Linear Regression and Model calculations and verification Code

May 21, 2021

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import datetime as dt
from datetime import timedelta
```

1 Importing datsets we are going to use

[2]:
```
#Here we can just import all datsets we're going to use
daily_vaccines = pd.read_csv('cleaned/us-daily-vaccines-discretize-normalized.
 ↪csv')
display(daily_vaccines)
covid_19_data = pd.read_csv('cleaned/Novel Corona Virus 2019 Dataset/
 ↪covid_19_data_normalized.csv')
display(covid_19_data)
#Should we transform dates or just drop/ignore?
#We can transorm it using this
#test_df['Date'].dt.strftime("%Y%m%d").astype(int)
covid_19_world = pd.read_csv("cleaned/COVID-19 World Vaccination Progress/
 ↪country_vaccinations_normalized.csv")
display(covid_19_world)
```

```
          Day  daily_vaccinations
0  2021-01-31            0.228328
1  2021-02-28            0.526468
2  2021-03-31            0.818961
```

```
    ObservationDate     Confirmed    Deaths  Recovered
0        2020-01-22  2.940369e-09  0.000000        0.0
1        2020-01-23  2.940369e-09  0.000000        0.0
2        2020-01-24  5.880739e-09  0.000000        0.0
3        2020-01-25  5.880739e-09  0.000000        0.0
4        2020-01-26  1.470185e-08  0.000000        0.0
..              …           …         …         …
462      2021-04-28  9.477060e-02  0.090126        0.0
463      2021-04-29  9.494173e-02  0.090260        0.0
```

```
464      2021-04-30  9.511204e-02  0.090423        0.0
465      2021-05-01  9.524525e-02  0.090500        0.0
466      2021-05-02  9.533128e-02  0.090551        0.0

[467 rows x 4 columns]
```

```
           date  total_vaccinations  people_vaccinated  \
0    2020-12-20            0.000533           0.000818
1    2020-12-21            0.000588           0.000904
2    2020-12-22            0.000588           0.000904
3    2020-12-23            0.000966           0.001483
4    2020-12-24            0.000966           0.001483
..          …                   …                  …
115  2021-04-14            0.186577           0.182325
116  2021-04-15            0.189953           0.185129
117  2021-04-16            0.193752           0.187954
118  2021-04-17            0.197190           0.190531
119  2021-04-18            0.200575           0.193111

     people_fully_vaccinated
0                   0.000000
1                   0.000000
2                   0.000000
3                   0.000000
4                   0.000000
..                       …
115                 0.200872
116                 0.205632
117                 0.211164
118                 0.216040
119                 0.220734

[120 rows x 4 columns]
```

2 Linear Regression us-daily-vaccines-normalized

[3]:
```
daily_vaccines = pd.read_csv('cleaned/us-daily-vaccines-normalized.csv')
daily_vaccines['Day'] = pd.to_datetime(daily_vaccines['Day'])
daily_vaccines['date_delta'] = (daily_vaccines['Day'] - daily_vaccines['Day'].
 ↪min())  / np.timedelta64(1,'D')
daily_vaccines.head()
```

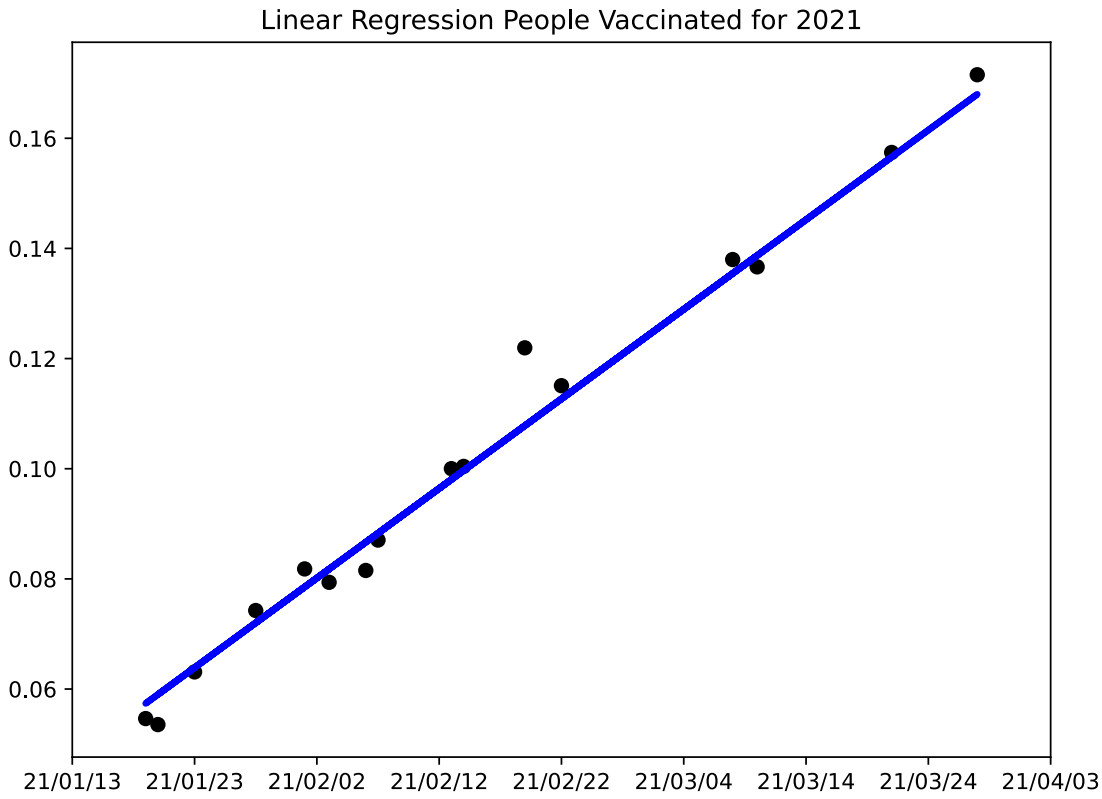
[3]:
```
         Day  daily_vaccinations  date_delta
0 2021-02-09            0.089862        27.0
1 2021-03-13            0.160251        59.0
2 2021-02-13            0.100012        31.0
3 2021-01-13            0.057914         0.0
```

```
4 2021-03-29            0.174406        75.0
```

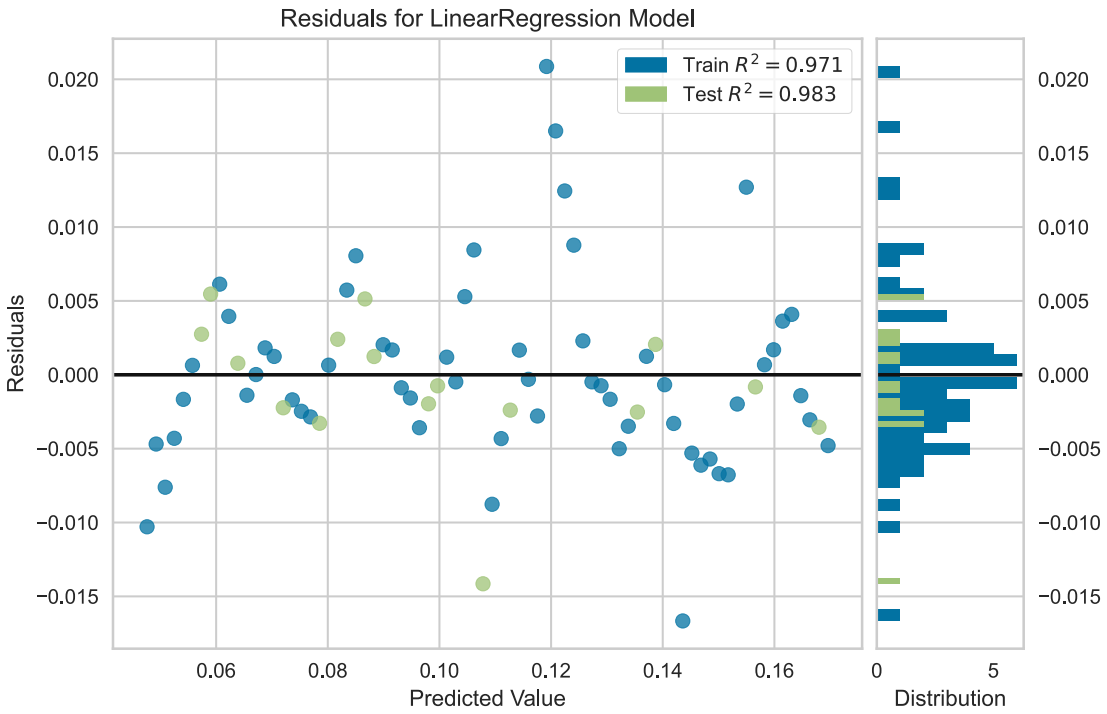
[4]:
```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, r2_score
import sklearn.metrics as metrics
# daily_vaccines = daily_vaccines.drop('Entity',axis=1)
# covid_19_data = covid_19_data.drop("ObservationDate",axis=1)
#These will be the attributes we want to use
X = daily_vaccines.date_delta.values
#We want y to be our target. What's are target going to be? Idk yet lol
y = daily_vaccines.daily_vaccinations.values

X = X.reshape(len(X), 1)
y = y.reshape(len(y), 1)

#Here we can choose a random state so we get consistent results across all␣
 ↪systems.
#80-20 or 70-30 for (test/training is standard)
train_x, test_x, train_y, test_y = train_test_split(X,y,test_size = 0.
 ↪20,random_state=1001)
lr = LinearRegression()
lr.fit(train_x,train_y)
pred_y = lr.predict(test_x)

# print(pred_y)
mse = metrics.mean_squared_error(test_y, pred_y)
mse = f"{mse:.9f}"
print("mean squared error:"+mse)
# print("R-squared: {0}".format(metrics.r2_score(Y,y_pred1)))

# Plot outputs
plt.figure(figsize=(8, 6))

plt.scatter(test_x, test_y,  color='black')
plt.plot(test_x, pred_y, color='blue', linewidth=3)
# plt.xticks(X)
# plt.yticks(())
# print(plt.xticks())
# plt.xticks((plt.xticks()[0],str(plt.xticks()[0])))
xticks=plt.xticks()[0]
xticks_str=[]
first=daily_vaccines['Day'].min()
for tick in xticks:
    # d=dt.datetime.strptime(str(int(tick)),"%Y%m%d")
    xticks_str.append((first+ timedelta(days=int(tick))).strftime("%y/%m/%d"))
plt.xticks(xticks,xticks_str)
```

```
plt.title("Linear Regression People Vaccinated for 2021")

plt.show()
```

```
mean squared error:0.000020100
```



[5]:
```
from yellowbrick.regressor import ResidualsPlot
visualizer = ResidualsPlot(lr)
visualizer.fit(train_x, train_y)  # Fit the training data to the visualizer
visualizer.score(test_x, test_y)  # Evaluate the model on the test data
visualizer.show()                 # Finalize and render the figure
```



[5]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x13c6f896250>
```

[6]:
```
covid_19_data = pd.read_csv('cleaned/Novel Corona Virus 2019 Dataset/
 ↪covid_19_data_2021.csv')
covid_19_data['ObservationDate'] = pd.
 ↪to_datetime(covid_19_data['ObservationDate'])
covid_19_data['date_delta'] = (covid_19_data['ObservationDate'] -␣
 ↪covid_19_data['ObservationDate'].min())  / np.timedelta64(1,'D')
diff=covid_19_data[["Confirmed"]].diff().fillna(0)
covid_19_data["Confirmed_diff"]=diff["Confirmed"]
covid_19_data.head()
```

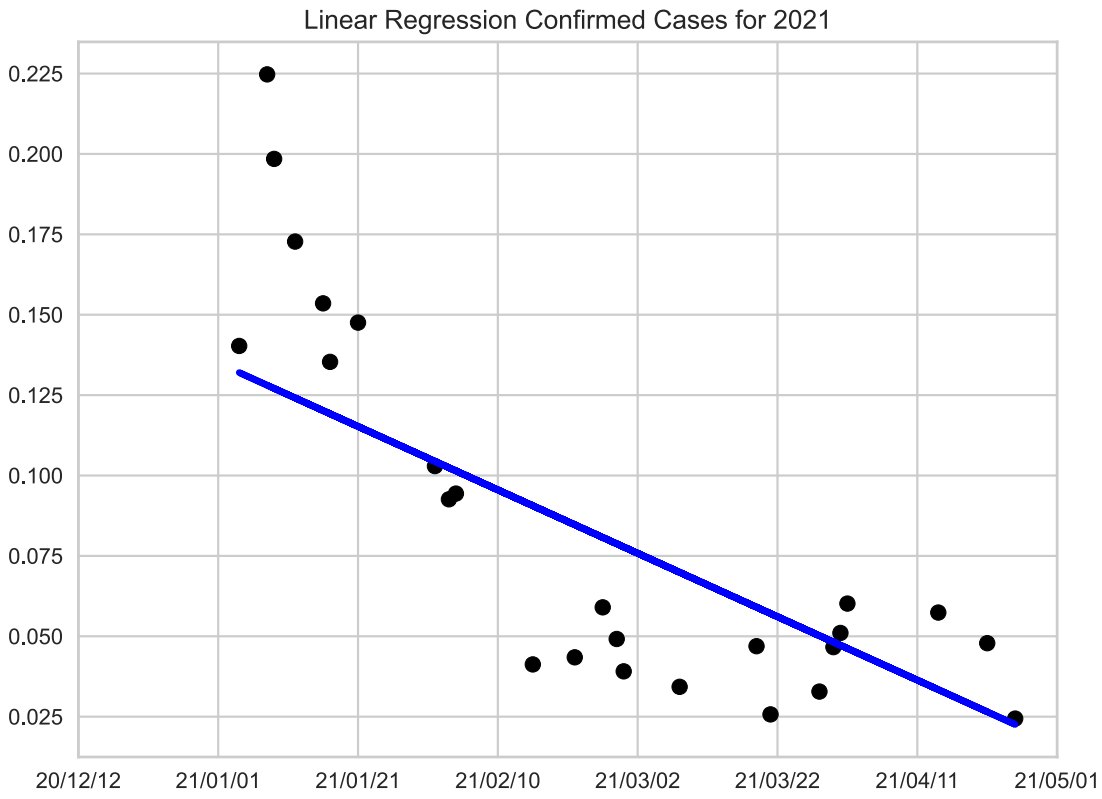
[6]:

	ObservationDate	Confirmed	Deaths	Recovered	date_delta	Confirmed_diff
0	2021-01-01	20252991	354242	0	0.0	0.0
1	2021-01-02	20553301	356749	0	1.0	300310.0
2	2021-01-03	20762047	358196	0	2.0	208746.0
3	2021-01-04	20946329	360288	0	3.0	184282.0
4	2021-01-05	21181440	364002	0	4.0	235111.0

[7]:
```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, r2_score
import sklearn.metrics as metrics
from sklearn import preprocessing
```

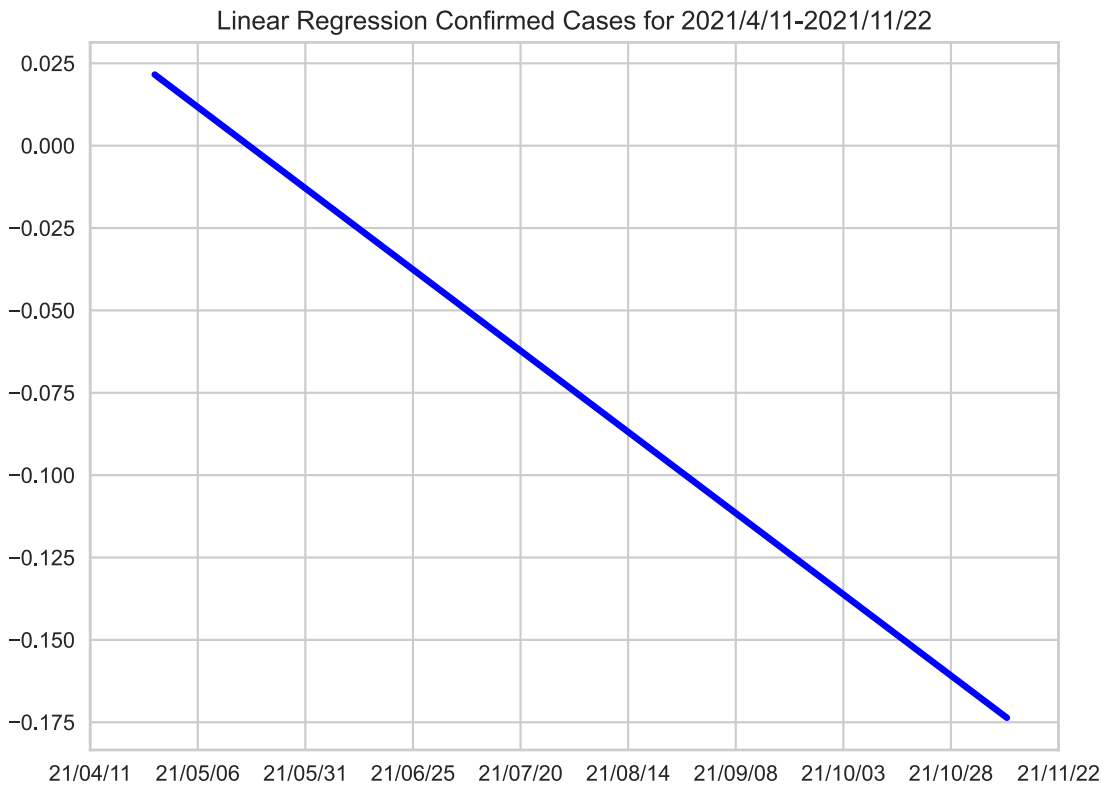
```
# daily_vaccines = daily_vaccines.drop('Entity',axis=1)
# covid_19_data = covid_19_data.drop("ObservationDate",axis=1)
#These will be the attributes we want to use
X = covid_19_data.date_delta.values
#We want y to be our target. What's are target going to be? Idk yet lol
# y = covid_19_data.Confirmed_diff.values
y=preprocessing.normalize([covid_19_data.Confirmed_diff.values])[0]


X = X.reshape(len(X), 1)
y = y.reshape(len(y), 1)

#Here we can choose a random state so we get consistent results across all␣
 ↪systems.
#80-20 or 70-30 for (test/training is standard)
train_x, test_x, train_y, test_y = train_test_split(X,y,test_size = 0.
 ↪20,random_state=1001)
lr = LinearRegression()
lr.fit(train_x,train_y)

pred_y = lr.predict(test_x)

mse = metrics.mean_squared_error(test_y, pred_y)
mse = f"{mse:.9f}"
print("mean squared error:"+mse)

# Plot outputs
plt.figure(figsize=(8, 6))

plt.scatter(test_x, test_y,  color='black')
plt.plot(test_x, pred_y, color='blue', linewidth=3)
# plt.xticks(X)
# plt.yticks(())
# print(plt.xticks())
# plt.xticks((plt.xticks()[0],str(plt.xticks()[0])))
xticks=plt.xticks()[0]
xticks_str=[]
first=covid_19_data['ObservationDate'].min()
for tick in xticks:
    # d=dt.datetime.strptime(str(int(tick)),"%Y%m%d")
    xticks_str.append((first+ timedelta(days=int(tick))).strftime("%y/%m/%d"))
plt.xticks(xticks,xticks_str)
plt.title("Linear Regression Confirmed Cases for 2021")

plt.show()
```

```
mean squared error:0.001214634
```



[8]:
```
import time
start_time = time.time()

max_x=test_x.max()
test_x=np.array([[x] for x in range(int(max_x)+1,int(max_x)+200)])

pred_y = lr.predict(test_x)


# Plot outputs
plt.figure(figsize=(8, 6))

plt.plot(test_x, pred_y, color='blue', linewidth=3)

xticks=plt.xticks()[0]
xticks_str=[]
first=covid_19_data['ObservationDate'].min()
for tick in xticks:
    xticks_str.append((first+ timedelta(days=int(tick))).strftime("%y/%m/%d"))
```

```
plt.xticks(xticks,xticks_str)
plt.title("Linear Regression Confirmed Cases for 2021/4/11-2021/11/22")

plt.show()


print("Model took %s seconds " % (time.time() - start_time))
```




```
Model took 0.14151954650878906 seconds
```

[9]:
```
daily_vaccines = pd.read_csv('cleaned/compare/us-daily-vaccines-normalized.csv')
covid_19_data = pd.read_csv('cleaned/compare/covid_19_data.csv')
daily_vaccines.head()
```

[9]:

	Day	daily_vaccinations
0	1/22/2021	0.058307
1	1/23/2021	0.063109
2	1/24/2021	0.066902
3	1/25/2021	0.067127
4	1/26/2021	0.066949

[10]:
```
covid_19_data['ObservationDate'] = pd.
 ↪to_datetime(covid_19_data['ObservationDate'])
covid_19_data['date_delta'] = (covid_19_data['ObservationDate'] -␣
 ↪covid_19_data['ObservationDate'].min())  / np.timedelta64(1,'D')
diff=covid_19_data[["Confirmed"]].diff().fillna(0)
covid_19_data["Confirmed_diff"]=diff["Confirmed"]
covid_19_data.head()
```

[10]:

	ObservationDate	Confirmed	Deaths	Recovered	date_delta	Confirmed_diff
0	2021-01-22	24902437	421849	0	0.0	0.0
1	2021-01-23	25073050	425194	0	1.0	170613.0
2	2021-01-24	25204112	427093	0	2.0	131062.0
3	2021-01-25	25356081	429066	0	3.0	151969.0
4	2021-01-26	25503621	433073	0	4.0	147540.0

[11]:
```
from scipy import stats
print("Pearson's correlation coefficient:"+str(stats.
 ↪pearsonr(covid_19_data["Confirmed_diff"],daily_vaccines["daily_vaccinations"]␣
 ↪)[0]))
```

```
Pearson's correlation coefficient:-0.6829676521183081
```

3 Linear Regression country_vaccinations_normalized

[12]:
```
covid_19_world = pd.read_csv("cleaned/COVID-19 World Vaccination Progress/
 ↪country_vaccinations_normalized.csv")
covid_19_world['date'] = pd.to_datetime(covid_19_world['date'])
covid_19_world['date_delta'] = (covid_19_world['date'] - covid_19_world['date'].
 ↪min())  / np.timedelta64(1,'D')
covid_19_world.head()
```

[12]:

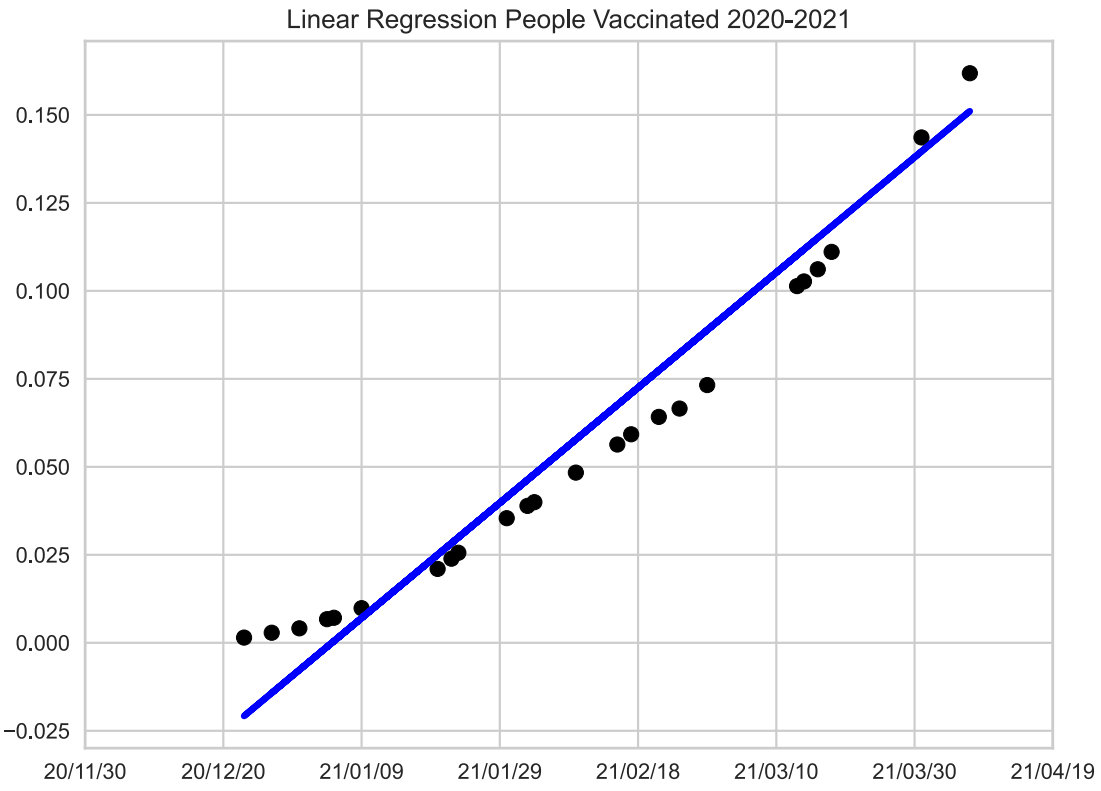
	date	total_vaccinations	people_vaccinated	people_fully_vaccinated	\
0	2020-12-20	0.000533	0.000818	0.0	
1	2020-12-21	0.000588	0.000904	0.0	
2	2020-12-22	0.000588	0.000904	0.0	
3	2020-12-23	0.000966	0.001483	0.0	
4	2020-12-24	0.000966	0.001483	0.0	

	date_delta
0	0.0
1	1.0
2	2.0
3	3.0
4	4.0

[ ]:
```

```

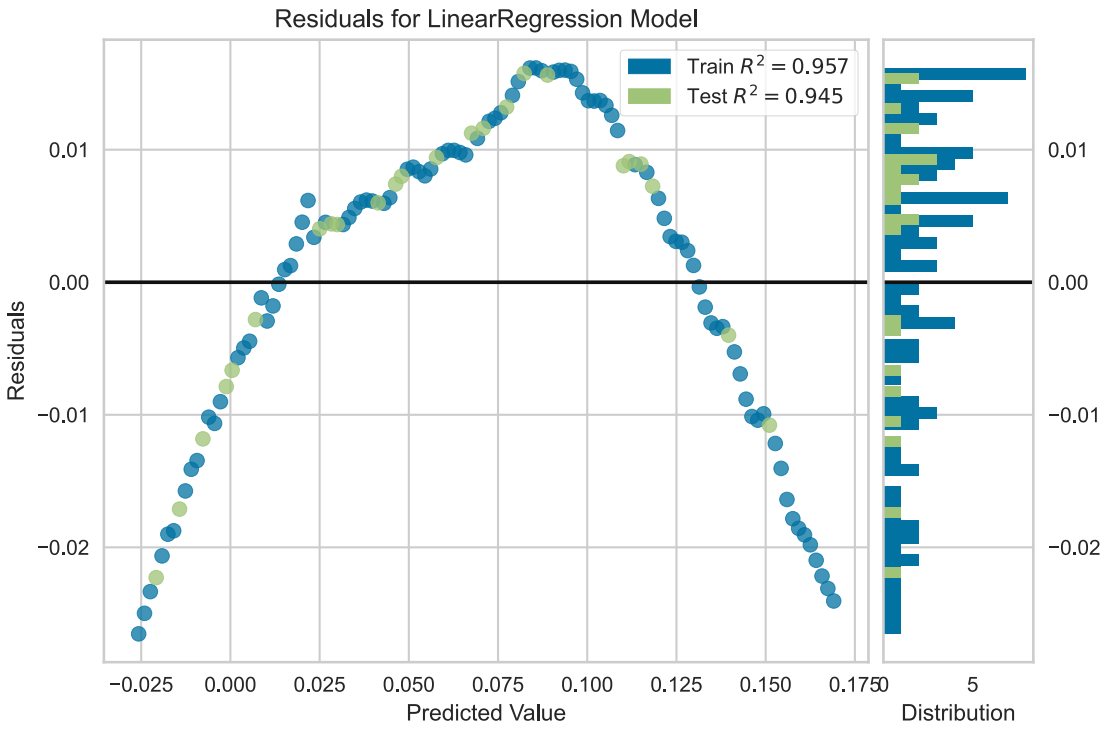
[13]:
```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, r2_score
import sklearn.metrics as metrics
# daily_vaccines = daily_vaccines.drop('Entity',axis=1)
# covid_19_data = covid_19_data.drop("ObservationDate",axis=1)
#These will be the attributes we want to use
X = covid_19_world.date_delta.values
#We want y to be our target. What's are target going to be? Idk yet lol
y = covid_19_world.people_vaccinated.values

X = X.reshape(len(X), 1)
y = y.reshape(len(y), 1)

#Here we can choose a random state so we get consistent results across all␣
 ↪systems.
#80-20 or 70-30 for (test/training is standard)
train_x, test_x, train_y, test_y = train_test_split(X,y,test_size = 0.
 ↪20,random_state=1001)
lr = LinearRegression()
lr.fit(train_x,train_y)
pred_y = lr.predict(test_x)
# print(pred_y)
mse = metrics.mean_squared_error(test_y, pred_y)
mse = f"{mse:.9f}"
print("mean squared error:"+mse)
# print("R-squared: {0}".format(metrics.r2_score(Y,y_pred1)))

# Plot outputs
plt.figure(figsize=(8, 6))

plt.scatter(test_x, test_y,  color='black')
plt.plot(test_x, pred_y, color='blue', linewidth=3)
# plt.xticks(X)
# plt.yticks(())
# print(plt.xticks())
# plt.xticks((plt.xticks()[0],str(plt.xticks()[0])))
xticks=plt.xticks()[0]
xticks_str=[]
first=covid_19_world['date'].min()
for tick in xticks:
    # d=dt.datetime.strptime(str(int(tick)),"%Y%m%d")
    xticks_str.append((first+ timedelta(days=int(tick))).strftime("%y/%m/%d"))
plt.xticks(xticks,xticks_str)
plt.title("Linear Regression People Vaccinated 2020-2021")

plt.show()
```

```
mean squared error:0.000112214
```



[ ]:

[14]:
```
from yellowbrick.regressor import ResidualsPlot
visualizer = ResidualsPlot(lr)
visualizer.fit(train_x, train_y)  # Fit the training data to the visualizer
visualizer.score(test_x, test_y)  # Evaluate the model on the test data
visualizer.show()                 # Finalize and render the figure
```



[14]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x13c6faee820>
```

3.1 Precentage of people fully vaccinated

[15]:
```
# TODO total people fully vaccinated /(usa population - fully vaccinated)
covid_19_world = pd.read_csv("cleaned/COVID-19 World Vaccination Progress/
 ↪country_vaccinations_grouped_by_month.csv")
```

[ ]:
```

```

[16]:
```
diff=covid_19_world[["people_fully_vaccinated"]].diff().fillna(0)
covid_19_world["fully_vaccinated_diff"]=diff["people_fully_vaccinated"]
```

[17]:
```
covid_19_world.head()
```

[17]:

	date	total_vaccinations	people_vaccinated	people_fully_vaccinated	\
0	2020-12-31	2794588.0	2794588.0	0.0	
1	2021-01-31	31123299.0	25201143.0	5657142.0	
2	2021-02-28	75236003.0	49772180.0	24779920.0	
3	2021-03-31	150273292.0	97593290.0	54607041.0	
4	2021-04-30	209406814.0	131247546.0	84263408.0	

	fully_vaccinated_diff

```
0                   0.0
1                5657142.0
2               19122778.0
3               29827121.0
4               29656367.0
```

[18]:
```
average_diff=covid_19_world["fully_vaccinated_diff"].mean()
print("Average number of additional people fully vaccinated every moneth:␣
 ↪"+str(average_diff))
```

```
Average number of additional people fully vaccinated every moneth: 16852681.6
```

[19]:
```
population=pd.read_csv("cleaned/Countries population by year 2020/
 ↪population_by_country_2020.csv")
population.head()
```

[19]:

	Country (or dependency)	Population (2020)	Density (P/Km)	Med. Age
0	United States	330610570	36	38

[20]:
```
population_num=list(population["Population (2020)"])[0]
print(population_num)
```

```
330610570
```

[21]:
```
last_full_vaccinated=covid_19_world["people_fully_vaccinated"][len(covid_19_world["people_full
percentage=(last_full_vaccinated/population_num)*100
print(percentage)
```

```
25.487209316991894
```

[22]:
```
need=(population_num*70)/100
need
```

[22]:
```
231427399.0
```

[23]:
```
print("we will get to 70% in "+str(need/average_diff)+" months")
```

```
we will get to 70% in 13.732378294027699 months
```