AIC=776.029, Time=0.11 sec
 ARIMA(5,1,2)(0,0,0)[0] intercept   : AIC=766.964, Time=0.52 sec
 ARIMA(4,1,2)(0,0,0)[0] intercept   : AIC=777.558, Time=0.65 sec
 ARIMA(5,1,3)(0,0,0)[0] intercept   : AIC=740.335, Time=0.57 sec
 ARIMA(4,1,3)(0,0,0)[0] intercept   : AIC=738.945, Time=0.49 sec
 ARIMA(3,1,3)(0,0,0)[0] intercept   : AIC=738.149, Time=0.43 sec
 ARIMA(2,1,3)(0,0,0)[0] intercept   : AIC=801.268, Time=0.33 sec
 ARIMA(3,1,4)(0,0,0)[0] intercept   : AIC=742.050, Time=0.50 sec
 ARIMA(2,1,4)(0,0,0)[0] intercept   : AIC=799.565, Time=0.39 sec
 ARIMA(4,1,4)(0,0,0)[0] intercept   : AIC=741.146, Time=0.64 sec
 ARIMA(3,1,3)(0,0,0)[0]             : AIC=750.706, Time=0.32 sec

Best model:  ARIMA(3,1,3)(0,0,0)[0] intercept
Total fit time: 7.321 seconds
```

In [20]:
```
# Plotting the prediction
plt.plot(train, color = "black")
plt.plot(test, color = "red")
plt.plot(forecast, color = "green")
plt.title(" Walmart Quarterly Net Income Prediction")
plt.ylabel("Quarterly Net Income")
plt.xlabel('Date')
sns.set()
plt.show()
```



In [21]:
```
from math import sqrt
from sklearn.metrics import mean_squared_error
rms = sqrt(mean_squared_error(test,forecast))
print("RMSE: ", rms)
```

```
RMSE:  795.3660204459867
```

SARIMA Model

In [ ]:
```
df=pd.read_excel('Walmart Quarterly Gross Profit.xlsx')
df = df.set_index('Date')
```

In [ ]:

```python
# set the typical ranges for p, d, q
p = d = q = range(0, 2)

#take all possible combination for p, d and q
pdq = list(itertools.product(p, d, q))
seasonal_pdq = [(x[0], x[1], x[2], 12) for x in list(itertools.product(p, d, q))]

print('Examples of parameter combinations for Seasonal ARIMA...')
print('SARIMAX: {} x {}'.format(pdq[1], seasonal_pdq[1]))
print('SARIMAX: {} x {}'.format(pdq[1], seasonal_pdq[2]))
print('SARIMAX: {} x {}'.format(pdq[2], seasonal_pdq[3]))
print('SARIMAX: {} x {}'.format(pdq[2], seasonal_pdq[4]))
```

```
Examples of parameter combinations for Seasonal ARIMA...
SARIMAX: (0, 0, 1) x (0, 0, 1, 12)
SARIMAX: (0, 0, 1) x (0, 1, 0, 12)
SARIMAX: (0, 1, 0) x (0, 1, 1, 12)
SARIMAX: (0, 1, 0) x (1, 0, 0, 12)
```

In [ ]:

```python
# Using Grid Search find the optimal set of parameters that yields the best performance
for param in pdq:
    for param_seasonal in seasonal_pdq:
        try:
            mod = sm.tsa.statespace.SARIMAX(df, order = param, seasonal_order = param_seasonal, enforce_stationary = False,enf
            result = mod.fit()
            print('SARIMA{}x{}12 - AIC:{}'.format(param, param_seasonal, result.aic))
        except:
            continue
```

```
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provi
ded, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provi
ded, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provi
ded, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provi
ded, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'

SARIMA(0, 0, 0)x(0, 0, 0, 12)12 - AIC:1319.260809022218
SARIMA(0, 0, 0)x(0, 0, 1, 12)12 - AIC:1299.3606413938437

/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provi
ded, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provi
```

In [ ]:

```python
#Fitting the SARIMA model using above optimal combination of p, d, q (optimal means combination at which we got lowest AIC sco

model = sm.tsa.statespace.SARIMAX(df, order = (1, 1, 1),
                                  seasonal_order = (1, 1, 0, 12)
                                 )
result = model.fit()
print(result.summary().tables[1])
```

```
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provide
d, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'
/usr/local/lib/python3.8/dist-packages/statsmodels/tsa/base/tsa_model.py:524: ValueWarning: No frequency information was provide
d, so inferred frequency Q-OCT will be used.
  warnings.warn('No frequency information was'

==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1         -0.6932      0.576     -1.202      0.229      -1.823       0.437
ma.L1          0.5590      0.672      0.832      0.406      -0.758       1.876
ar.S.L12      -0.0334      0.162     -0.206      0.837      -0.351       0.284
sigma2      3.845e+05   7.61e+04      5.051      0.000    2.35e+05    5.34e+05
==============================================================================
```

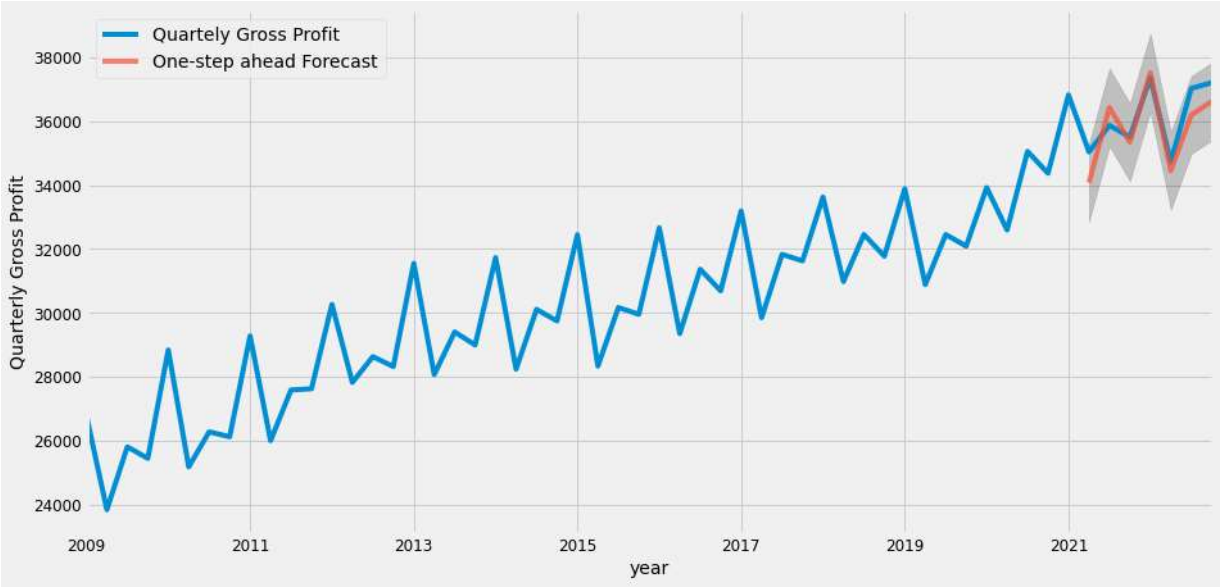
In [ ]:

```python
prediction = result.get_prediction(start = pd.to_datetime('2021-04-30'), dynamic = False)
prediction_ci = prediction.conf_int()
prediction_ci
```

Out[13]:

	lower Quartely Gross Profit	upper Quartely Gross Profit
2021-04-30	32857.872160	35288.511639
2021-07-31	35215.102362	37645.741841
2021-10-31	34126.986510	36557.625989
2022-01-31	36295.730420	38726.369899
2022-04-30	33232.407619	35663.047098
2022-07-31	34975.561730	37406.201209
2022-10-31	35396.471258	37827.110737

In [ ]:
```
#Visualize the forecasting
ax = df['2009':].plot(label = 'observed')
prediction.predicted_mean.plot(ax = ax, label = 'One-step ahead Forecast', alpha = 0.7, figsize = (14, 7))
ax.fill_between(prediction_ci.index, prediction_ci.iloc[:, 0], prediction_ci.iloc[:, 1], color = 'k', alpha = 0.2)
ax.set_xlabel("year")
ax.set_ylabel('Quarterly Gross Profit')
plt.legend()
plt.show()
```



In [ ]:
```
# Evaluation metrics are Squared Mean Error(SME) and Root Mean Squared Error(RMSE)

from sklearn.metrics import mean_squared_error

y_hat = prediction.predicted_mean
y_truth = df['2021-03-31':]
mse = mean_squared_error(y_truth,y_hat)
rmse = np.sqrt(mse)

print('The Mean Squared Error of our forecasts is', mse)
print('The Root Mean Squared Error of our forecasts is', rmse)
```

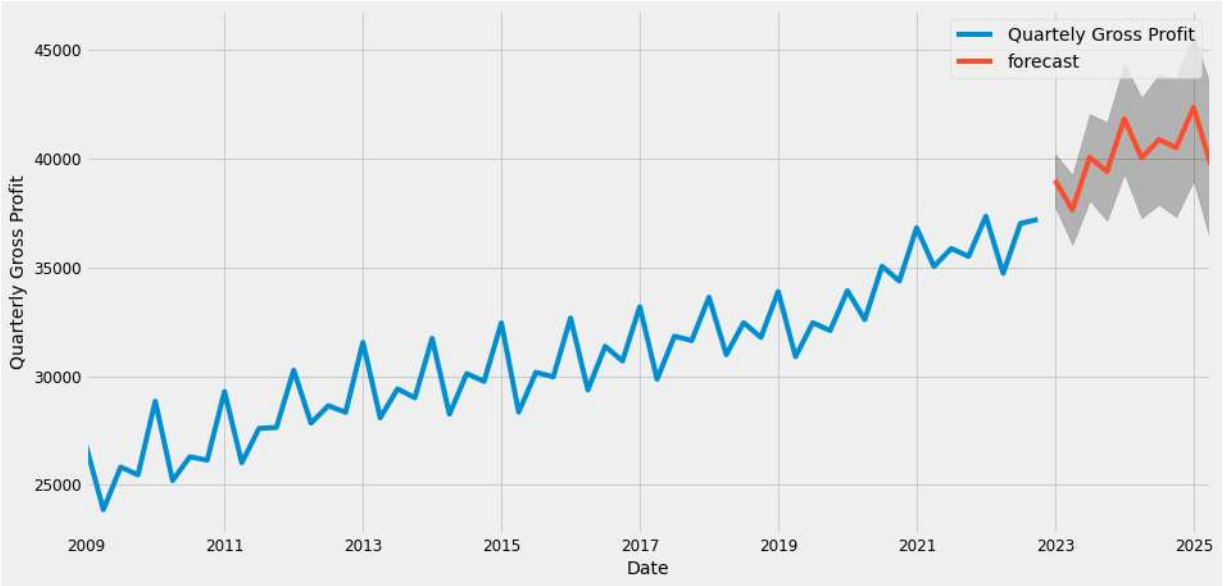
```
The Mean Squared Error of our forecasts is 344661.6083567878
The Root Mean Squared Error of our forecasts is 587.0788774575251
```

In [ ]:
```
# forcasting for out of sample data
pred_uc = result.get_forecast(steps = 10)
pred_ci = pred_uc.conf_int()

ax = df.plot(label = 'observed', figsize = (14, 7))
pred_uc.predicted_mean.plot(ax = ax, label = 'forecast')
ax.fill_between(pred_ci.index, pred_ci.iloc[:, 0], pred_ci.iloc[:, 1], color = 'k', alpha = 0.25)
ax.set_xlabel('Date')
ax.set_ylabel('Quarterly Gross Profit')

plt.legend()
plt.show()

```



DNN MODEL

In [ ]:
```
def convert2matrix(data_arr, look_back):
    X, Y =[], []
    for i in range(len(data_arr)-look_back):
        d=i+look_back
        X.append(data_arr[i:d,0])
        Y.append(data_arr[d,0])
    return np.array(X).astype('int'), np.array(Y).astype('int')
```

In [ ]:
```
df=pd.read_excel('Walmart Quarterly Gross Profit.xlsx')

df = df.set_index('Date')

```

In [ ]:
```
df1 = df
#Split data set into testing dataset and train dataset
train_size = 49
train, test =df1.values[0:train_size,:],df1.values[train_size:len(df1.values),:]
# setup look_back window
look_back = 4
#convert dataset into right shape in order to input into the DNN
trainX, trainY = convert2matrix(train, look_back)
testX, testY = convert2matrix(test, look_back)
```

In [ ]:
```
from keras.models import Sequential
from keras.layers import Dense
def model_dnn(look_back):
    model=Sequential()
    model.add(Dense(units=32, input_dim=look_back, activation='relu'))
    model.add(Dense(8, activation='relu'))
    model.add(Dense(1))
    model.compile(loss='mean_squared_error',  optimizer='adam',metrics = ['mse', 'mae'])
    return model
```

In [ ]:
```
model=model_dnn(look_back)
history=model.fit(trainX,trainY, epochs=500, batch_size=4, verbose=1, validation_data=(testX,testY),shuffle=False)
```

```
Epoch 1/500
12/12 [==============================] - 1s 28ms/step - loss: 733065728.0000 - mse: 733065728.0000 - mae: 27035.9141 - val_los
s: 674150592.0000 - val_mse: 674150592.0000 - val_mae: 25941.2969
Epoch 2/500
12/12 [==============================] - 0s 5ms/step - loss: 326192384.0000 - mse: 326192384.0000 - mae: 17984.2949 - val_los
s: 241177600.0000 - val_mse: 241177600.0000 - val_mae: 15491.7451
Epoch 3/500
12/12 [==============================] - 0s 5ms/step - loss: 97188968.0000 - mse: 97188968.0000 - mae: 9684.1953 - val_loss: 4
2310372.0000 - val_mse: 42310372.0000 - val_mae: 6414.0586
Epoch 4/500
12/12 [==============================] - 0s 6ms/step - loss: 12307298.0000 - mse: 12307298.0000 - mae: 3051.8325 - val_loss: 1
188411.6250 - val_mse: 1188411.6250 - val_mae: 1065.2422
Epoch 5/500
12/12 [==============================] - 0s 6ms/step - loss: 2697772.5000 - mse: 2697772.5000 - mae: 1361.0554 - val_loss: 614
0484.0000 - val_mse: 6140484.0000 - val_mae: 2232.1941
Epoch 6/500
12/12 [==============================] - 0s 6ms/step - loss: 4224405.0000 - mse: 4224405.0000 - mae: 1774.1111 - val_loss: 452
0942.5000 - val_mse: 4520942.5000 - val_mae: 1833.9037
Epoch 7/500
```

In [ ]:
```
def model_loss(history):
    plt.figure(figsize=(8,4))
    plt.plot(history.history['loss'], label='Train Loss')
    plt.plot(history.history['val_loss'], label='Test Loss')
    plt.title('model loss')
    plt.ylabel('loss')
    plt.xlabel('epochs')
    plt.legend(loc='upper right')
    plt.show();
```

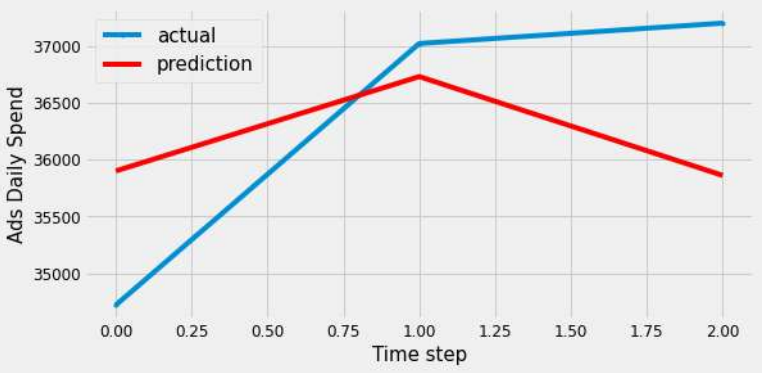
In [ ]:
```
train_score = model.evaluate(trainX, trainY, verbose=0)
print('Train Root Mean Squared Error(RMSE): %.2f; Train Mean Absolute Error(MAE) : %.2f '
% (np.sqrt(train_score[1]), train_score[2]))
test_score = model.evaluate(testX, testY, verbose=0)
print(train_score)
print(test_score)
print('Test Root Mean Squared Error(RMSE): %.2f; Test Mean Absolute Error(MAE) : %.2f '
% (np.sqrt(test_score[1]), test_score[2]))
```

```
Train Root Mean Squared Error(RMSE): 726.05; Train Mean Absolute Error(MAE) : 558.04
[527151.25, 527151.25, 558.036865234375]
[1088594.875, 1088594.875, 936.0260620117188]
Test Root Mean Squared Error(RMSE): 1043.36; Test Mean Absolute Error(MAE) : 936.03
```

In [ ]:
```
def prediction_plot(testY, test_predict):
      len_prediction=[x for x in range(len(testY))]
      plt.figure(figsize=(8,4))
      plt.plot(len_prediction, testY[:8], marker='.', label="actual")
      plt.plot(len_prediction, test_predict[:8], 'r', label="prediction")
      plt.tight_layout()
      #sns.despine(top=True)
      plt.subplots_adjust(left=0.07)
      plt.ylabel('Ads Daily Spend', size=15)
      plt.xlabel('Time step', size=15)
      plt.legend(fontsize=15)
      plt.show();
```

In [ ]:
```
test_predict = model.predict(testX)
prediction_plot(testY, test_predict)
```

```
1/1 [==============================] - 0s 20ms/step
```



GRU and BiLSTM Models

In [ ]:
```
df=pd.read_excel('Walmart Quarterly Gross Profit.xlsx')
df.head()
```

Out[33]:

	Date	Quartely Gross Profit
0	2009-01-31	26797
1	2009-04-30	23854
2	2009-07-31	25820
3	2009-10-31	25458
4	2010-01-31	28847

In [ ]:
```
df = df.set_index('Date')
df.head()
```

Out[34]:

Date	Quartely Gross Profit
2009-01-31	26797
2009-04-30	23854
2009-07-31	25820
2009-10-31	25458
2010-01-31	28847

In [ ]:
```
# Split train data and test data
train_size = int(len(df)*0.8)

train_data = df.iloc[:train_size]
test_data = df.iloc[train_size:]
```

In [ ]:
```
scaler = MinMaxScaler().fit(train_data)
train_scaled = scaler.transform(train_data)
test_scaled = scaler.transform(test_data)
```

In [ ]:

```python
# Create input dataset
def create_dataset (X, look_back = 1):
    Xs, ys = [], []

    for i in range(len(X)-look_back):
        v = X[i:i+look_back]
        Xs.append(v)
        ys.append(X[i+look_back])

    return np.array(Xs), np.array(ys)
LOOK_BACK = 4
X_train, y_train = create_dataset(train_scaled,LOOK_BACK)
X_test, y_test = create_dataset(test_scaled,LOOK_BACK)
# Print data shape
print('X_train.shape: ', X_train.shape)
print('y_train.shape: ', y_train.shape)
print('X_test.shape: ', X_test.shape)
print('y_test.shape: ', y_test.shape)
```

```
X_train.shape:  (40, 4, 1)
y_train.shape:  (40, 1)
X_test.shape:  (8, 4, 1)
y_test.shape:  (8, 1)
```

In [ ]:

```python
# Create BiLSTM model
def create_bilstm(units):
    model = Sequential()
    # Input layer
    model.add(Bidirectional(
              LSTM(units = units, return_sequences=True),
              input_shape=(X_train.shape[1], X_train.shape[2])))
    # Hidden layer
    model.add(Bidirectional(LSTM(units = units)))
    model.add(Dense(1))
    #Compile model
    model.compile(optimizer='adam',loss='mse')
    return model
model_bilstm = create_bilstm(64)
# Create GRU model
def create_gru(units):
    model = Sequential()
    # Input layer
    model.add(GRU (units = units, return_sequences = True,
    input_shape = [X_train.shape[1], X_train.shape[2]]))
    model.add(Dropout(0.2))
    # Hidden layer
    model.add(GRU(units = units))
    model.add(Dropout(0.2))
    model.add(Dense(units = 1))
    #Compile model
    model.compile(optimizer='adam',loss='mse')
    return model
model_gru = create_gru(64)
```

In [ ]:

```
def fit_model(model):
    early_stop = keras.callbacks.EarlyStopping(monitor = 'val_loss',
                                               patience = 10)
    history = model.fit(X_train, y_train, epochs = 100,
                        validation_split = 0.2,
                        batch_size = 16, shuffle = False,
                        callbacks = [early_stop])
    return history
history_gru = fit_model(model_gru)
```

```
Epoch 1/100
2/2 [==============================] - 4s 849ms/step - loss: 0.3370 - val_loss: 0.5017
Epoch 2/100
2/2 [==============================] - 0s 32ms/step - loss: 0.2054 - val_loss: 0.2937
Epoch 3/100
2/2 [==============================] - 0s 32ms/step - loss: 0.1062 - val_loss: 0.1415
Epoch 4/100
2/2 [==============================] - 0s 39ms/step - loss: 0.0464 - val_loss: 0.0476
Epoch 5/100
2/2 [==============================] - 0s 33ms/step - loss: 0.0234 - val_loss: 0.0122
Epoch 6/100
2/2 [==============================] - 0s 31ms/step - loss: 0.0334 - val_loss: 0.0186
Epoch 7/100
2/2 [==============================] - 0s 30ms/step - loss: 0.0495 - val_loss: 0.0294
Epoch 8/100
2/2 [==============================] - 0s 35ms/step - loss: 0.0520 - val_loss: 0.0254
Epoch 9/100
2/2 [==============================] - 0s 31ms/step - loss: 0.0431 - val_loss: 0.0162
Epoch 10/100
2/2 [==============================] - 0s 32ms/step - loss: 0.0306 - val_loss: 0.0115
Epoch 11/100
2/2 [==============================] - 0s 49ms/step - loss: 0.0277 - val_loss: 0.0139
Epoch 12/100
2/2 [==============================] - 0s 41ms/step - loss: 0.0194 - val_loss: 0.0212
Epoch 13/100
2/2 [==============================] - 0s 59ms/step - loss: 0.0248 - val_loss: 0.0288
Epoch 14/100
2/2 [==============================] - 0s 37ms/step - loss: 0.0255 - val_loss: 0.0331
Epoch 15/100
2/2 [==============================] - 0s 39ms/step - loss: 0.0255 - val_loss: 0.0336
Epoch 16/100
2/2 [==============================] - 0s 36ms/step - loss: 0.0261 - val_loss: 0.0305
Epoch 17/100
2/2 [==============================] - 0s 40ms/step - loss: 0.0185 - val_loss: 0.0256
Epoch 18/100
2/2 [==============================] - 0s 40ms/step - loss: 0.0195 - val_loss: 0.0208
Epoch 19/100
2/2 [==============================] - 0s 41ms/step - loss: 0.0246 - val_loss: 0.0166
Epoch 20/100
2/2 [==============================] - 0s 38ms/step - loss: 0.0239 - val_loss: 0.0137
```

In [ ]:

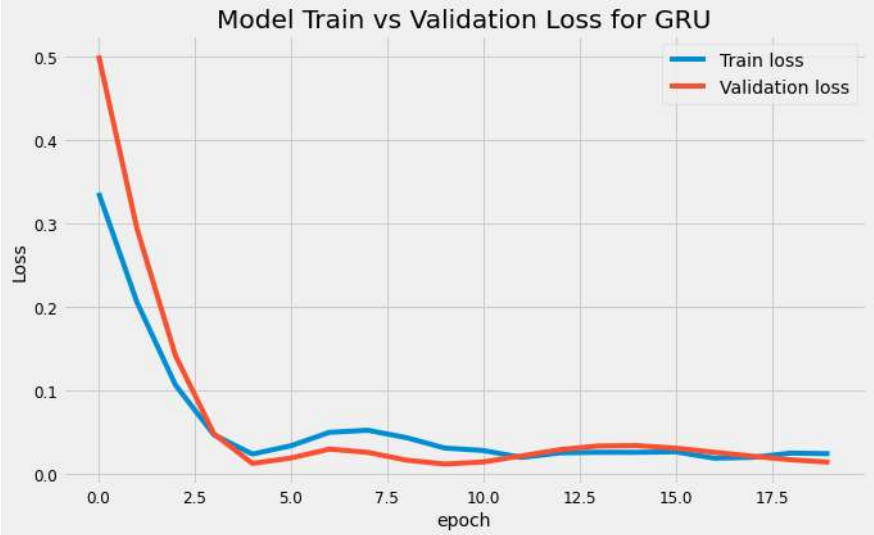
```
history_bilstm = fit_model(model_bilstm)
```

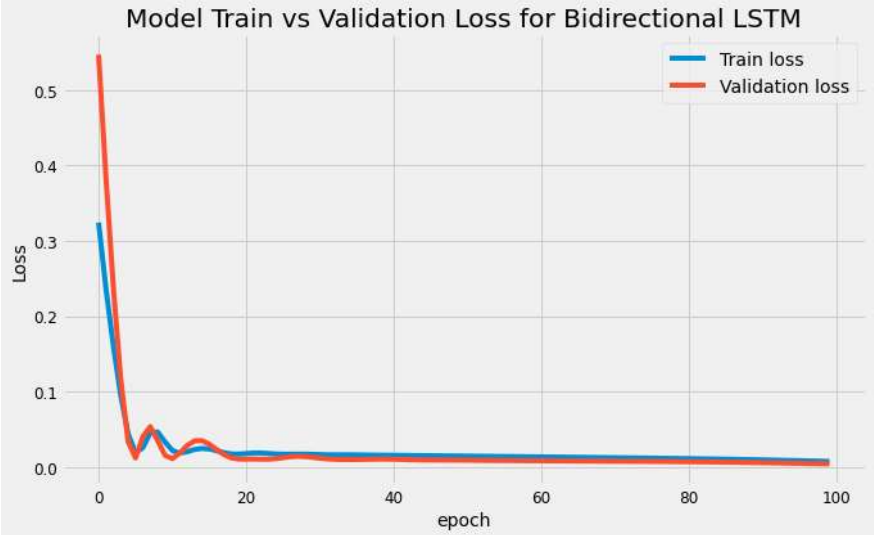
```
Epoch 1/100
2/2 [==============================] - 9s 2s/step - loss: 0.3242 - val_loss: 0.5467
Epoch 2/100
2/2 [==============================] - 0s 38ms/step - loss: 0.2366 - val_loss: 0.3836
Epoch 3/100
2/2 [==============================] - 0s 35ms/step - loss: 0.1606 - val_loss: 0.2384
Epoch 4/100
2/2 [==============================] - 0s 39ms/step - loss: 0.0950 - val_loss: 0.1166
Epoch 5/100
2/2 [==============================] - 0s 37ms/step - loss: 0.0446 - val_loss: 0.0340
Epoch 6/100
2/2 [==============================] - 0s 35ms/step - loss: 0.0190 - val_loss: 0.0122
Epoch 7/100
2/2 [==============================] - 0s 36ms/step - loss: 0.0260 - val_loss: 0.0407
Epoch 8/100
2/2 [==============================] - 0s 40ms/step - loss: 0.0457 - val_loss: 0.0538
Epoch 9/100
2/2 [==============================] - 0s 70ms/step - loss: 0.0467 - val_loss: 0.0353
Epoch 10/100
```

In [ ]:

```
def plot_loss (history, model_name):
    plt.figure(figsize = (10, 6))
    plt.plot(history.history['loss'])
    plt.plot(history.history['val_loss'])
    plt.title('Model Train vs Validation Loss for ' + model_name)
    plt.ylabel('Loss')
    plt.xlabel('epoch')
    plt.legend(['Train loss', 'Validation loss'], loc='upper right')

plot_loss (history_gru, 'GRU')
plot_loss (history_bilstm, 'Bidirectional LSTM')
```



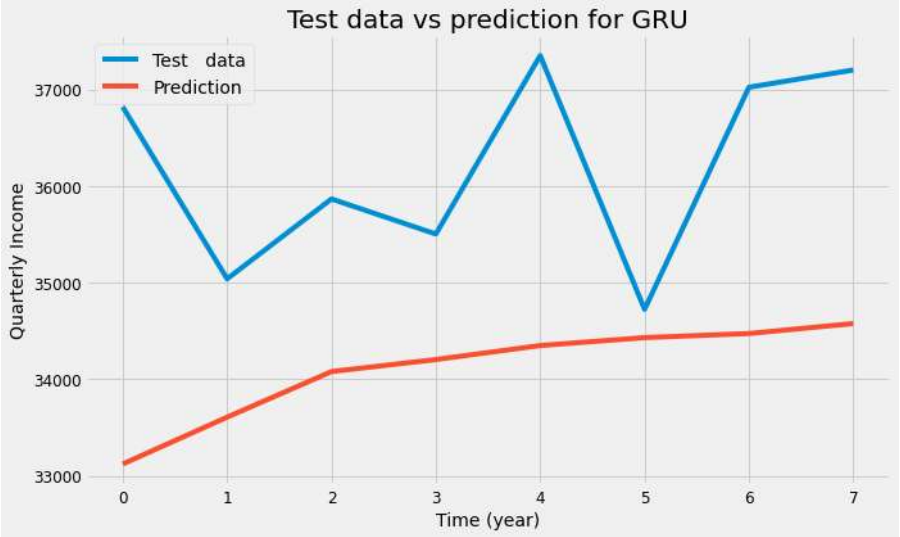


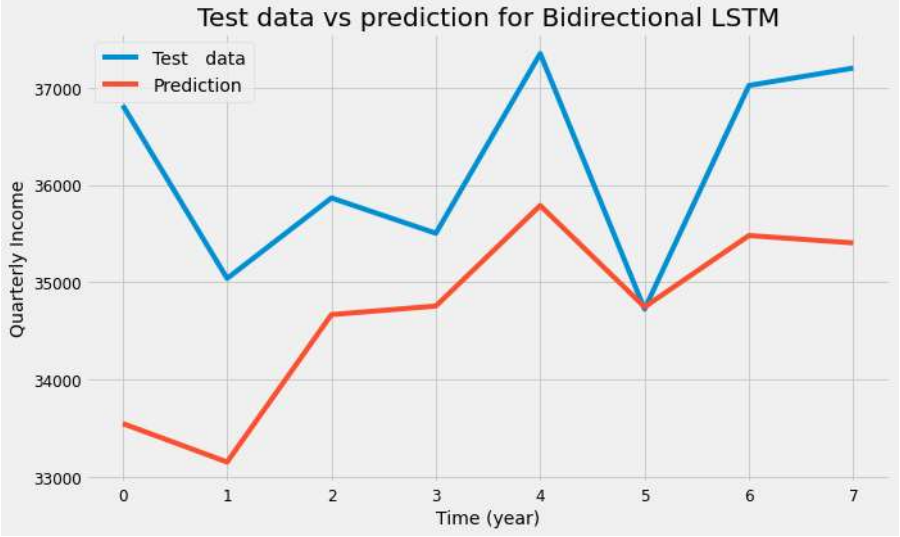
In [ ]:

```python
# Make prediction
def prediction(model):
    prediction = model.predict(X_test)
    prediction = scaler.inverse_transform(prediction)
    return prediction
prediction_gru = prediction(model_gru)
prediction_bilstm = prediction(model_bilstm)
# Plot test data vs prediction
def plot_future(prediction, model_name, y_test):
    plt.figure(figsize=(10, 6))
    range_future = len(prediction)
    plt.plot(np.arange(range_future), np.array(scaler.inverse_transform(y_test)),
             label='Test   data')
    plt.plot(np.arange(range_future),
             np.array(prediction),label='Prediction')
    plt.title('Test data vs prediction for ' + model_name)
    plt.legend(loc='upper left')
    plt.xlabel('Time (year)')
    plt.ylabel('Quarterly Income')

plot_future(prediction_gru, 'GRU', y_test)
plot_future(prediction_bilstm, 'Bidirectional LSTM', y_test)
```

```
1/1 [==============================] - 1s 822ms/step
1/1 [==============================] - 2s 2s/step
```





In [ ]:

```python
def evaluate_prediction(predictions, actual, model_name):
    errors = predictions - actual
    mse = np.square(errors).mean()
    rmse = np.sqrt(mse)
    mae = np.abs(errors).mean()
    print(model_name + ':')
    print('Mean Absolute Error: {:.4f}'.format(mae))
    print('Root Mean Square Error: {:.4f}'.format(rmse))
    print('')
evaluate_prediction(prediction_gru, scaler.inverse_transform(y_test), 'GRU')
evaluate_prediction(prediction_bilstm, scaler.inverse_transform(y_test), 'Bidirectional LSTM')
```

```
GRU:
Mean Absolute Error: 2085.2383
Root Mean Square Error: 2320.4647

Bidirectional LSTM:
Mean Absolute Error: 1503.6255
Root Mean Square Error: 1743.0772
```

In [ ]:

```python
def evaluate_prediction(predictions, actual, model_name):
    errors = predictions - actual
    mse = np.square(errors).mean()
    rmse = np.sqrt(mse)
    mae = np.abs(errors).mean()
    print(model_name + ':')
    print('Mean Absolute Error: {:.4f}'.format(mae))
    print('Root Mean Square Error: {:.4f}'.format(rmse))
    print('')
evaluate_prediction(scaler.transform(prediction_gru), y_test, 'GRU')
evaluate_prediction(scaler.transform(prediction_bilstm), y_test, 'Bidirectional LSTM')
```

```
GRU:
Mean Absolute Error: 0.2079
Root Mean Square Error: 0.2313

Bidirectional LSTM:
Mean Absolute Error: 0.1499
Root Mean Square Error: 0.1738


/usr/local/lib/python3.8/dist-packages/sklearn/base.py:450: UserWarning: X does not have valid feature names, but MinMaxScaler wa
s fitted with feature names
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/base.py:450: UserWarning: X does not have valid feature names, but MinMaxScaler wa
s fitted with feature names
  warnings.warn(
```