Time Series Analysis & Forecasting- Project

Problem Statement:

```
Fit a seasonal ARIMA model of your choice to the U.S. Live Birth Series (birth).

Use the estimated model to forecast the next 12 months.
```

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Import necessary libraries

In [1]:

```
import warnings
warnings.filterwarnings("ignore")

import requests
from bs4 import BeautifulSoup

import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns

from pylab import rcParams

from statsmodels.tsa.stattools import adfuller

from statsmodels.tsa.arima_model import ARIMA
```

Reading the dataset from Webpage and Importing into dataframe

In [2]:

```
page = requests.get('https://www.infoplease.com/us/population/live-births-and-birth-rates-y

bs4 = BeautifulSoup(page.content,'html.parser')

table = bs4.find("table", id="A0005068")

headers = []
for i in table.find_all("th"):
    title = i.text
    headers.append(title)

df = pd.DataFrame(columns = headers)

for j in table.find_all("tr")[1:]:
    row_data = j.find_all("td")
    row = [i.text for i in row_data]
    length = len(df)
    df.loc[length] = row
```

Properties of dataset

In [3]:

```
df.head()
```

Out[3]:

	Year	Births1	Rate2
0	1910	2,777,000	30.1
1	1915	2,965,000	29.5
2	1920	2,950,000	27.7
3	1925	2,909,000	25.1
4	1930	2,618,000	21.3

In [4]:

```
df.tail()
```

Out[4]:

	Year	Births1	Rate2
58	2002	4,021,726	13.9
59	2003	4,089,950	14.1
60	2004	4,112,052	14.0
61	2005	4,138,349	14.0
62	2009	4,131,019	13.8

In [5]:

```
df.shape
```

Out[5]:

```
(63, 3)
```

In [6]:

```
df.size
```

Out[6]:

```
189
```

In [7]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 63 entries, 0 to 62
Data columns (total 3 columns):
 #   Column   Non-Null Count  Dtype 
---  ------   --------------  ----- 
 0   Year     63 non-null     object
 1   Births1  63 non-null     object
 2   Rate2    63 non-null     object
dtypes: object(3)
memory usage: 2.0+ KB
```

Pre-processing

Dropping unwanted columns

In [8]:

```
df.drop('Births1', inplace=True, axis=1)
```

Changing the values as required

In [9]:

```
df.iloc[9,0] = '1952'
df.iloc[10,0] = '1953'
df.iloc[11,0] = '1954'
df.iloc[13,0] = '1956'
df.iloc[14,0] = '1957'
df.iloc[15,0] = '1958'
df.iloc[16,0] = '1959'
df.iloc[17,0] = '1960'
df.iloc[18,0] = '1961'
df.iloc[19,0] = '1962'
df.iloc[20,0] = '1963'
df.iloc[21,0] = '1964'
df.iloc[22,0] = '1965'
df.iloc[23,0] = '1966'
df.iloc[24,0] = '1967'
df.iloc[25,0] = '1968'
df.iloc[26,0] = '1969'
df.iloc[27,0] = '1970'
df.iloc[28,0] = '1971'
```

Converting datatype of the elements in dataset

In [10]:

```
df['Year'] = df['Year'].astype('int')
df['Rate2'] = df['Rate2'].astype('float')
```

In [11]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 63 entries, 0 to 62
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   Year    63 non-null     int32  
 1   Rate2   63 non-null     float64
dtypes: float64(1), int32(1)
memory usage: 1.2 KB
```

Setting Year as Index labels

In [12]:

```
df.set_index('Year',inplace=True)
```

Renaming the column

In [13]:

```
df.rename(columns = {'Rate2':'Birth_Rate'}, inplace = True)
```

In [14]:

```
df.head()
```

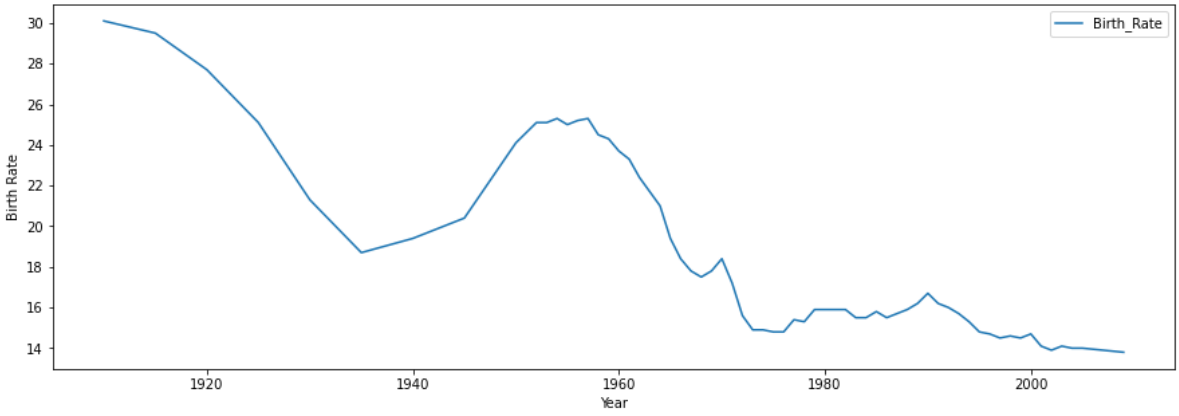
Out[14]:

Year	Birth_Rate
1910	30.1
1915	29.5
1920	27.7
1925	25.1
1930	21.3

Plotting the Time Series

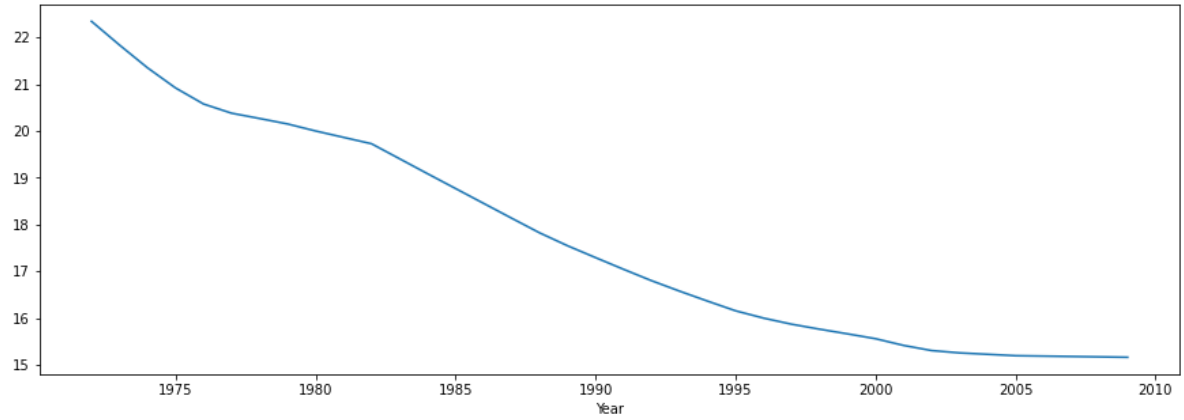
In [15]:

```
rcParams['figure.figsize'] = 15,5
df.plot()
plt.xlabel('Year')
plt.ylabel('Birth Rate')
plt.show()
```



In [16]:

```
df.Birth_Rate.rolling(window=30).mean().plot()
plt.show()
```



Checking for Stationarity

In [17]:

```
test_result = adfuller(df['Birth_Rate'])
```

In [18]:

```
def adfuller_test(br):
    test_result = adfuller(br)
    labels = ['ADF Test Statistic','p-value','#Lags Used','Number of Observations']
    for value, label in zip(test_result,labels):
        print(label+' : '+str(value) )

if test_result[1] <= 0.05:
    print("Strong evidence against the null hypothesis(Ho), reject the null hypothesis. Dat
else:
    print("Weak evidence against null hypothesis(Ho), indicating it is non-stationary ")

adfuller_test(df['Birth_Rate'])
```

```
Weak evidence against null hypothesis(Ho), indicating it is non-stationary
ADF Test Statistic : -2.635845300334956
p-value : 0.08581273678851786
#Lags Used : 1
Number of Observations : 61
```

Here P-value is 0.08 which is greater than 0.05, which means data is accepting the null hypothesis, which means data is non-stationary.

Differencing to make the model as Stationary

In [19]:

```
df['Difference'] = df['Birth_Rate'] - df['Birth_Rate'].shift()
df.head()
```

Out[19]:

Year	Birth_Rate	Difference
1910	30.1	NaN
1915	29.5	-0.6
1920	27.7	-1.8
1925	25.1	-2.6
1930	21.3	-3.8

Again testing if data is stationary

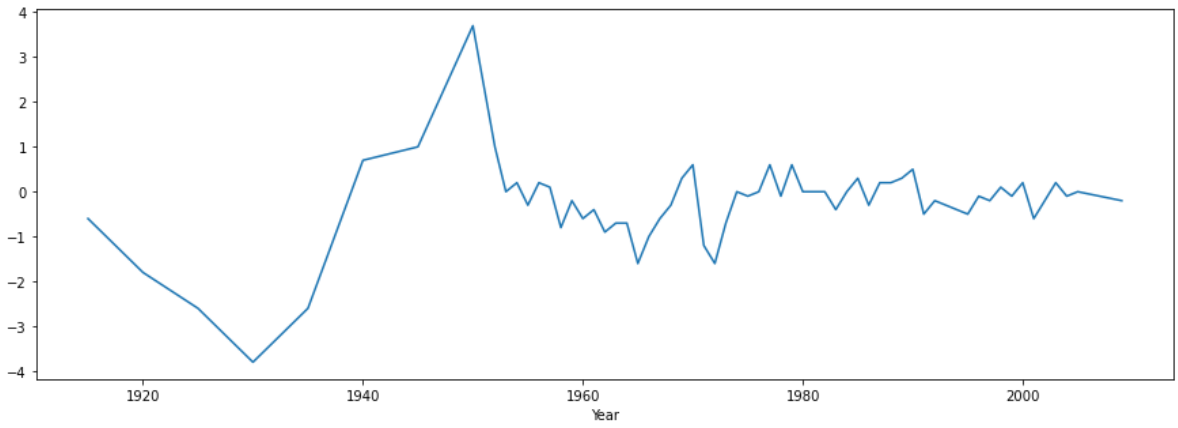
In [20]:

```
adfuller_test(df['Difference'].dropna())
```

```
ADF Test Statistic : -3.7970030167159248
p-value : 0.0029381273220641124
#Lags Used : 0
Number of Observations : 61
```

In [21]:

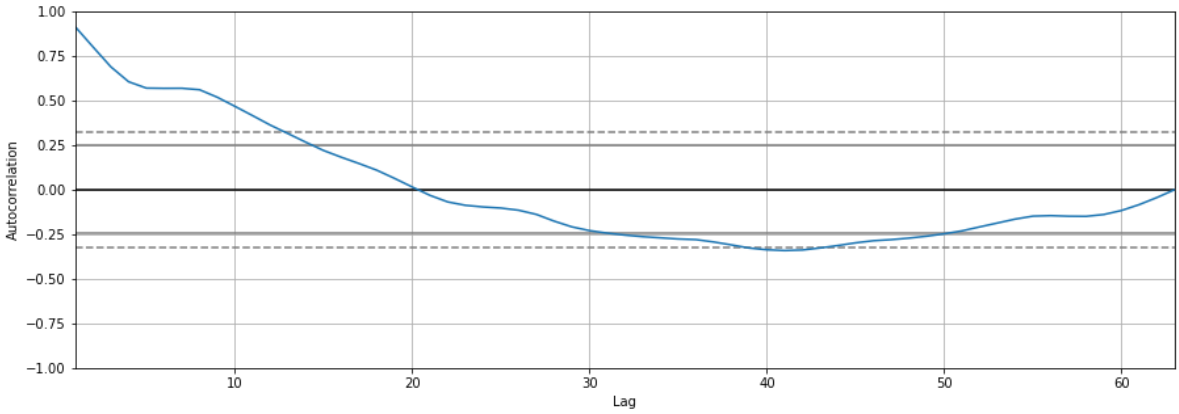
```
df['Difference'].plot()
plt.show()
```



ACF Plotting

In [22]:

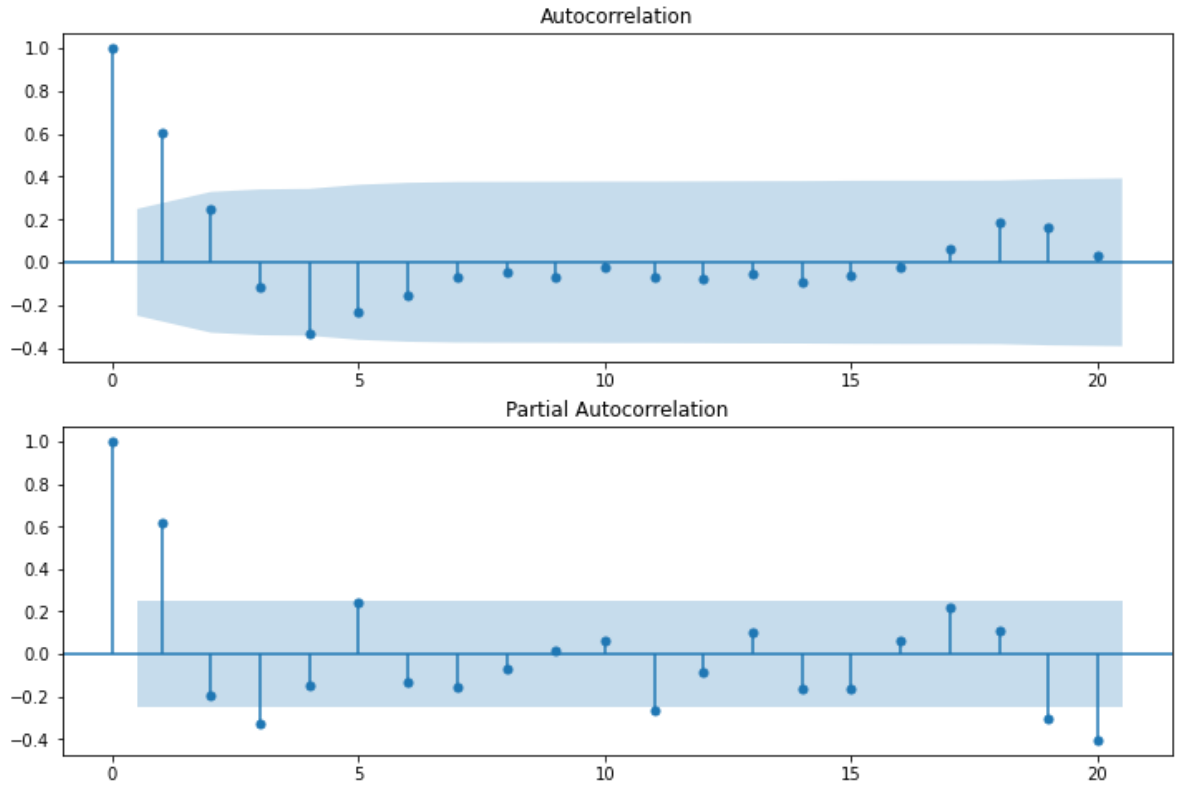
```
from pandas.plotting import autocorrelation_plot
autocorrelation_plot(df['Birth_Rate'])
plt.show()
```



PACF Plotting

In [23]:

```
from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
import statsmodels.api as sm
fig = plt.figure(figsize=(12,8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(df['Difference'].dropna(),lags=20,ax=ax1)
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(df['Difference'].dropna(),lags=20,ax=ax2)
```



Model

In [24]:

```
model=ARIMA(df['Birth_Rate'],order=(2,0,1))
model_fit=model.fit()
model_fit.summary()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\base\tsa_model.p
y:578: ValueWarning: An unsupported index was provided and will be ignored w
hen e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be'
```

Out[24]:

ARMA Model Results

Dep. Variable:	Birth_Rate	**No. Observations:**	63
Model:	ARMA(2, 1)	**Log Likelihood**	-74.707
Method:	css-mle	**S.D. of innovations**	0.764
Date:	Tue, 31 May 2022	**AIC**	159.415
Time:	22:07:48	**BIC**	170.130
Sample:	0	**HQIC**	163.629

	coef	std err	z	P>|z|	[0.025	0.975]
const	19.6583	3.283	5.988	0.000	13.224	26.093
ar.L1.Birth_Rate	1.5592	0.138	11.262	0.000	1.288	1.831
ar.L2.Birth_Rate	-0.5873	0.142	-4.138	0.000	-0.865	-0.309
ma.L1.Birth_Rate	0.1197	0.151	0.795	0.427	-0.175	0.415

Roots

	Real	Imaginary	Modulus	Frequency
AR.1	1.0837	+0.0000j	1.0837	0.0000
AR.2	1.5713	+0.0000j	1.5713	0.0000
MA.1	-8.3564	+0.0000j	8.3564	0.5000

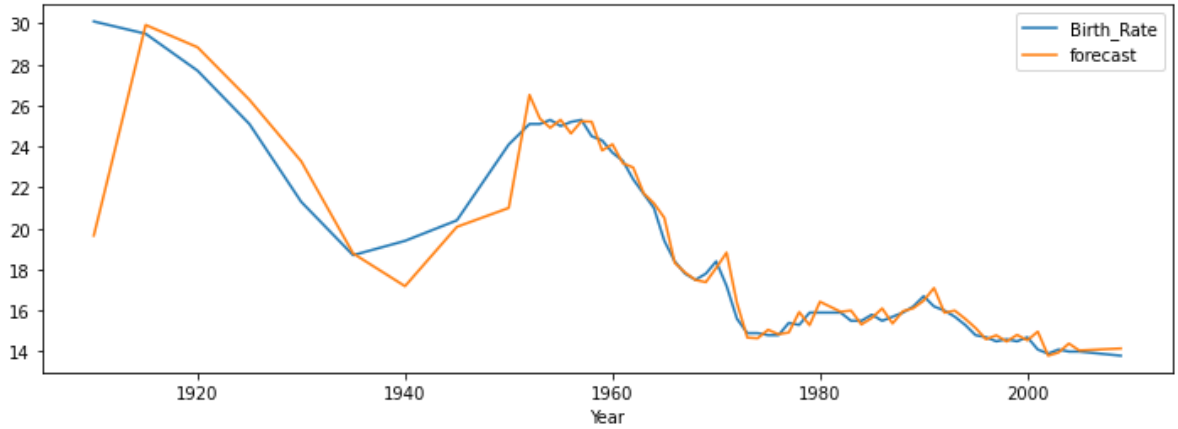
Forecasting

In [25]:

```
df['forecast'] = model_fit.predict()
df[['Birth_Rate','forecast']].plot(figsize=(12,4))
```

Out[25]:

```
<AxesSubplot:xlabel='Year'>
```



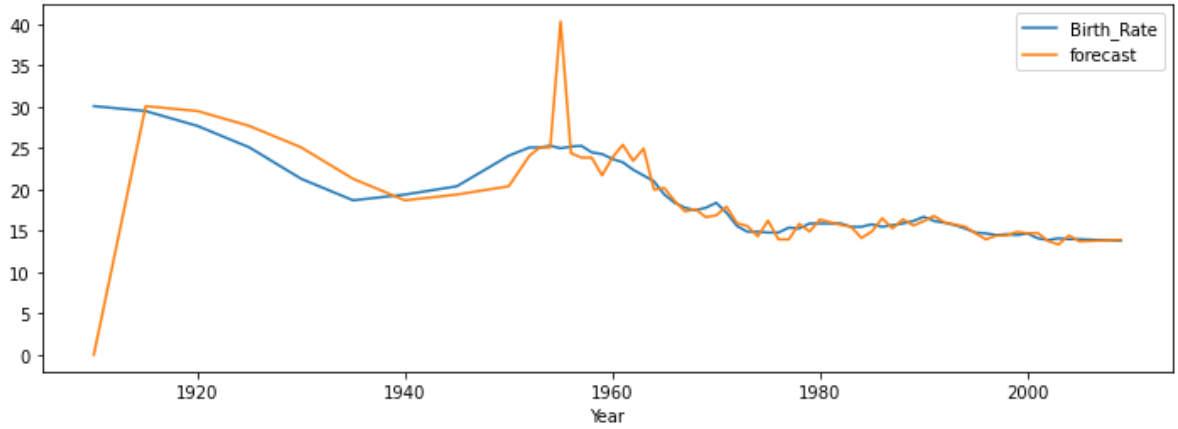
In [26]:

```
import statsmodels.api as sm
model=sm.tsa.statespace.SARIMAX(df['Birth_Rate'],order=(1, 1, 1),seasonal_order=(1,1,1,12))
results=model.fit()
df['forecast']=results.predict()
df[['Birth_Rate','forecast']].plot(figsize=(12,4))
```

```
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\base\tsa_model.p
y:578: ValueWarning: An unsupported index was provided and will be ignored w
hen e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be'
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\base\tsa_model.p
y:578: ValueWarning: An unsupported index was provided and will be ignored w
hen e.g. forecasting.
  warnings.warn('An unsupported index was provided and will be'
```

Out[26]:

```
<AxesSubplot:xlabel='Year'>
```



In [ ]: