Data Mining Project - Sustainability Around The World

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Time Series Analysis

In [1]:

```
# Import libs
import pandas as pd
import numpy as np
import os, fnmatch
import matplotlib.pyplot as plt
import statsmodels.api as sm
import sklearn.metrics as mt
import seaborn as sns
from pmdarima.arima import auto_arima
from chart_studio.plotly import plot_mpl
from statsmodels.tsa.seasonal import seasonal_decompose
import datetime
```

Read Data

In [4]:

```
data_path = "./master.csv"
```

In [5]:

```
data = pd.read_csv(data_path)
```

In [6]:

```
data[0:5]
```

Out[6]:

	year	iso	country	region	EPI	AIR	H2O	BDH	WRS
0	2022	AFG	Afghanistan	Southern Asia	43.6	15.5	28.1	30.7	0.0
1	2022	ALB	Albania	Eastern Europe	47.1	37.5	54.1	63.9	1.9
2	2022	DZA	Algeria	Greater Middle East	29.6	39.4	53.3	22.7	33.1
3	2022	AGO	Angola	Sub-Saharan Africa	30.5	23.1	12.8	30.1	0.0
4	2022	ATG	Antigua and Barbuda	Latin America & Caribbean	52.4	56.5	50.1	54.2	15.7

Preprocess and Analysis

Get countries with sufficient data points

In [7]:

```
selected_countries = data[data['year'].isin([2018,2020,2022])]['country'].unique()
```

In [8]:

```
selected_countries
```

```
Out[8]: array(['Afghanistan', 'Albania', 'Algeria', 'Angola',
               'Antigua and Barbuda', 'Argentina', 'Armenia', 'Australia',
               'Austria', 'Azerbaijan', 'Bahamas', 'Bahrain', 'Bangladesh',
               'Barbados', 'Belarus', 'Belgium', 'Belize', 'Benin', 'Bhutan',
               'Bolivia', 'Bosnia and Herzegovina', 'Botswana', 'Brazil',
               'Brunei Darussalam', 'Bulgaria', 'Burkina Faso', 'Burundi',
               'Cabo Verde', 'Cambodia', 'Cameroon', 'Canada',
               'Central African Republic', 'Chad', 'Chile', 'China', 'Colombia',
               'Comoros', 'Costa Rica', "Cote d'Ivoire", 'Croatia', 'Cuba',
               'Cyprus', 'Czech Republic', 'Dem. Rep. Congo', 'Denmark',
               'Djibouti', 'Dominica', 'Dominican Republic', 'Ecuador', 'Egypt',
               'El Salvador', 'Equatorial Guinea', 'Eritrea', 'Estonia',
               'Eswatini', 'Ethiopia', 'Fiji', 'Finland', 'France', 'Gabon',
               'Gambia', 'Georgia', 'Germany', 'Ghana', 'Greece', 'Grenada',
               'Guatemala', 'Guinea', 'Guinea-Bissau', 'Guyana', 'Haiti',
               'Honduras', 'Hungary', 'Iceland', 'India', 'Indonesia', 'Iran',
               'Iraq', 'Ireland', 'Israel', 'Italy', 'Jamaica', 'Japan', 'Jordan',
               'Kazakhstan', 'Kenya', 'Kiribati', 'Kuwait', 'Kyrgyzstan', 'Laos',
               'Latvia', 'Lebanon', 'Lesotho', 'Liberia', 'Lithuania',
               'Luxembourg', 'Madagascar', 'Malawi', 'Malaysia', 'Maldives',
               'Mali', 'Malta', 'Marshall Islands', 'Mauritania', 'Mauritius',
               'Mexico', 'Micronesia', 'Moldova', 'Mongolia', 'Montenegro',
               'Morocco', 'Mozambique', 'Myanmar', 'Namibia', 'Nepal',
               'Netherlands', 'New Zealand', 'Nicaragua', 'Niger', 'Nigeria',
               'North Macedonia', 'Norway', 'Oman', 'Pakistan', 'Panama',
               'Papua New Guinea', 'Paraguay', 'Peru', 'Philippines', 'Poland',
               'Portugal', 'Qatar', 'Republic of Congo', 'Romania', 'Russia',
               'Rwanda', 'Saint Lucia', 'Saint Vincent and the Grenadines',
               'Samoa', 'Sao Tome and Principe', 'Saudi Arabia', 'Senegal',
               'Serbia', 'Seychelles', 'Sierra Leone', 'Singapore', 'Slovakia',
               'Slovenia', 'Solomon Islands', 'South Africa', 'South Korea',
               'Spain', 'Sri Lanka', 'Sudan', 'Suriname', 'Sweden', 'Switzerland',
               'Taiwan', 'Tajikistan', 'Tanzania', 'Thailand', 'Timor-Leste',
               'Togo', 'Tonga', 'Trinidad and Tobago', 'Tunisia', 'Turkey',
               'Turkmenistan', 'Uganda', 'Ukraine', 'United Arab Emirates',
               'United Kingdom', 'United States of America', 'Uruguay',
               'Uzbekistan', 'Vanuatu', 'Venezuela', 'Viet Nam', 'Zambia',
               'Zimbabwe', "CÃƒÂ´te d'Ivoire", 'Macedonia',
               'SÃƒÂ£o TomÃƒÂ© and PrÃƒÂ\xadncipe', 'Swaziland'], dtype=object)
```

```
In [9]: data = data[data['country'].isin(selected_countries)]
```

```
In [10]: data
```

Out[10]:

	year	iso	country	region	EPI	AIR	H2O	BDH	WRS
0	2022	AFG	Afghanistan	Southern Asia	43.60	15.50	28.10	30.70	0.00
1	2022	ALB	Albania	Eastern Europe	47.10	37.50	54.10	63.90	1.90
2	2022	DZA	Algeria	Greater Middle East	29.60	39.40	53.30	22.70	33.10
3	2022	AGO	Angola	Sub-Saharan Africa	30.50	23.10	12.80	30.10	0.00
4	2022	ATG	Antigua and Barbuda	Latin America & Caribbean	52.40	56.50	50.10	54.20	15.70
...	...	...	...	...	...	...	...	...	...
1170	2010	UZB	Uzbekistan	Former Soviet States	42.27	65.07	87.41	21.75	21.53
1171	2010	VEN	Venezuela	Latin America & Caribbean	62.90	97.37	83.52	78.19	56.12
1172	2010	VNM	Viet Nam	Asia-Pacific	59.00	41.47	73.46	41.28	78.05
1173	2010	ZMB	Zambia	Sub-Saharan Africa	47.00	36.76	36.86	100.00	70.28
1174	2010	ZWE	Zimbabwe	Sub-Saharan Africa	47.82	54.81	53.32	93.75	67.69

1164 rows × 9 columns

In [11]:
```
data_count = data.groupby(['country'])['year'].count().reset_index(name='counts').
```

In [12]:
```
selected_countries = data_count[data_count['counts']>6]['country'].unique()
```

In [13]:
```
data = data[data['country'].isin(selected_countries)]
```

In [14]:
```
data[1:5]
```

Out[14]:

	year	iso	country	region	EPI	AIR	H2O	BDH	WRS
2	2022	DZA	Algeria	Greater Middle East	29.6	39.4	53.3	22.7	33.1
3	2022	AGO	Angola	Sub-Saharan Africa	30.5	23.1	12.8	30.1	0.0
5	2022	ARG	Argentina	Latin America & Caribbean	41.1	52.0	64.8	42.4	5.9
6	2022	ARM	Armenia	Former Soviet States	48.3	32.1	57.3	73.3	4.5

In [15]:
```
data = data.reset_index(drop=True)
```

In [16]:
```
data.isnull().sum(axis = 0)
```

Out[16]:
```
year        0
iso         0
country     0
region      0
EPI         0
AIR         0
H2O         0
BDH         0
WRS         0
dtype: int64
```

Handle Null Values

In [17]:

```
# data = data.sort_values(['country', 'year'])
# data['index'] = data.groupby(['country']).cumcount()
```

In [18]:

```
idx = data[['year']].drop_duplicates().sort_values('year', axis=0).reset_index(dro
idx['idx'] = idx.index
# idx['idx'] = idx['idx'].astype(str)
```

In [19]:

```
idx
```

Out[19]:

	year	idx
0	2010	0
1	2012	1
2	2014	2
3	2016	3
4	2018	4
5	2020	5
6	2022	6

In [20]:

```
data = data.merge(idx, on='year')
```

Models - Predict 2020

Data Sets

In [21]:

```
data_train = data[data['year'] < 2020]
data_test = data[data['year'].isin([2020])]
```

In [22]:

```
data_train.sort_values(['country', 'year'])[1:5]
```

Out[22]:

	year	iso	country	region	EPI	AIR	H2O	BDH	WRS	idx
615	2012	ALB	Albania	Eastern Europe	65.85	100.00	72.28	61.72	23.19	1
492	2014	ALB	Albania	Eastern Europe	54.73	68.24	55.91	63.19	3.36	2
369	2016	ALB	Albania	Eastern Europe	29.61	37.41	48.46	26.07	2.70	3
246	2018	ALB	Albania	Eastern Europe	38.80	37.10	51.50	57.10	2.70	4

In [23]:

```
data_test[1:5]
```

Out[23]:

	year	iso	country	region	EPI	AIR	H2O	BDH	WRS	idx
124	2020	DZA	Algeria	Greater Middle East	44.8	45.3	53.2	39.0	33.1	5
125	2020	AGO	Angola	Sub-Saharan Africa	29.7	26.8	12.8	39.3	0.0	5
126	2020	ARG	Argentina	Latin America & Caribbean	52.2	56.9	64.7	49.1	5.9	5
127	2020	ARM	Armenia	Former Soviet States	52.3	36.3	57.2	79.2	8.8	5

Simple Linear Regression

In [24]:

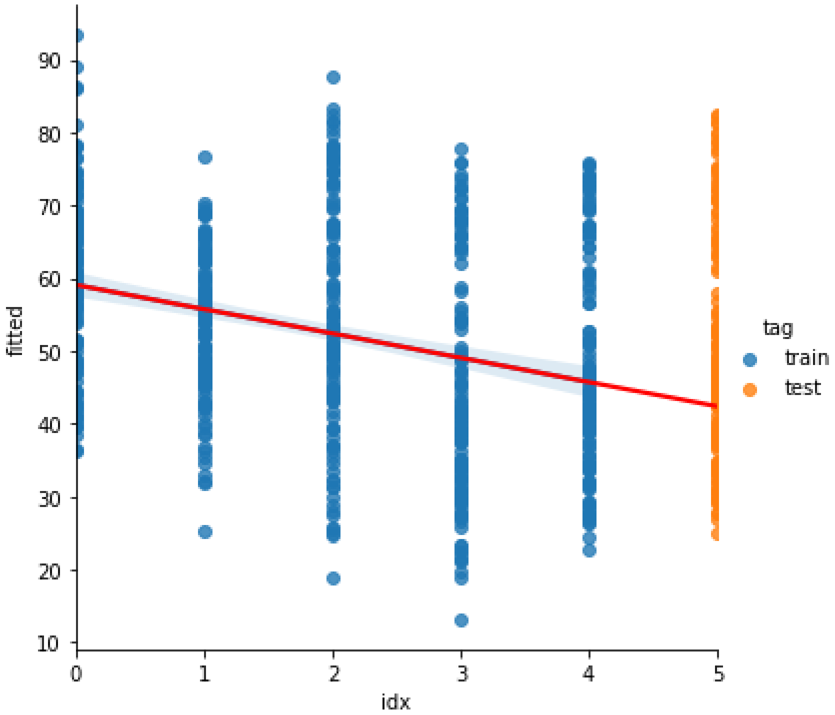
```python
# Train-predict and plot for all countries
x_train = data_train[['idx']]
y_train = data_train['EPI']

x_test = data_test[['idx']]
y_test = data_test['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=True)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    EPI   R-squared:                       0.099
Model:                            OLS   Adj. R-squared:                  0.098
Method:                 Least Squares   F-statistic:                     67.46
Date:                Sun, 11 Dec 2022   Prob (F-statistic):           1.28e-15
Time:                        03:18:21   Log-Likelihood:                -2506.3
No. Observations:                 615   AIC:                             5017.
Df Residuals:                     613   BIC:                             5025.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         59.0999      0.996     59.313      0.000      57.143      61.057
idx           -3.3410      0.407     -8.213      0.000      -4.140      -2.542
==============================================================================
Omnibus:                       23.974   Durbin-Watson:                   1.812
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               13.442
Skew:                           0.189   Prob(JB):                      0.00121
Kurtosis:                       2.382   Cond. No.                         4.74
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:18: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:19: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:21: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

Out[24]:

```
<AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [25]:

```
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [26]:

```
mt.mean_squared_error(y_test, predictions)
```

Out[26]:

```
320.56405438271065
```

Sample Country

In [27]:

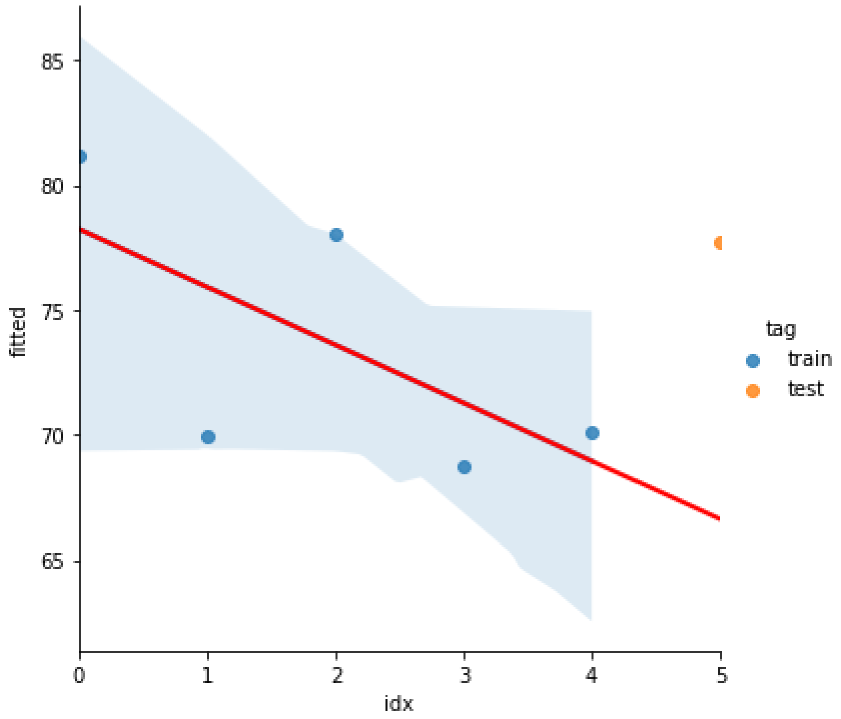
```
# Train-predict and plot for sample country Norway
country = 'Norway'
x_train = data_train[data_train['country'] == country][['idx']]
y_train = data_train[data_train['country'] == country]['EPI']

x_test = data_test[data_test['country'] == country][['idx']]
y_test = data_test[data_test['country'] == country]['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train[data_train['country'] == country]
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test[data_test['country'] == country]
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=True)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\stats\stattools.py:75: ValueWarning: omni_normtest is not valid with less than
8 observations; 5 samples were given.
  "samples were given." % int(n), ValueWarning)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:19: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:20: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:23: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
                            OLS Regression Results                            
==============================================================================
Dep. Variable:                    EPI   R-squared:                       0.429
Model:                            OLS   Adj. R-squared:                  0.239
Method:                 Least Squares   F-statistic:                     2.256
Date:                Sun, 11 Dec 2022   Prob (F-statistic):              0.230
Time:                        03:18:42   Log-Likelihood:                -13.755
No. Observations:                   5   AIC:                             31.51
Df Residuals:                       3   BIC:                             30.73
Df Model:                           1                                         
Covariance Type:            nonrobust                                         
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         78.2340      3.789     20.650      0.000      66.177      90.291
idx           -2.3230      1.547     -1.502      0.230      -7.245       2.599
==============================================================================
Omnibus:                          nan   Durbin-Watson:                   3.484
Prob(Omnibus):                    nan   Jarque-Bera (JB):                0.484
Skew:                          -0.430   Prob(JB):                        0.785
Kurtosis:                       1.741   Cond. No.                         4.74
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
```

Out[27]:

```
<AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [28]:

```python
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [29]:

```python
mt.mean_squared_error(y_test, predictions)
```

Out[29]:

```
122.78856100000007
```

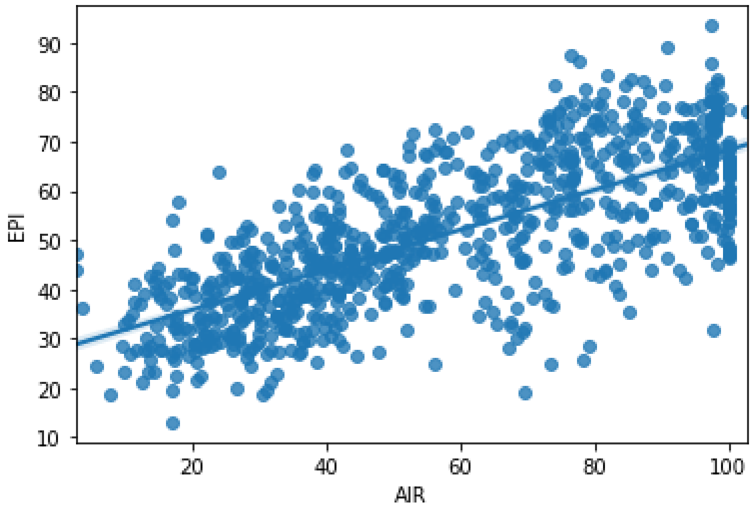
Multiple Linear Regression

In [30]:

```python
sns.regplot(x='AIR', y='EPI', data=data)
```

Out[30]:

```
<AxesSubplot:xlabel='AIR', ylabel='EPI'>
```



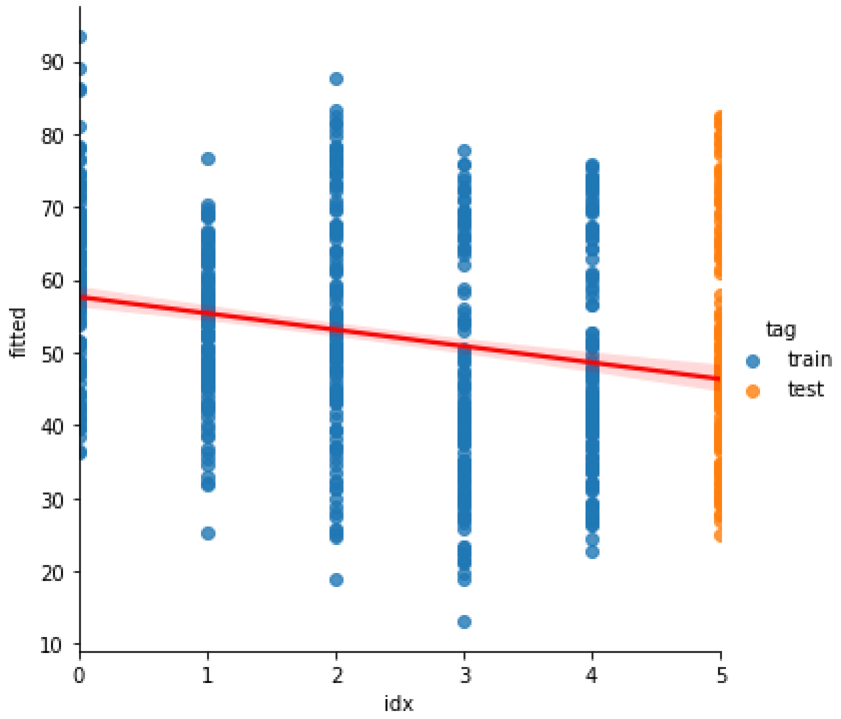
In [31]:

```
x_train = data_train[['idx', 'AIR', 'H2O', 'BDH', 'WRS']]
y_train = data_train['EPI']

x_test = data_test[['idx', 'AIR', 'H2O', 'BDH', 'WRS']]
y_test = data_test['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + \
                            data_plot_train['AIR'] * p.AIR + \
                            data_plot_train['H2O'] * p.H2O + \
                            data_plot_train['BDH'] * p.BDH + \
                            data_plot_train['WRS'] * p.WRS + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + \
                            data_plot_test['AIR'] * p.AIR + \
                            data_plot_test['H2O'] * p.H2O + \
                            data_plot_test['BDH'] * p.BDH + \
                            data_plot_test['WRS'] * p.WRS + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=False)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
                            OLS Regression Results                            
==============================================================================
Dep. Variable:                    EPI   R-squared:                       0.846
Model:                            OLS   Adj. R-squared:                  0.845
Method:                 Least Squares   F-statistic:                     668.4
Date:                Sun, 11 Dec 2022   Prob (F-statistic):          1.62e-244
Time:                        03:19:03   Log-Likelihood:                -1963.4
No. Observations:                 615   AIC:                             3939.
Df Residuals:                     609   BIC:                             3965.
Df Model:                           5                                         
Covariance Type:            nonrobust                                         
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         17.7819      0.956     18.610      0.000      15.905      19.658
idx            0.1390      0.189      0.734      0.463      -0.233       0.511
AIR            0.1306      0.012     10.521      0.000       0.106       0.155
H2O            0.1854      0.012     15.749      0.000       0.162       0.209
BDH            0.1582      0.010     15.343      0.000       0.138       0.178
WRS            0.1622      0.010     16.698      0.000       0.143       0.181
==============================================================================
Omnibus:                        6.288   Durbin-Watson:                   1.926
Prob(Omnibus):                  0.043   Jarque-Bera (JB):                6.337
Skew:                          -0.198   Prob(JB):                       0.0421
Kurtosis:                       3.300   Cond. No.                         475.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
```

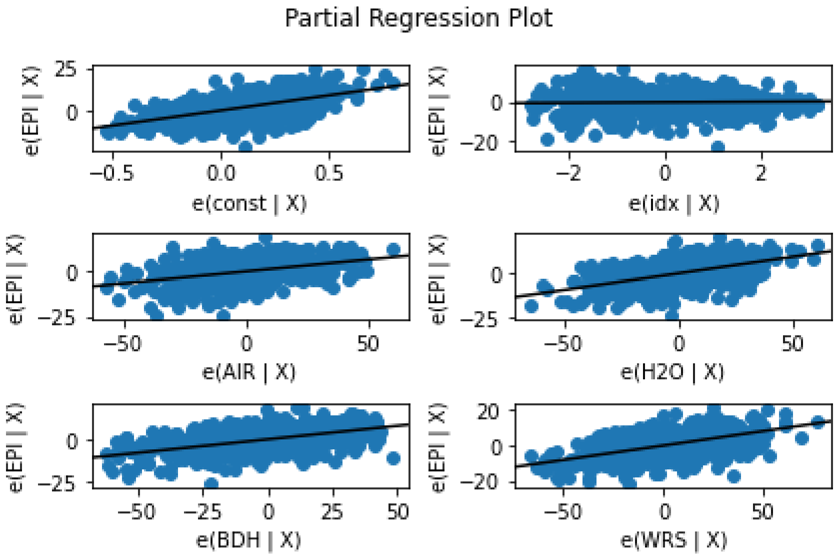
```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:21: SettingWithCopyWarning: 
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:28: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:29: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
Out[31]: <AxesSubplot:xlabel='idx', ylabel='fitted'>
```



```
In [32]: fig = sm.graphics.plot_partregress_grid(model)
         fig.tight_layout(pad=1.0)
```

```
eval_env: 1
eval_env: 1
eval_env: 1
eval_env: 1
eval_env: 1
eval_env: 1
```



```
In [33]: x_test = sm.add_constant(x_test, has_constant='add')
         predictions = model.predict(x_test)
```

```
In [34]: mt.mean_squared_error(y_test, predictions)
```

```
Out[34]: 20.794376334029756
```

Sample Country

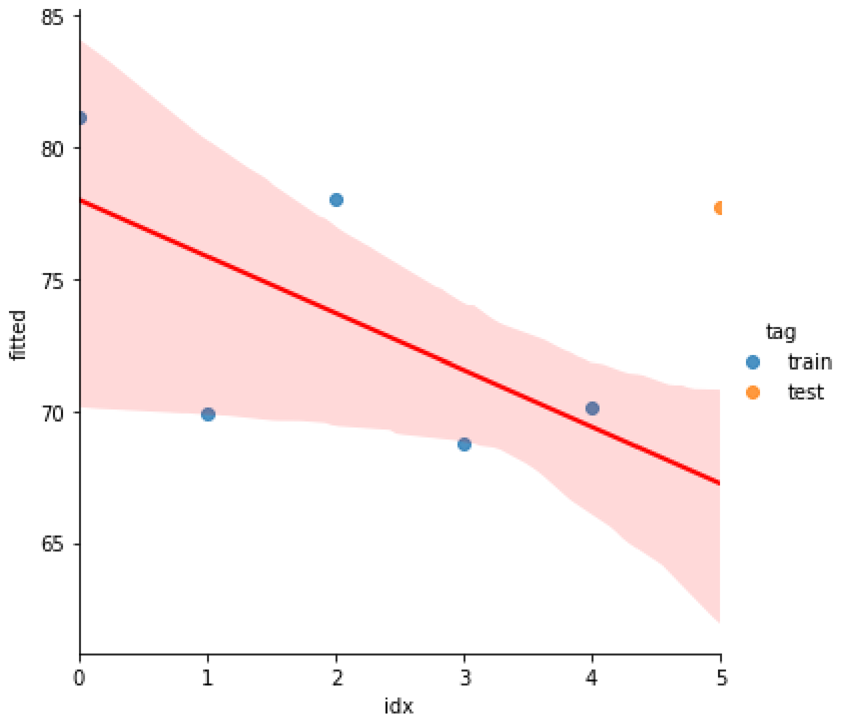
```
In [35]: # Train-predict and plot for sample country Norway
         x_train = data_train[data_train['country'] == country][['idx', 'AIR', 'H2O', 'BDH'
```

```
y_train = data_train[data_train['country'] == country]['EPI']

x_test = data_test[data_test['country'] == country][['idx', 'AIR', 'H2O', 'BDH', '
y_test = data_test[data_test['country'] == country]['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train[data_train['country'] == country]
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + \
                            data_plot_train['AIR'] * p.AIR + \
                            data_plot_train['H2O'] * p.H2O + \
                            data_plot_train['BDH'] * p.BDH + \
                            data_plot_train['WRS'] * p.WRS + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test[data_test['country'] == country]
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + \
                            data_plot_test['AIR'] * p.AIR + \
                            data_plot_test['H2O'] * p.H2O + \
                            data_plot_test['BDH'] * p.BDH + \
                            data_plot_test['WRS'] * p.WRS + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=False)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\stats\stattools.py:75: ValueWarning: omni_normtest is not valid with less than
8 observations; 5 samples were given.
  "samples were given." % int(n), ValueWarning)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\regression\linear_model.py:1765: RuntimeWarning: divide by zero encountered in
true_divide
  return 1 - (np.divide(self.nobs - self.k_constant, self.df_resid)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\regression\linear_model.py:1766: RuntimeWarning: invalid value encountered in
double_scalars
  * (1 - self.rsquared))
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\regression\linear_model.py:1687: RuntimeWarning: divide by zero encountered in
double_scalars
  return np.dot(wresid, wresid) / self.df_resid
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:23: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:29: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:30: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    EPI   R-squared:                       1.000
Model:                            OLS   Adj. R-squared:                    nan
Method:                 Least Squares   F-statistic:                       nan
Date:                Sun, 11 Dec 2022   Prob (F-statistic):                nan
Time:                        03:19:23   Log-Likelihood:                 144.69
No. Observations:                   5   AIC:                            -279.4
Df Residuals:                       0   BIC:                            -281.3
Df Model:                           4
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0034        inf          0        nan         nan         nan
idx           -2.0882        inf         -0        nan         nan         nan
AIR           -0.3160        inf         -0        nan         nan         nan
H2O            0.6633        inf          0        nan         nan         nan
BDH            0.3145        inf          0        nan         nan         nan
WRS            0.3167        inf          0        nan         nan         nan
==============================================================================
Omnibus:                          nan   Durbin-Watson:                   0.660
Prob(Omnibus):                    nan   Jarque-Bera (JB):                0.359
Skew:                          -0.607   Prob(JB):                        0.836
Kurtosis:                       2.500   Cond. No.                         748.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
[2] The input rank is higher than the number of observations.
```

Out[35]:

```
<AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [36]:

```python
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [37]:

```python
mt.mean_squared_error(y_test, predictions)
```

Out[37]:

```
97.68311940770529
```

Models - Predict 2022

Data Sets

In [38]:

```
data_train = data[(data['year'] < 2022)]
data_test = data[data['year'].isin([2022])]
```

Simple Linear Regression

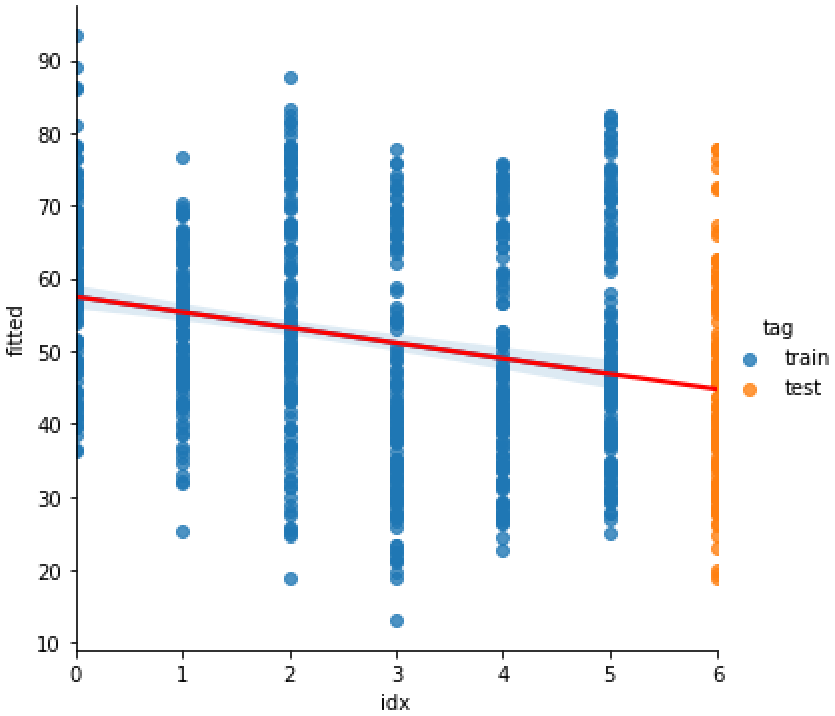
In [39]:

```
x_train = data_train[['idx']]
y_train = data_train['EPI']

x_test = data_test[['idx']]
y_test = data_test['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=True)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    EPI   R-squared:                       0.057
Model:                            OLS   Adj. R-squared:                  0.056
Method:                 Least Squares   F-statistic:                     44.67
Date:                Sun, 11 Dec 2022   Prob (F-statistic):           4.61e-11
Time:                        03:19:40   Log-Likelihood:                -3030.8
No. Observations:                 738   AIC:                             6066.
Df Residuals:                     736   BIC:                             6075.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         57.4727      0.961     59.827      0.000      55.587      59.359
idx           -2.1206      0.317     -6.684      0.000      -2.744      -1.498
==============================================================================
Omnibus:                       30.015   Durbin-Watson:                   1.770
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               16.693
Skew:                           0.197   Prob(JB):                     0.000237
Kurtosis:                       2.377   Cond. No.                         5.78
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:17: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:18: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:20: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:21: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
Out[39]: <AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [40]:
```
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [41]:
```
mt.mean_squared_error(y_test, predictions)
```

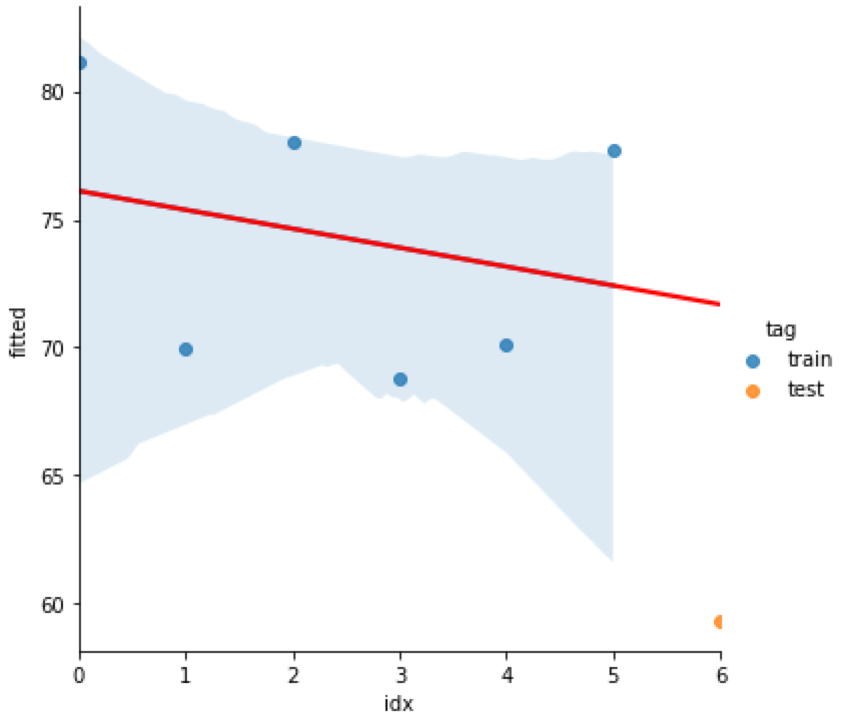
Out[41]:
```
183.67397634532637
```

Sample Country

In [42]:
```
# Train-predict and plot for sample country Norway
x_train = data_train[data_train['country'] == country][['idx']]
y_train = data_train[data_train['country'] == country]['EPI']

x_test = data_test[data_test['country'] == country][['idx']]
y_test = data_test[data_test['country'] == country]['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train[data_train['country'] == country]
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test[data_test['country'] == country]
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=True)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\stats\stattools.py:75: ValueWarning: omni_normtest is not valid with less than
8 observations; 6 samples were given.
  "samples were given." % int(n), ValueWarning)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:18: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:19: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:21: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
                            OLS Regression Results                            
==============================================================================
Dep. Variable:                    EPI   R-squared:                       0.069
Model:                            OLS   Adj. R-squared:                 -0.164
Method:                 Least Squares   F-statistic:                    0.2943
Date:                Sun, 11 Dec 2022   Prob (F-statistic):              0.616
Time:                        03:20:47   Log-Likelihood:                -17.746
No. Observations:                   6   AIC:                             39.49
Df Residuals:                       4   BIC:                             39.08
Df Model:                           1                                         
Covariance Type:            nonrobust                                         
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         76.1233      4.130     18.433      0.000      64.657      87.589
idx           -0.7400      1.364     -0.543      0.616      -4.527       3.047
==============================================================================
Omnibus:                          nan   Durbin-Watson:                   2.573
Prob(Omnibus):                    nan   Jarque-Bera (JB):                0.866
Skew:                          -0.028   Prob(JB):                        0.648
Kurtosis:                       1.139   Cond. No.                         5.78
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
```

Out[42]:
```
<AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [43]:

```
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [44]:

```
mt.mean_squared_error(y_test, predictions)
```

Out[44]:

```
153.3469444444439
```

Multiple Linear Regression

In [45]:

```
x_train = data_train[['idx','AIR', 'H2O', 'BDH', 'WRS']]
y_train = data_train['EPI']

x_test = data_test[['idx','AIR', 'H2O', 'BDH', 'WRS']]
y_test = data_test['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + \
                            data_plot_train['AIR'] * p.AIR + \
                            data_plot_train['H2O'] * p.H2O + \
                            data_plot_train['BDH'] * p.BDH + \
                            data_plot_train['WRS'] * p.WRS + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + \
                            data_plot_test['AIR'] * p.AIR + \
                            data_plot_test['H2O'] * p.H2O + \
                            data_plot_test['BDH'] * p.BDH + \
                            data_plot_test['WRS'] * p.WRS + p.const
data_plot_test['tag'] = 'test'
```

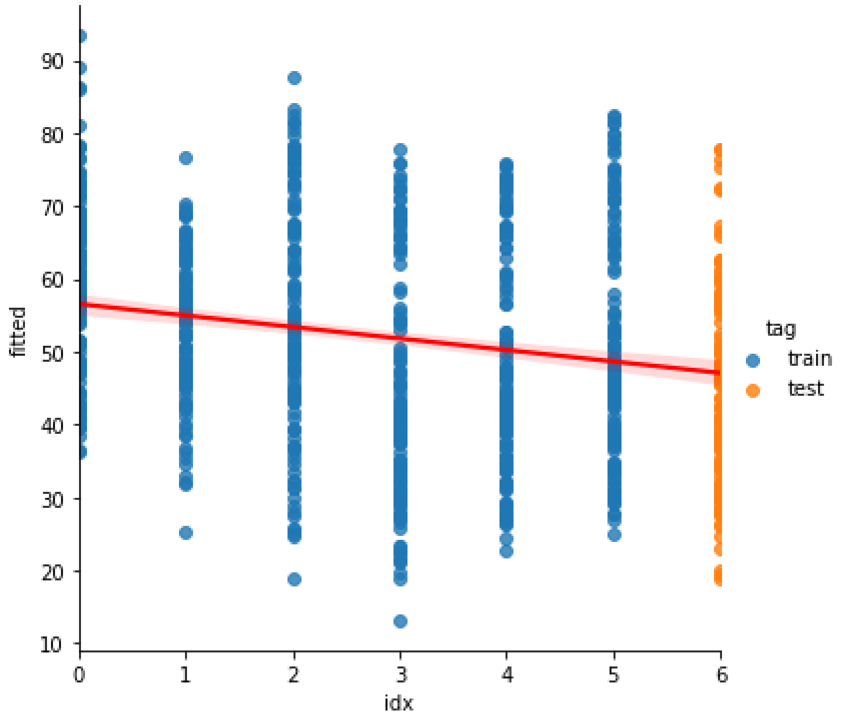
```python
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=False)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
                            OLS Regression Results                            
==============================================================================
Dep. Variable:                    EPI   R-squared:                       0.859
Model:                            OLS   Adj. R-squared:                  0.859
Method:                 Least Squares   F-statistic:                     895.4
Date:                Sun, 11 Dec 2022   Prob (F-statistic):          5.09e-309
Time:                        03:20:58   Log-Likelihood:                -2328.5
No. Observations:                 738   AIC:                             4669.
Df Residuals:                     732   BIC:                             4697.
Df Model:                           5                                         
Covariance Type:            nonrobust                                         
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         16.8606      0.824     20.470      0.000      15.244      18.478
idx            0.2858      0.137      2.082      0.038       0.016       0.555
AIR            0.1320      0.011     11.569      0.000       0.110       0.154
H2O            0.1968      0.011     18.136      0.000       0.176       0.218
BDH            0.1626      0.009     17.305      0.000       0.144       0.181
WRS            0.1545      0.009     18.049      0.000       0.138       0.171
==============================================================================
Omnibus:                        9.169   Durbin-Watson:                   1.941
Prob(Omnibus):                  0.010   Jarque-Bera (JB):               10.622
Skew:                          -0.179   Prob(JB):                      0.00494
Kurtosis:                       3.466   Cond. No.                         459.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:21: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:28: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:29: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

Out[45]:

```
<AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [46]:

```
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [47]:

```
mt.mean_squared_error(y_test, predictions)
```

Out[47]:

```
77.71281286078752
```

Sample Country

In [48]:

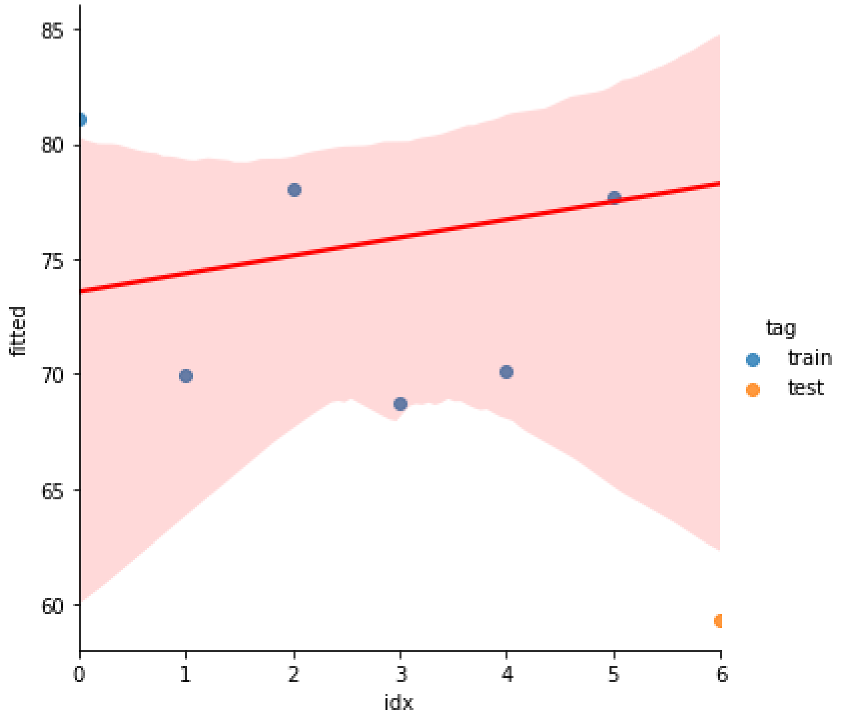
```
# Train-predict and plot for sample country Norway
x_train = data_train[data_train['country'] == country][['idx', 'AIR', 'H2O', 'BDH'
y_train = data_train[data_train['country'] == country]['EPI']

x_test = data_test[data_test['country'] == country][['idx', 'AIR', 'H2O', 'BDH', '
y_test = data_test[data_test['country'] == country]['EPI']

# with statsmodels
x_train = sm.add_constant(x_train) # adding a constant
model = sm.OLS(y_train, x_train).fit()
predictions_train = model.predict(x_train)

print_model = model.summary()
print(print_model)

p = model.params
data_plot_train = data_train[data_train['country'] == country]
data_plot_train['fitted'] = data_plot_train['idx'] * p.idx + \
                            data_plot_train['AIR'] * p.AIR + \
                            data_plot_train['H2O'] * p.H2O + \
                            data_plot_train['BDH'] * p.BDH + \
                            data_plot_train['WRS'] * p.WRS + p.const
data_plot_train['tag'] = 'train'
data_plot_test = data_test[data_test['country'] == country]
data_plot_test['fitted'] = data_plot_test['idx'] * p.idx + \
                            data_plot_test['AIR'] * p.AIR + \
                            data_plot_test['H2O'] * p.H2O + \
                            data_plot_test['BDH'] * p.BDH + \
                             data_plot_test['WRS'] * p.WRS + p.const
data_plot_test['tag'] = 'test'
data_plot = pd.concat([data_plot_train,data_plot_test], axis=0)

sns.lmplot(x='idx', y='EPI', data=data_plot, hue='tag', fit_reg=False)
sns.regplot(x='idx', y='fitted', data=data_plot, color='red', scatter=False)
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\stats\stattools.py:75: ValueWarning: omni_normtest is not valid with less than
8 observations; 6 samples were given.
  "samples were given." % int(n), ValueWarning)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\regression\linear_model.py:1765: RuntimeWarning: divide by zero encountered in
true_divide
  return 1 - (np.divide(self.nobs - self.k_constant, self.df_resid)
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\regression\linear_model.py:1766: RuntimeWarning: invalid value encountered in
double_scalars
  * (1 - self.rsquared))
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\statsmod
els\regression\linear_model.py:1687: RuntimeWarning: divide by zero encountered in
double_scalars
  return np.dot(wresid, wresid) / self.df_resid
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:22: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:23: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:29: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:30: 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/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    EPI   R-squared:                       1.000
Model:                            OLS   Adj. R-squared:                    nan
Method:                 Least Squares   F-statistic:                       nan
Date:                Sun, 11 Dec 2022   Prob (F-statistic):                nan
Time:                        03:21:30   Log-Likelihood:                 146.03
No. Observations:                   6   AIC:                            -280.1
Df Residuals:                       0   BIC:                            -281.3
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const      -1390.5510        inf         -0        nan         nan         nan
idx            0.5853        inf          0        nan         nan         nan
AIR           -1.3900        inf         -0        nan         nan         nan
H2O           15.8391        inf          0        nan         nan         nan
BDH            0.0554        inf          0        nan         nan         nan
WRS            0.2105        inf          0        nan         nan         nan
==============================================================================
Omnibus:                          nan   Durbin-Watson:                   0.002
Prob(Omnibus):                    nan   Jarque-Bera (JB):                0.205
Skew:                           0.446   Prob(JB):                        0.903
Kurtosis:                       2.838   Cond. No.                     2.91e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly s
pecified.
[2] The condition number is large, 2.91e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Out[48]:

```
<AxesSubplot:xlabel='idx', ylabel='fitted'>
```



In [49]:

```python
x_test = sm.add_constant(x_test, has_constant='add')
predictions = model.predict(x_test)
```

In [50]:

```python
mt.mean_squared_error(y_test, predictions)
```

Out[50]:

```
708.281056503761
```

ARIMA

Data prep

In [51]:

```
d = {'year': [2010, 2012, 2014, 2016, 2018, 2020, 2022],
     'date': ['2010-01-01','2012-01-01','2014-01-01','2016-01-01','2018-01-01','20
data_lookup = pd.DataFrame(data=d)
```

In [52]:

```
data = data.merge(data_lookup, on='year')
```

Predict 2020

All Countries Avg

In [53]:

```
data_arima_all = data.groupby(['date', 'year'], as_index=False).mean()
```

In [54]:

```
data_arima_all
```

Out[54]:

	date	year	EPI	AIR	H2O	BDH	WRS	idx
0	2010-01-01	2010	60.251138	67.837967	77.512683	58.312114	68.656992	0.0
1	2012-01-01	2012	53.542439	71.842927	57.831789	60.059106	31.310000	1.0
2	2014-01-01	2014	55.251382	80.631463	57.126748	61.361057	32.226748	2.0
3	2016-01-01	2016	45.454146	43.607154	46.896911	53.589024	30.661789	3.0
4	2018-01-01	2018	47.590244	44.652033	51.738211	58.256098	30.661789	4.0
5	2020-01-01	2020	50.937398	49.315447	55.434146	62.035772	30.661789	5.0
6	2022-01-01	2022	44.358537	44.569106	55.507317	58.218699	32.001626	6.0

In [55]:

```
data_train_arima = data_arima_all[data_arima_all['year'] < 2020].sort_values('year
data_test_arima = data_arima_all[data_arima_all['year'].isin([2020])].sort_values(
```

In [56]:

```
data_train_arima
```

Out[56]:

	date	year	EPI	AIR	H2O	BDH	WRS	idx
0	2010-01-01	2010	60.251138	67.837967	77.512683	58.312114	68.656992	0.0
1	2012-01-01	2012	53.542439	71.842927	57.831789	60.059106	31.310000	1.0
2	2014-01-01	2014	55.251382	80.631463	57.126748	61.361057	32.226748	2.0
3	2016-01-01	2016	45.454146	43.607154	46.896911	53.589024	30.661789	3.0
4	2018-01-01	2018	47.590244	44.652033	51.738211	58.256098	30.661789	4.0

In [57]:

```
data_train_arima = data_train_arima[['date', 'EPI']]
data_test_arima = data_test_arima[['date', 'EPI']]

data_train_arima.set_index('date', inplace=True)
data_test_arima.set_index('date', inplace=True)
```

```
data_train_arima.index = pd.to_datetime(data_train_arima.index)
data_test_arima.index = pd.to_datetime(data_test_arima.index)

stepwise_model = auto_arima(data_train_arima,
                            start_p=1, start_q=1,
                            max_p=5, max_q=5,
                            m=1,
                            seasonal=False,
                            d=1, trace=True,
                            error_action='ignore',
                            suppress_warnings=True,
                            stepwise=False)
print(stepwise_model.aic())

stepwise_model.fit(data_train_arima)

future_forecast = stepwise_model.predict(n_periods=1)
data_test_arima['Prediction'] = future_forecast
data_arima = pd.concat([data_train_arima, data_test_arima])
data_arima['idx'] = data_arima.index #.astype(str)
```

```
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=28.550, Time=0.03 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.08 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=22.223, Time=0.02 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.12 sec

Best model:  ARIMA(1,1,0)(0,0,0)[0] intercept
Total fit time: 0.265 seconds
22.22342320426996
```

In [58]:

```
future_forecast
```

Out[58]:

```
2020-01-01    38.791233
Freq: 2AS-JAN, dtype: float64
```

In [59]:

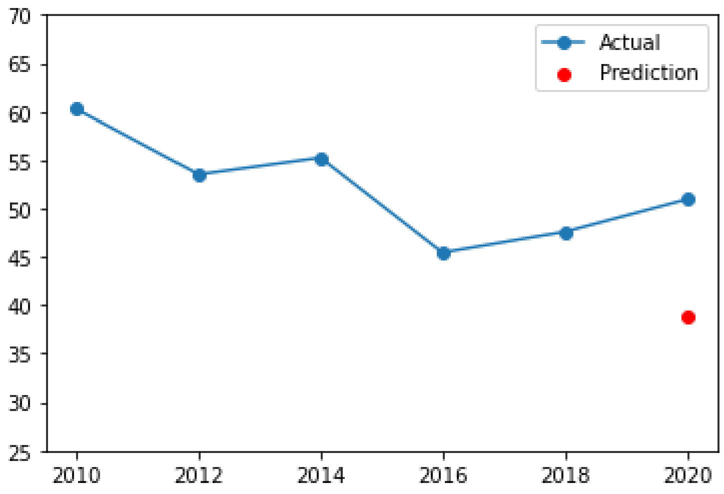
```
data_arima[['EPI','Prediction']]
```

Out[59]:

	EPI	Prediction
date		
2010-01-01	60.251138	NaN
2012-01-01	53.542439	NaN
2014-01-01	55.251382	NaN
2016-01-01	45.454146	NaN
2018-01-01	47.590244	NaN
2020-01-01	50.937398	38.791233

In [60]:

```
plt.plot(data_arima.idx.dt.year, data_arima.EPI, 'o-', label = "Actual")
plt.scatter(data_arima.idx.dt.year, data_arima.Prediction, label = "Prediction", c
plt.legend()
plt.ylim([25, 70])
plt.show()
```



In [61]:

```
mt.mean_squared_error(data_test_arima.EPI, data_test_arima.Prediction)
```

Out[61]:

```
147.52932490439358
```

Sample Country

In [62]:

```
data_train_arima = data[data['year'] < 2020][data['country'] == country].sort_valu
data_test_arima = data[data['year'].isin([2020])][data['country'] == country].sort_
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:1: UserWarning: Boolean Series key will be reindexed to match DataFr
ame index.
  """Entry point for launching an IPython kernel.
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:2: UserWarning: Boolean Series key will be reindexed to match DataFr
ame index.
```

In [63]:

```
data_train_arima = data_train_arima[['date', 'EPI']]
data_test_arima = data_test_arima[['date', 'EPI']]

data_train_arima.set_index('date', inplace=True)
data_test_arima.set_index('date', inplace=True)

data_train_arima.index = pd.to_datetime(data_train_arima.index)
data_test_arima.index = pd.to_datetime(data_test_arima.index)
```

In [64]:

```
data_train_arima
```

Out[64]:

	EPI
date	
2010-01-01	81.13
2012-01-01	69.92
2014-01-01	78.04
2016-01-01	68.75
2018-01-01	70.10

In [65]:

```
data_test_arima
```

Out[65]:

	EPI
date	
2020-01-01	77.7

In [66]:

```
stepwise_model = auto_arima(data_train_arima,
                            start_p=1, start_q=1,
                            max_p=5, max_q=5,
                            m=1,
                            seasonal=False,
                            d=1, trace=True,
                            error_action='ignore',
                            suppress_warnings=True,
                            stepwise=False)
print(stepwise_model.aic())
```

```
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=31.881, Time=0.01 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.07 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=27.418, Time=0.02 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.09 sec

Best model:  ARIMA(1,1,0)(0,0,0)[0] intercept
Total fit time: 0.197 seconds
27.417919922228585
```

In [67]:

```
stepwise_model.fit(data_train_arima)
```

Out[67]:

```
ARIMA(maxiter=50, method='lbfgs', order=(1, 1, 0), out_of_sample_size=0,
      scoring='mse', scoring_args={}, seasonal_order=(0, 0, 0, 0),
      start_params=None, suppress_warnings=True, trend=None,
      with_intercept=True)
```

In [68]:

```
future_forecast = stepwise_model.predict(n_periods=1)
data_test_arima['Prediction'] = future_forecast
data_arima = pd.concat([data_train_arima, data_test_arima])
data_arima['idx'] = data_arima.index #.astype(str)
```

In [69]:

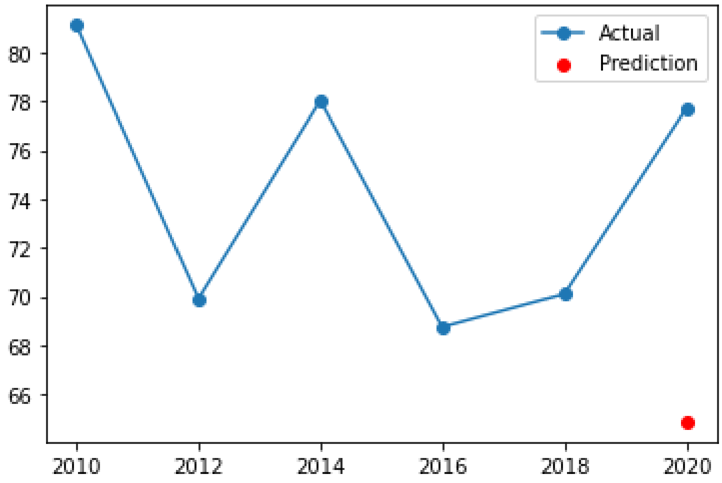
```
data_arima[['EPI','Prediction']]
```

Out[69]:

	EPI	Prediction
date		
2010-01-01	81.13	NaN
2012-01-01	69.92	NaN
2014-01-01	78.04	NaN
2016-01-01	68.75	NaN
2018-01-01	70.10	NaN
2020-01-01	77.70	64.872379

In [70]:

```
plt.plot(data_arima.idx.dt.year, data_arima.EPI, 'o-', label = "Actual")
plt.scatter(data_arima.idx.dt.year, data_arima.Prediction, label = "Prediction", c
plt.legend()
plt.show()
```



Predict 2022

All Countries

In [71]:

```
data_train_arima = data_arima_all[data_arima_all['year'] < 2022].sort_values('year
data_test_arima = data_arima_all[data_arima_all['year'].isin([2022])].sort_values(
```

In [72]:

```
data_train_arima = data_train_arima[['date', 'EPI']]
data_test_arima = data_test_arima[['date', 'EPI']]

data_train_arima.set_index('date', inplace=True)
data_test_arima.set_index('date', inplace=True)

data_train_arima.index = pd.to_datetime(data_train_arima.index)
data_test_arima.index = pd.to_datetime(data_test_arima.index)

stepwise_model = auto_arima(data_train_arima,
                            start_p=1, start_q=1,
                            max_p=5, max_q=5,
                            m=1,
                            seasonal=False,
                            d=1, trace=True,
                            error_action='ignore',
                            suppress_warnings=True,
                            stepwise=False)
print(stepwise_model.aic())

stepwise_model.fit(data_train_arima)

future_forecast = stepwise_model.predict(n_periods=1)
data_test_arima['Prediction'] = future_forecast
data_arima = pd.concat([data_train_arima, data_test_arima])
data_arima['idx'] = data_arima.index #.astype(str)
```

```
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=34.933, Time=0.01 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=34.852, Time=0.10 sec
 ARIMA(0,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.10 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=35.868, Time=0.02 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=2438603.608, Time=0.05 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.11 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=39.553, Time=0.14 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=38.514, Time=0.15 sec
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.23 sec

Best model:  ARIMA(0,1,1)(0,0,0)[0] intercept
Total fit time: 0.921 seconds
34.8522281264441
```

In [73]:

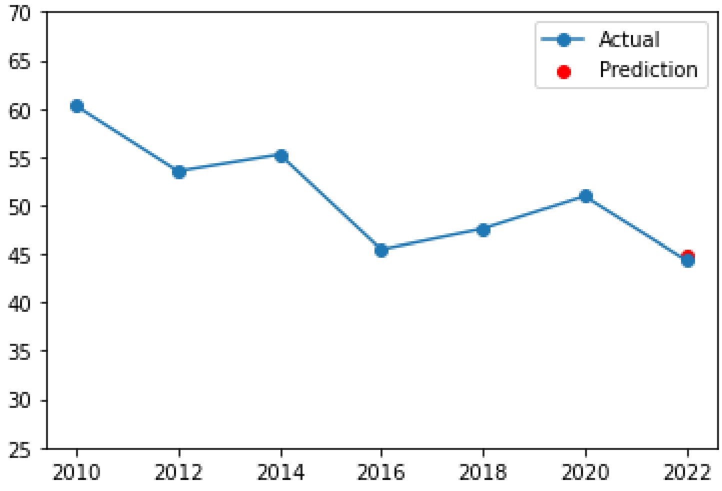
```
data_arima[['EPI','Prediction']]
```

Out[73]:

	EPI	Prediction
date		
2010-01-01	60.251138	NaN
2012-01-01	53.542439	NaN
2014-01-01	55.251382	NaN
2016-01-01	45.454146	NaN
2018-01-01	47.590244	NaN
2020-01-01	50.937398	NaN
2022-01-01	44.358537	44.756014

In [74]:

```
plt.plot(data_arima.idx, data_arima.EPI, 'o-', label = "Actual")
plt.scatter(data_arima.idx, data_arima.Prediction, label = "Prediction", color='re
plt.legend()
plt.ylim([25, 70])
plt.show()
```



In [75]:

```
mt.mean_squared_error(data_test_arima.EPI, data_test_arima.Prediction)
```

Out[75]:

```
0.15798856585889806
```

Sample Country

In [76]:

```
data_train_arima = data[data['year'] < 2022][data['country'] == country].sort_valu
data_test_arima = data[data['year'].isin([2022])][data['country'] == country].sort_
```

```
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:1: UserWarning: Boolean Series key will be reindexed to match DataFr
ame index.
  """Entry point for launching an IPython kernel.
C:\Users\ozlem.gunes\AppData\Local\Continuum\miniconda3\lib\site-packages\ipykerne
l_launcher.py:2: UserWarning: Boolean Series key will be reindexed to match DataFr
ame index.
```

In [77]:

```
data_train_arima = data_train_arima[['date', 'EPI']]
data_test_arima = data_test_arima[['date', 'EPI']]

data_train_arima.set_index('date', inplace=True)
data_test_arima.set_index('date', inplace=True)

data_train_arima.index = pd.to_datetime(data_train_arima.index)
data_test_arima.index = pd.to_datetime(data_test_arima.index)
```

In [78]:

```
data_train_arima
```

Out[78]:

	EPI
date	
2010-01-01	81.13
2012-01-01	69.92
2014-01-01	78.04
2016-01-01	68.75
2018-01-01	70.10
2020-01-01	77.70

In [79]:

```
data_test_arima
```

Out[79]:

	EPI
date	
2022-01-01	59.3

In [80]:

```
stepwise_model = auto_arima(data_train_arima,
                            start_p=1, start_q=1,
                            max_p=5, max_q=5,
                            m=1,
                            seasonal=False,
                            d=1, trace=True,
                            error_action='ignore',
                            suppress_warnings=True,
                            stepwise=False)
print(stepwise_model.aic())
```

```
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=39.215, Time=0.01 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.13 sec
 ARIMA(0,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.10 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=38.598, Time=0.02 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.12 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.13 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=37.529, Time=0.12 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=1397421.593, Time=0.05 sec
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.19 sec

Best model:  ARIMA(2,1,0)(0,0,0)[0] intercept
Total fit time: 0.877 seconds
37.528581428326504
```

In [81]:

```python
stepwise_model.fit(data_train_arima)
```

Out[81]:

```
ARIMA(maxiter=50, method='lbfgs', order=(2, 1, 0), out_of_sample_size=0,
      scoring='mse', scoring_args={}, seasonal_order=(0, 0, 0, 0),
      start_params=None, suppress_warnings=True, trend=None,
      with_intercept=True)
```

In [82]:

```python
future_forecast = stepwise_model.predict(n_periods=1)
data_test_arima['Prediction'] = future_forecast
data_arima = pd.concat([data_train_arima, data_test_arima])
data_arima['idx'] = data_arima.index #.astype(str)
```

In [83]:

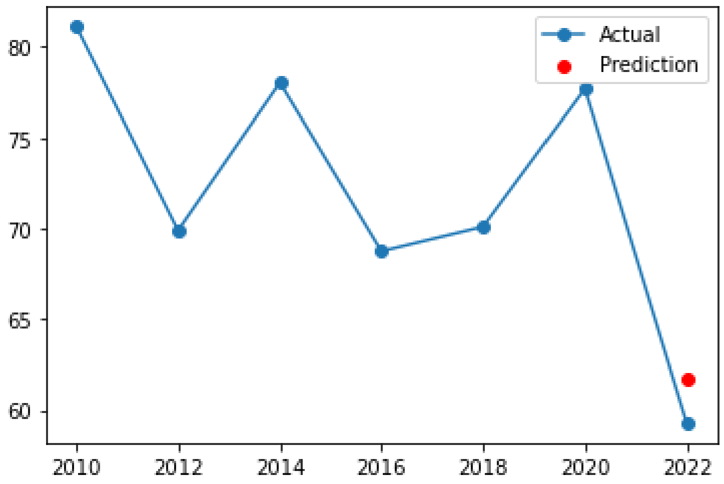
```python
data_arima[['EPI','Prediction']]
```

Out[83]:

	EPI	Prediction
date		
2010-01-01	81.13	NaN
2012-01-01	69.92	NaN
2014-01-01	78.04	NaN
2016-01-01	68.75	NaN
2018-01-01	70.10	NaN
2020-01-01	77.70	NaN
2022-01-01	59.30	61.724263

In [84]:

```python
plt.plot(data_arima.idx, data_arima.EPI, 'o-', label = "Actual")
plt.scatter(data_arima.idx, data_arima.Prediction, label = "Prediction", color='re
plt.legend()
plt.show()
```


Actual
Prediction
80
75
70
65
60
2010
2012
2014
2016
2018
2020
2022

```
In [ ]:
```