exploratory_data_analysis

December 13, 2020

[595]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import matplotlib

from sklearn.neighbors import KNeighborsClassifier
from sklearn import metrics
from sklearn.cluster import KMeans
from sklearn.datasets import fetch_20newsgroups
from sklearn.linear_model import SGDClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import LinearRegression
from sklearn.pipeline import Pipeline
from sklearn import datasets
from sklearn.metrics import confusion_matrix
from sklearn.svm import SVC
from sklearn.decomposition import PCA
from sklearn.model_selection import GridSearchCV, train_test_split
from sklearn.datasets import make_blobs
from sklearn.mixture import GaussianMixture
from sklearn import linear_model
from sklearn.linear_model import TweedieRegressor
from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import StandardScaler


from math import sqrt

import math

import folium

%matplotlib inline
```

[596]:
```
import statsmodels.api as sm
import statsmodels.formula.api as smf

from itertools import groupby
from operator import itemgetter

from mpl_toolkits.mplot3d import Axes3D

import mlxtend

from mlxtend.preprocessing import minmax_scaling
```

[3]:
```
parse_dates = ['date']

covid_tigeryi = pd.read_csv("covid_tigeryi.csv", parse_dates=parse_dates,␣
 ↪index_col=False)

covid_tigeryi.head()
```

[3]:
```
    state state_code       date  cases  positive  probableCases  negative  \
0  Alabama         AL 2020-03-07      0       0.0            NaN       NaN
1  Alabama         AL 2020-03-08      0       0.0            NaN       NaN
2  Alabama         AL 2020-03-09      0       0.0            NaN       NaN
3  Alabama         AL 2020-03-10      0       0.0            NaN       0.0
4  Alabama         AL 2020-03-11      3       0.0            NaN      10.0

   totalTestResults  death  hospitalized  total  positive_rate  \
0               0.0    NaN           NaN      0            NaN
1               0.0    NaN           NaN      0            NaN
2               0.0    NaN           NaN      0            NaN
3               0.0    NaN           NaN      0            NaN
4              10.0    NaN           NaN     10            0.0

   positive_negative_ratio  positive_delta  negative_delta  \
0                      NaN             NaN             NaN
1                      NaN             0.0             NaN
2                      NaN             0.0             NaN
3                      NaN             0.0             NaN
4                      0.0             0.0            10.0

   totalTestResults_delta  death_delta  positive_rate_delta  \
0                     NaN          NaN                  NaN
1                     0.0          NaN                  NaN
2                     0.0          NaN                  NaN
3                     0.0          NaN                  NaN
4                    10.0          NaN                  0.0

   positive_negative_ratio_delta
```

```
0                           NaN
1                           NaN
2                           NaN
3                           NaN
4                           0.0
```

[4]:
```
demographic_tigeryi = pd.read_csv("demographic_tigeryi.csv", index_col=False)

demographic_tigeryi.head()
```

[4]:
```
      county state_code  percentage16_Donald_Trump  \
0  Abbeville         SC                  62.868333
1     Acadia         LA                  77.262105
2   Accomack         VA                  54.471596
3        Ada         ID                  47.931611
4      Adair         IA                  65.336526

   percentage16_Hillary_Clinton  total_votes16  votes16_Donald_Trump  \
0                     34.613950        10724.0                6742.0
1                     20.587161        27386.0               21159.0
2                     42.761028        15755.0                8582.0
3                     38.691733       195587.0               93748.0
4                     29.981378         3759.0                2456.0

   votes16_Hillary_Clinton  percentage20_Donald_Trump  percentage20_Joe_Biden  \
0                   3712.0                  66.074157               32.984799
1                   5638.0                  79.493404               19.148637
2                   6737.0                  54.150431               44.739639
3                  75676.0                  50.387256               46.470359
4                   1127.0                  69.734640               28.615826

   total_votes20  ...           state    cases  deaths  dem_16_margin  \
0        12433.0  ...  South Carolina    808.0    18.0     -28.254383
1        28425.0  ...       Louisiana   3291.0   103.0     -56.674943
2        16938.0  ...        Virginia   1229.0    19.0     -11.710568
3       259389.0  ...           Idaho  17828.0   184.0      -9.239878
4         4183.0  ...            Iowa    250.0     1.0     -35.355148

   dem_20_margin  dem_margin_shift  cases_rate  deaths_rate  men_percent  \
0     -33.089359         -4.834976    3.259642     0.072616    48.588026
1     -60.344767         -3.669824    5.256601     0.164518    48.609580
2      -9.410792          2.299776    3.742387     0.057856    48.961632
3      -3.916897          5.322981    4.097289     0.042287    50.101237
4     -41.118814         -5.763667    3.476085     0.013904    49.388209

   women_percent
0      51.411974
1      51.390420
```

```
2      51.038368
3      49.898763
4      50.611791

[5 rows x 58 columns]
```

[5]:
```
election_tigeryi = pd.read_csv("election_tigeryi.csv", index_col=False)

election_tigeryi.head()
```

[5]:
```
        state called final  dem_2020  rep_2020  other_2020  dem_percent  \
0  U.S. Total      D    No  81281890  74222108     2884357    51.318097
1     Arizona      D   Yes   1672143   1661686       53497    49.364691
2     Florida      R   Yes   5297045   5668731      101680    47.861451
3     Georgia      D   Yes   2474507   2461837       62138    49.505170
4        Iowa      R   Yes    759061    897672       34138    44.891716

   rep_percent  other_percent  dem_2020_margin  ...  vote_change  state_code  \
0    46.860836       1.821066         4.457261  ...    15.916665         NaN
1    49.055981       1.579328         0.308710  ...    31.640451          AZ
2    51.219820       0.918730        -3.358369  ...    17.488431          FL
3    49.251693       1.243137         0.253477  ...    22.141408          GA
4    53.089325       2.018959        -8.197609  ...     7.971745          IA

     EV   dem_2016   rep_2016  2016 Margin  Total 2016 Votes  \
0   NaN        NaN        NaN     2.099456         136639848
1  11.0  1161167.0  1252401.0    -3.545595           2573165
2  29.0  4504975.0  4617886.0    -1.198626           9420039
3  16.0  1877963.0  2089104.0    -5.131343           4092373
4   6.0   653669.0   800983.0    -9.406838           1566031

   Total 2020 Votes  usa_state_latitude  usa_state_longitude
0         158388355                 NaN                  NaN
1           3387326           34.048928          -111.093731
2          11067456           27.664827           -81.515754
3           4998482           32.157435           -82.907123
4           1690871           41.878003           -93.097702

[5 rows x 21 columns]
```

[6]:
```
poll_tigeryi = pd.read_csv("poll_tigeryi.csv", index_col=False,␣
↪parse_dates=parse_dates)

poll_tigeryi.head()
```

[6]:
```
     state       date  rep_poll_2020  dem_poll_2020  dem_lead  \
0  Alabama 2020-02-27        59.14228       38.22156 -20.92072
1  Alabama 2020-02-28        59.17695       38.39190 -20.78505
2  Alabama 2020-02-29        59.23509       38.38301 -20.85208
```

```
3  Alabama 2020-03-01       59.23509       38.38301 -20.85208
4  Alabama 2020-03-02       59.23489       38.38627 -20.84862

   dem_lead_rolling_7 usa_state_code  usa_state_latitude  usa_state_longitude  \
0          -20.920720             AL           32.318231           -86.902298
1          -20.852885             AL           32.318231           -86.902298
2          -20.852617             AL           32.318231           -86.902298
3          -20.852483             AL           32.318231           -86.902298
4          -20.851710             AL           32.318231           -86.902298

   dem_lead_rolling_30 called  dem_percent  rep_percent  dem_2020_margin  \
0           -20.920720      R     36.56999    62.031643       -25.461653
1           -20.852885      R     36.56999    62.031643       -25.461653
2           -20.852617      R     36.56999    62.031643       -25.461653
3           -20.852483      R     36.56999    62.031643       -25.461653
4           -20.851710      R     36.56999    62.031643       -25.461653

   dem_result_poll_diff  rep_result_poll_diff  dem_lead_result_poll_diff  \
0               -1.65157              2.889363                   -4.540933
1               -1.82191              2.854693                   -4.676603
2               -1.81302              2.796553                   -4.609573
3               -1.81302              2.796553                   -4.609573
4               -1.81628              2.796753                   -4.613033

   dem_lead_rolling_7_diff  dem_lead_rolling_30_diff
0                -4.540933                -4.540933
1                -4.608768                -4.608768
2                -4.609036                -4.609036
3                -4.609170                -4.609170
4                -4.609943                -4.609943
```

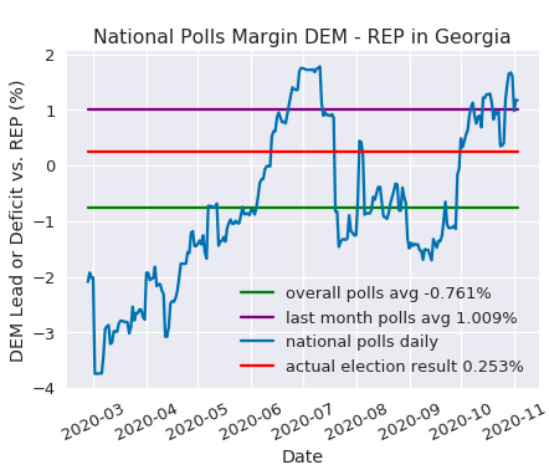
[915]:
```
def poll_state(poll_tigeryi, state="Florida", usa_state_code=None):
    if state in poll_tigeryi['state'].tolist():
        poll_state = poll_tigeryi[poll_tigeryi['state']==state]
    elif usa_state_code in poll_tigeryi['usa_state_code'].tolist():
        poll_state =␣
 ↪poll_tigeryi[poll_tigeryi['usa_state_code']==usa_state_code]
    else:
        raise ValueError("state not valid")

    actual_result = poll_state['dem_2020_margin'].tolist()[0]
    actual_result = np.round(actual_result, 3)

    poll_average = np.mean(poll_state["dem_lead"])
    poll_average = np.round(poll_average, 3)

    last_month_avg = np.mean(poll_state["dem_lead"][-31:-1])
```

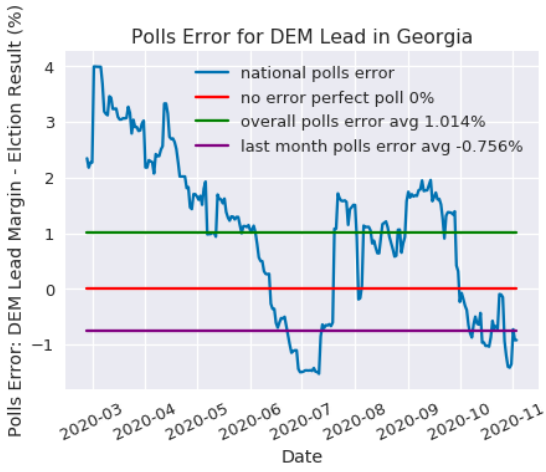
```
    last_month_avg = np.round(last_month_avg, 3)

    error_average = np.mean(poll_state["dem_lead_result_poll_diff"])
    error_average = np.round(error_average, 3)

    last_month_error = np.mean(poll_state["dem_lead_result_poll_diff"][-31:-1])
    last_month_error = np.round(last_month_error, 3)

    plt.subplots(figsize = (15,5))

    plt.subplot(1,2,1)

    plt.plot(poll_state["date"], [poll_average]*len(poll_state["date"]),␣
↪"green", label=f"overall polls avg {poll_average}%")
    plt.plot(poll_state["date"], [last_month_avg]*len(poll_state["date"]),␣
↪"purple", label=f"last month polls avg {last_month_avg}%")
    plt.plot(poll_state["date"], poll_state["dem_lead"], "-" , label="national␣
↪polls daily") #
    plt.plot(poll_state["date"], poll_state["dem_2020_margin"], "r-",␣
↪label=f"actual election result {actual_result}%")
    plt.legend(loc="lower right")
    plt.xlabel("Date")
    plt.xticks(rotation = 25)
    plt.ylabel("DEM Lead or Deficit vs. REP (%)")

    plt.title(f"National Polls Margin DEM - REP in {state or usa_state_code}")


    plt.subplot(1,2,2)

    plt.title(f"Polls Error for DEM Lead in {state or usa_state_code}")

    plt.plot(poll_state["date"], poll_state["dem_lead_result_poll_diff"], "-" ,␣
↪label="national polls error")
    plt.xlabel("Date")
    plt.xticks(rotation = 25)
    plt.ylabel("Polls Error: DEM Lead Margin - Elction Result (%)")
    plt.plot(poll_state["date"], [0]*len(poll_state["date"]), "red", label="no␣
↪error perfect poll 0%")

    plt.plot(poll_state["date"], [error_average]*len(poll_state["date"]),␣
↪"green", label=f"overall polls error avg {error_average}%")
    plt.plot(poll_state["date"], [last_month_error]*len(poll_state["date"]),␣
↪"purple", label=f"last month polls error avg {last_month_error}%")
```

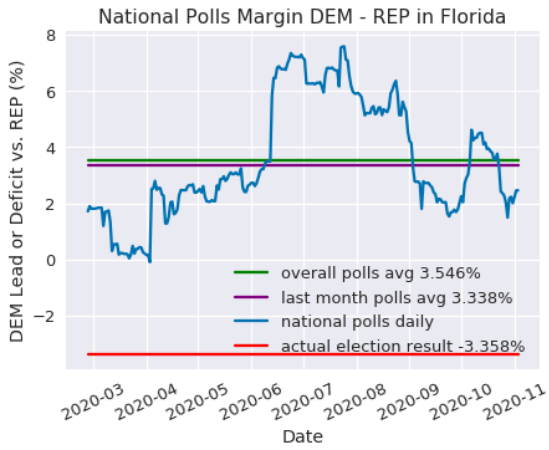
```
    plt.legend(loc="upper right")


    #return poll_state
```

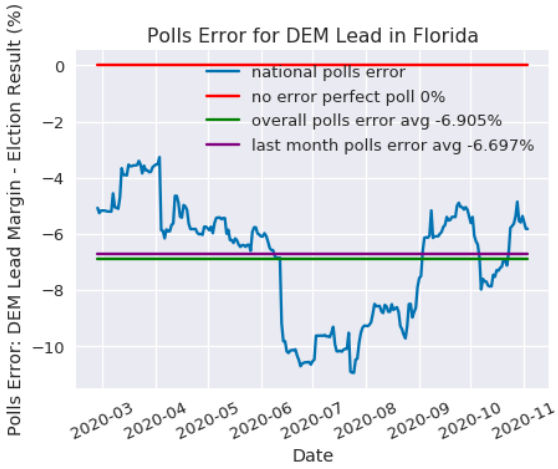
[916]:
```
poll_state(poll_tigeryi, "Georgia")
poll_state(poll_tigeryi, "Florida")
```

```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```

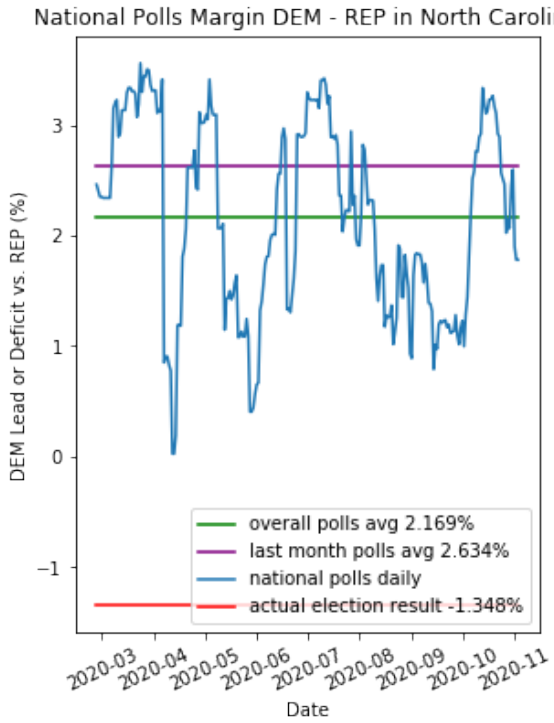


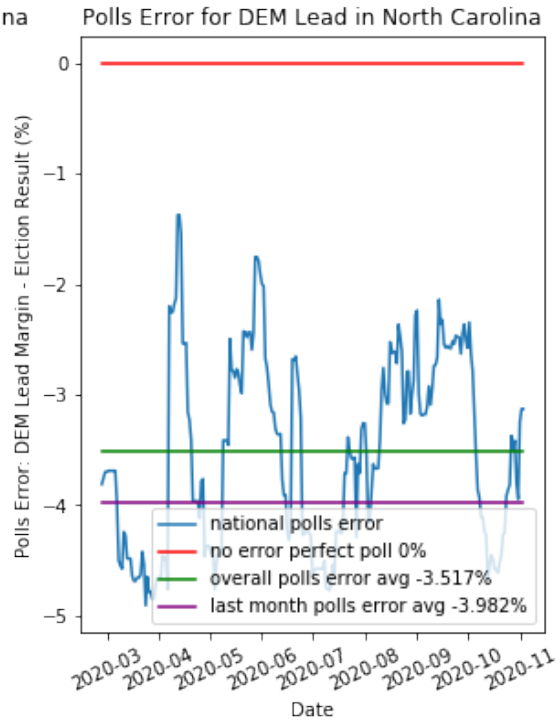


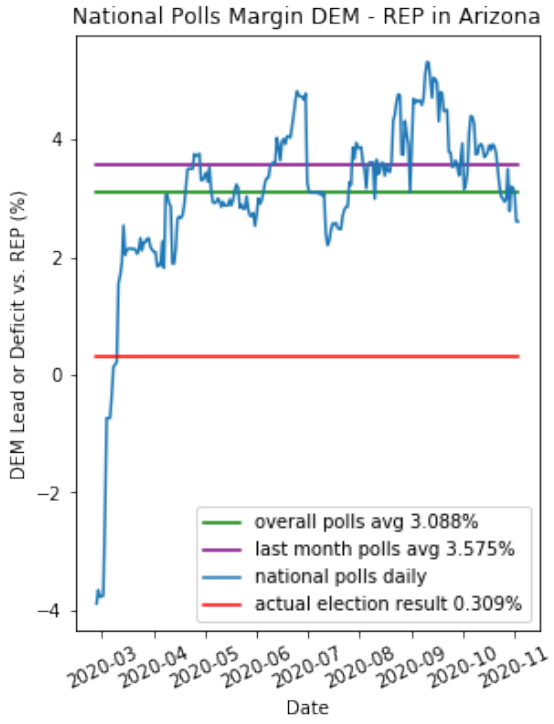


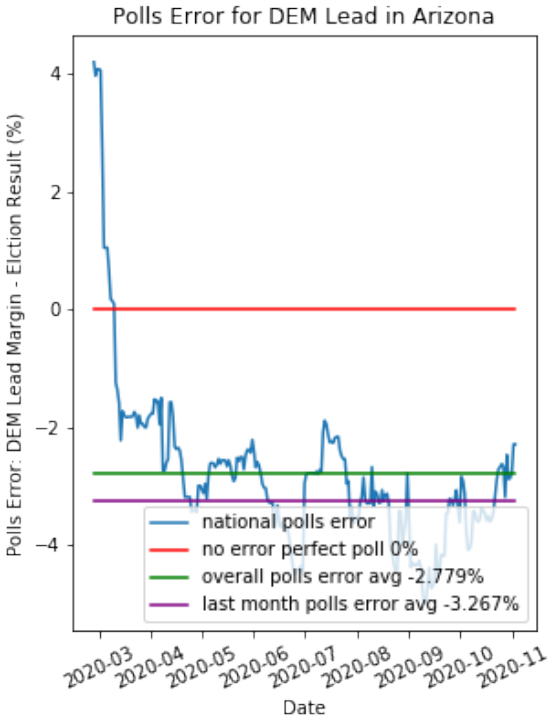


[10]:
```
poll_state(poll_tigeryi, "North Carolina")
poll_state(poll_tigeryi, "Arizona")
```

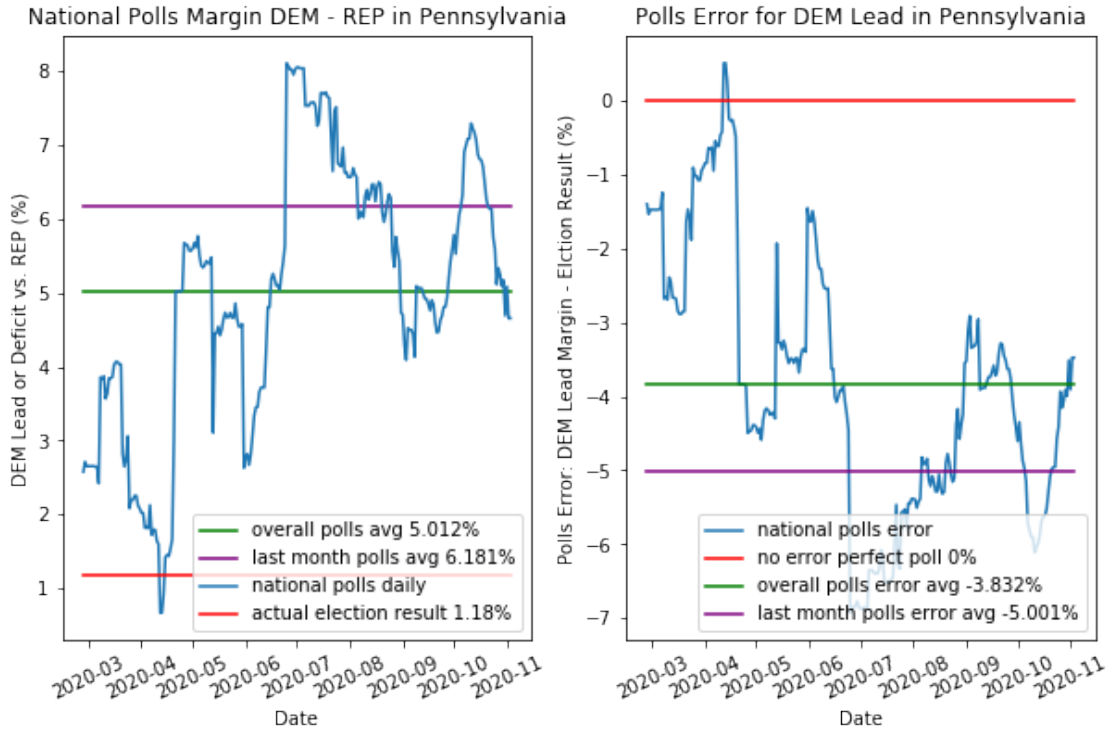


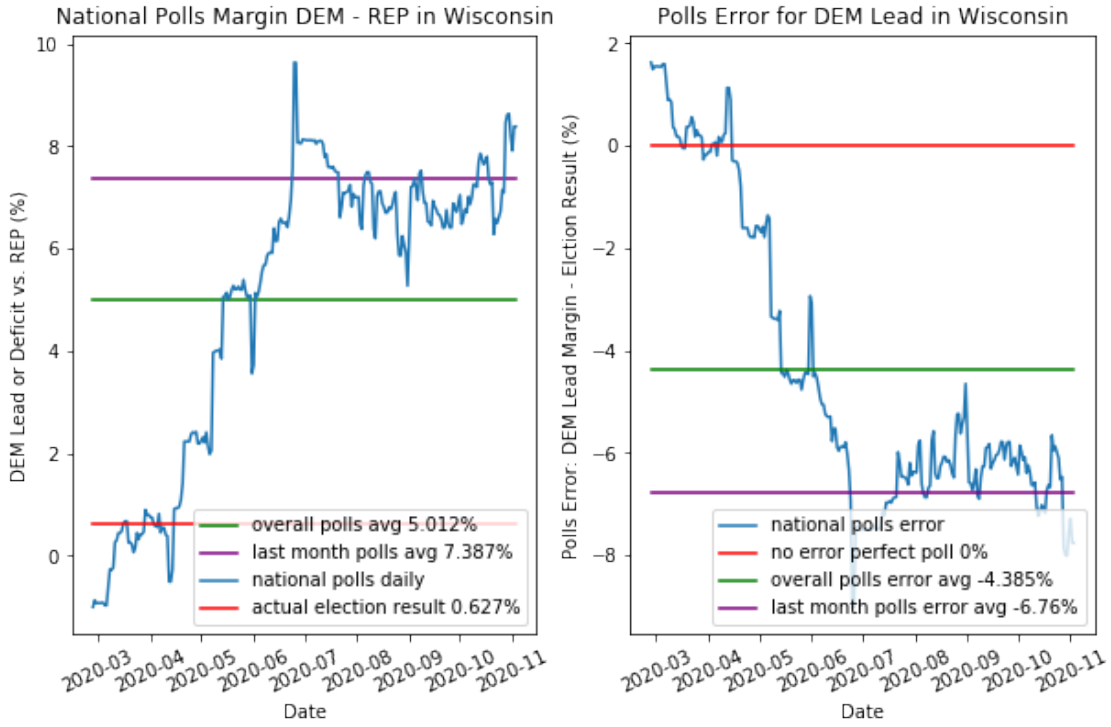




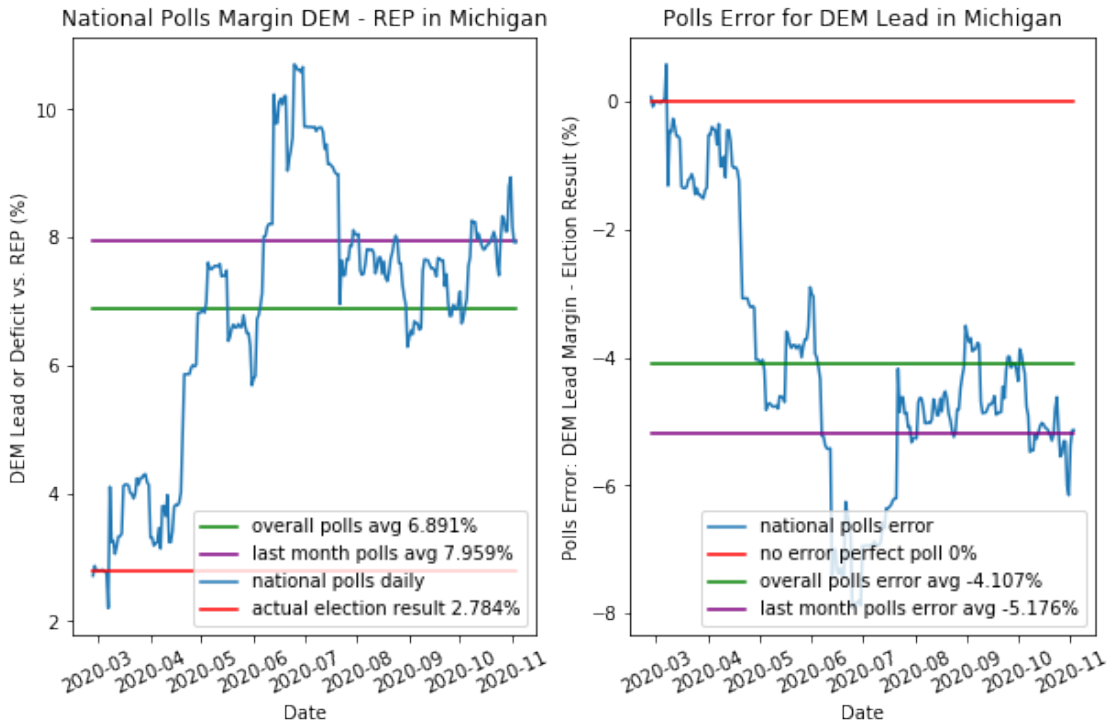


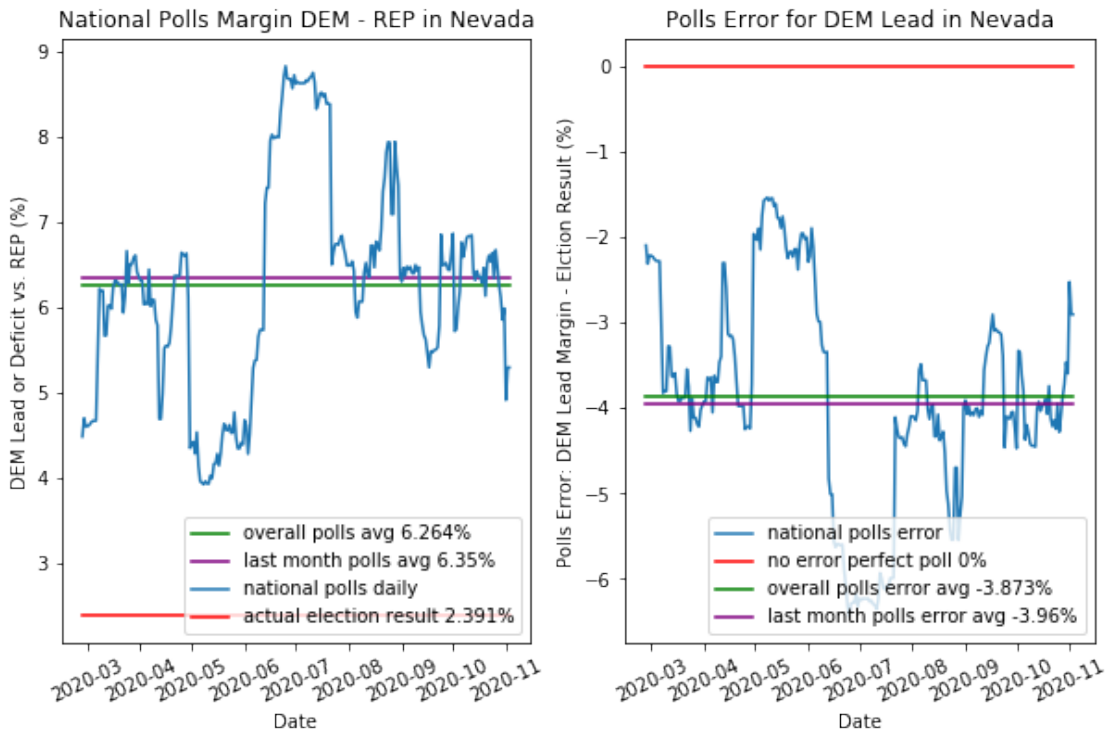
[11]:
```
poll_state(poll_tigeryi, "Pennsylvania")
poll_state(poll_tigeryi, "Wisconsin")
```





[12]:
```
poll_state(poll_tigeryi, "Michigan")
poll_state(poll_tigeryi, "Nevada")
```





[346]:
```
# df222 = poll_tigeryi[poll_tigeryi['state']=='Wisconsin']#.loc['2020-06-01':]
# df222 = df222.set_index(['date'])
# df222.loc['2020-6-1':'2020-11-03']
# mask = (df222['date'] >= '2020-03-01') & (df222['date'] <= '2020-11-03')
# df222.loc[mask]
# df222["dem_lead"][-3:-1]
```

[354]:
```
poll_covid = pd.merge(poll_tigeryi, covid_tigeryi, how = 'inner',
                      left_on = ['state', 'date','usa_state_code'], right_on =␣
 ↪['state', 'date','state_code']
                     )
```

[359]:
```
poll_covid = poll_covid.dropna(subset=['death_delta','death'], axis=0)
```

[366]:
```
# poll_covid = poll_covid.drop(5197,axis=0)
```

[388]:
```
poll_covid['positive_delta_rolling7'] = poll_covid['positive_delta'].rolling(7,␣
 ↪min_periods = 0).mean()
poll_covid['negative_delta_rolling7'] = poll_covid['negative_delta'].rolling(7,␣
 ↪min_periods = 0).mean()
poll_covid['totalTestResults_delta_rolling7'] =␣
 ↪poll_covid['totalTestResults_delta'].rolling(7, min_periods = 0).mean()
```

```
poll_covid['death_delta_rolling7'] = poll_covid['death_delta'].rolling(7,␣
↪min_periods = 0).mean()

poll_covid['positive_rate_delta_rolling7'] = 100*␣
↪poll_covid['positive_delta_rolling7']/
↪poll_covid['totalTestResults_delta_rolling7']

poll_covid = poll_covid.replace(np.inf, np.nan)
```

[398]:
```
mask = (poll_covid['positive_rate_delta_rolling7'] >= 0) &␣
↪(poll_covid['positive_rate_delta_rolling7'] <= 100)
poll_covid = poll_covid.loc[mask]
```

[400]:
```
poll_covid.to_csv('poll_covid_tigeryi.csv', index=False)
```

[13]:
```
poll_covid = pd.read_csv('poll_covid_tigeryi.csv', parse_dates=parse_dates,␣
↪index_col=False)
```

[14]:
```
# poll_covid_nevada = poll_covid[poll_covid['state']=='Nevada']
```

[195]:
```
def poll_cov(poll, state="Florida", usa_state_code=None):
    if state in poll['state'].tolist():
        poll_state = poll[poll['state']==state]
    elif usa_state_code in poll['usa_state_code'].tolist():
        poll_state = poll[poll['usa_state_code']==usa_state_code]
    else:
        raise ValueError("state not valid")




    actual_result = poll_state['dem_2020_margin'].tolist()[0]
    actual_result = np.round(actual_result, 3)

    poll_average = np.mean(poll_state["dem_lead_rolling_7"])
    poll_average = np.round(poll_average, 3)

    last_month_avg = np.mean(poll_state["dem_lead_rolling_7"][-31:-1])
    last_month_avg = np.round(last_month_avg, 3)

    error_average = np.mean(poll_state["dem_lead_rolling_7_diff"])
    error_average = np.round(error_average, 3)

    last_month_error = np.mean(poll_state["dem_lead_rolling_7_diff"][-31:-1])
    last_month_error = np.round(last_month_error, 3)


    plt.subplots(figsize = (20,20))
```

```
   plt.subplot(2,3,1)

   plt.plot(poll_state['date'],poll_state['positive_rate_delta_rolling7']) #␣
↪positive_rate_delta_rolling7
   plt.legend(loc="lower right")
   plt.xlabel("Date")
   plt.xticks(rotation = 25)
   plt.ylabel("Covid-19 Positive Rate 7 day rolling (%)")

   plt.title(f"Covid-19 Positive Rate (7 day rolling) in {state or␣
↪usa_state_code}")


   plt.subplot(2,3,2)

   plt.title(f"National Polls Margin DEM - REP (7 day rolling) in {state or␣
↪usa_state_code}")
   plt.plot(poll_state['date'], poll_state['dem_lead_rolling_7'],␣
↪label="national polls DEM margin")


   # add here
   plt.plot(poll_state["date"], [poll_average]*len(poll_state["date"]),␣
↪"green", label=f"overall polls avg {poll_average}%")
   plt.plot(poll_state["date"], [last_month_avg]*len(poll_state["date"]),␣
↪"purple", label=f"last month polls avg {last_month_avg}%")
   plt.plot(poll_state["date"], poll_state["dem_2020_margin"], "r-",␣
↪label=f"actual election result {actual_result}%")



   plt.xlabel("Date")
   plt.xticks(rotation = 25)
   plt.ylabel("Nation Polls DEM Lead or Deficit vs. REP 7 day rolling (%)")

   plt.legend(loc="lower right")


   plt.subplot(2,3,3)


   plt.title(f"Polls Error of DEM Lead (7 day rolling) in {state or␣
↪usa_state_code}")

   plt.plot(poll_state["date"], poll_state["dem_lead_rolling_7_diff"], "-" ,␣
↪label="national polls error")
```

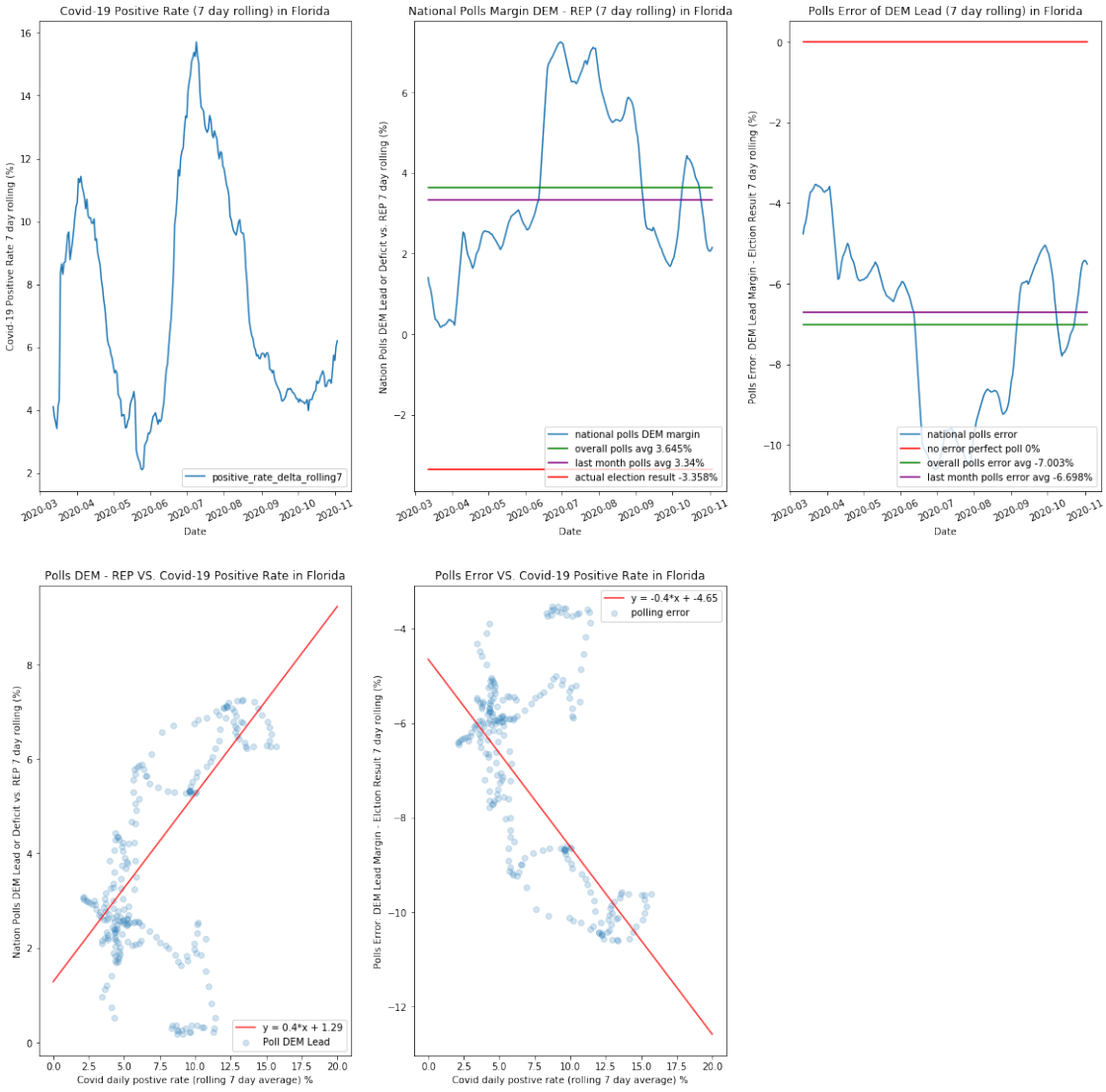
```
   plt.xlabel("Date")
   plt.xticks(rotation = 25)
   plt.ylabel("Polls Error: DEM Lead Margin - Elction Result 7 day rolling␣
↪(%)")

   # add here
   plt.plot(poll_state["date"], [0]*len(poll_state["date"]), "red", label="no␣
↪error perfect poll 0%")
   plt.plot(poll_state["date"], [error_average]*len(poll_state["date"]),␣
↪"green", label=f"overall polls error avg {error_average}%")
   plt.plot(poll_state["date"], [last_month_error]*len(poll_state["date"]),␣
↪"purple", label=f"last month polls error avg {last_month_error}%")




   plt.legend(loc="lower right")



   plt.subplot(2,3,4)

   plt.title(f"Polls DEM - REP VS. Covid-19 Positive Rate in {state or␣
↪usa_state_code}")

   X1 = poll_state['positive_rate_delta_rolling7']
   Y1 = poll_state['dem_lead_rolling_7']

   plt.scatter(X1, Y1, alpha=0.2, label='Poll DEM Lead')

   results = sm.WLS(Y1, sm.add_constant(X1), weights=list(range(0,len(X1)))).
↪fit() # OLS
   X_plot = np.linspace(0, 20, 101)
   a1 = results.params[1]
   b1 = results.params[0]
   Y_plot = X_plot*a1 + b1
   plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a1,2)}*x + {np.
↪round(b1,2)}", alpha=0.8)
   plt.legend(loc="lower right")
   plt.xlabel("Covid daily postive rate (rolling 7 day average) %")
   plt.ylabel("Nation Polls DEM Lead or Deficit vs. REP 7 day rolling (%)")

   #print(results.params)
   #print(results.summary())
   print()
```

```
    plt.subplot(2,3,5)

    plt.title(f"Polls Error VS. Covid-19 Positive Rate in {state or␣
↪usa_state_code}")

    X2 = poll_state['positive_rate_delta_rolling7']
    Y2 = poll_state['dem_lead_rolling_7_diff']
    plt.scatter(X2, Y2, alpha=0.2, label='polling error')

    results2 = sm.WLS(Y2, sm.add_constant(X2), weights=list(range(0,len(X2)))).
↪fit()
    X_plot = np.linspace(0, 20, 101)
    a2 = results2.params[1]
    b2 = results2.params[0]
    Y_plot = X_plot*a2 + b2
    plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a2,2)}*x + {np.
↪round(b2,2)}", alpha=0.8)
    plt.legend(loc="upper right")
    plt.xlabel("Covid daily postive rate (rolling 7 day average) %")
    plt.ylabel("Polls Error: DEM Lead Margin - Elction Result 7 day rolling␣
↪(%)")

    #print(results2.params)
    print(results2.summary())
```

[196]:
```
poll_cov(poll_covid, "Florida")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))


                            WLS Regression Results
==============================================================================
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.577
Model:                                 WLS   Adj. R-squared:
```

```
0.576
Method:                       Least Squares   F-statistic:
321.1
Date:                    Sat, 12 Dec 2020   Prob (F-statistic):
7.57e-46
Time:                            15:30:31   Log-Likelihood:
-inf
No. Observations:                     237   AIC:
inf
Df Residuals:                         235   BIC:
inf
Df Model:                               1
Covariance Type:                nonrobust
================================================================================
================
                                 coef    std err          t      P>|t|
[0.025      0.975]
--------------------------------------------------------------------------------
----------------
const                          -4.6460      0.174    -26.747      0.000
-4.988      -4.304
positive_rate_delta_rolling7   -0.3970      0.022    -17.919      0.000
-0.441      -0.353
==============================================================================
Omnibus:                        6.409   Durbin-Watson:                   0.025
Prob(Omnibus):                  0.041   Jarque-Bera (JB):                4.602
Skew:                          -0.210   Prob(JB):                        0.100
Kurtosis:                       2.461   Cond. No.                         18.0
==============================================================================

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

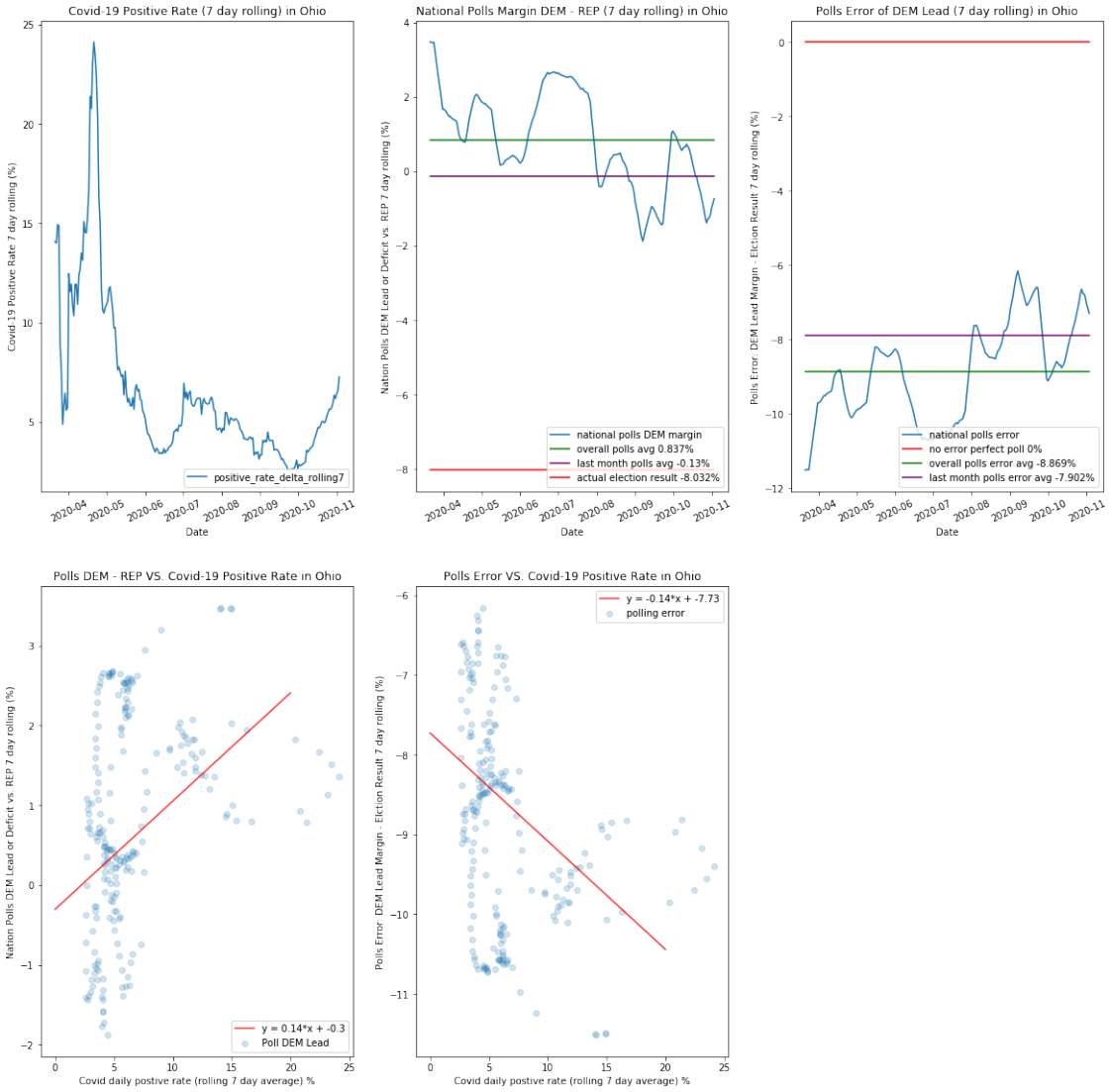


[197]:
```
poll_cov(poll_covid, "Ohio")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))
```

```
                            WLS Regression Results
==============================================================================
```

```
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.069
Model:                                 WLS   Adj. R-squared:
0.065
Method:                      Least Squares   F-statistic:
16.73
Date:                     Sat, 12 Dec 2020   Prob (F-statistic):
5.99e-05
Time:                             15:30:38   Log-Likelihood:
-inf
No. Observations:                      228   AIC:
inf
Df Residuals:                          226   BIC:
inf
Df Model:                                1
Covariance Type:                 nonrobust
==============================================================================
================
                                   coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
const                            -7.7287      0.184    -42.053      0.000
-8.091      -7.366
positive_rate_delta_rolling7     -0.1356      0.033     -4.090      0.000
-0.201      -0.070
==============================================================================
Omnibus:                        4.322   Durbin-Watson:                   0.016
Prob(Omnibus):                  0.115   Jarque-Bera (JB):                3.354
Skew:                           0.176   Prob(JB):                        0.187
Kurtosis:                       2.521   Cond. No.                         12.8
==============================================================================

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

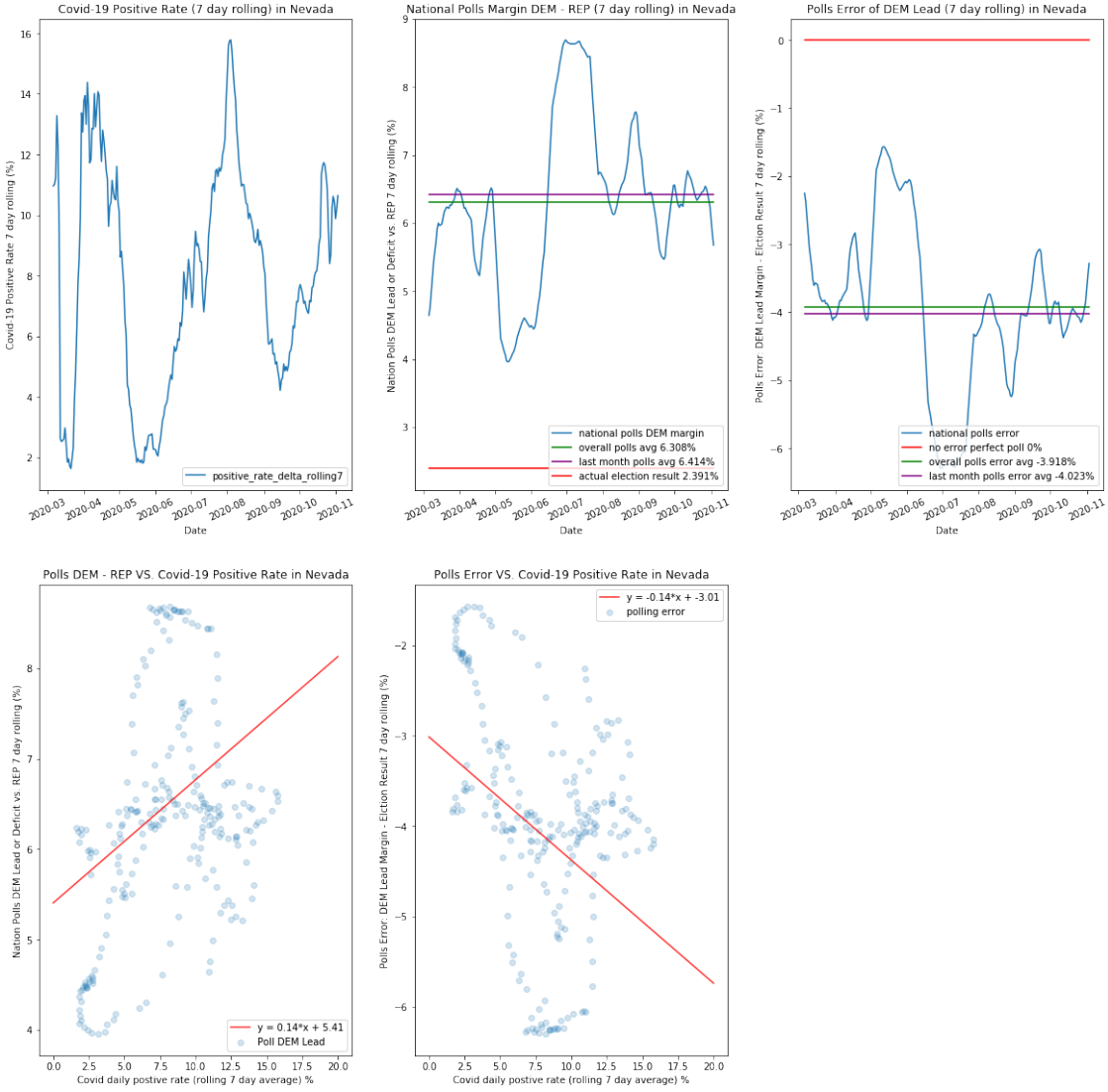


[198]:
```
poll_cov(poll_covid, "Nevada")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))
```

```
                            WLS Regression Results
==============================================================================
```

```
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.156
Model:                                WLS   Adj. R-squared:
0.152
Method:                     Least Squares   F-statistic:
44.47
Date:                    Sat, 12 Dec 2020   Prob (F-statistic):
1.75e-10
Time:                            15:30:42   Log-Likelihood:
-inf
No. Observations:                     243   AIC:
inf
Df Residuals:                         241   BIC:
inf
Df Model:                               1
Covariance Type:                nonrobust
================================================================================
================
                                   coef    std err          t      P>|t|
[0.025      0.975]
--------------------------------------------------------------------------------
----------------
const                           -3.0146      0.179    -16.878      0.000
-3.366      -2.663
positive_rate_delta_rolling7    -0.1363      0.020     -6.669      0.000
-0.177      -0.096
==============================================================================
Omnibus:                       25.326   Durbin-Watson:                   0.018
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               31.200
Skew:                          -0.876   Prob(JB):                     1.68e-07
Kurtosis:                       2.908   Cond. No.                         24.6
==============================================================================

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

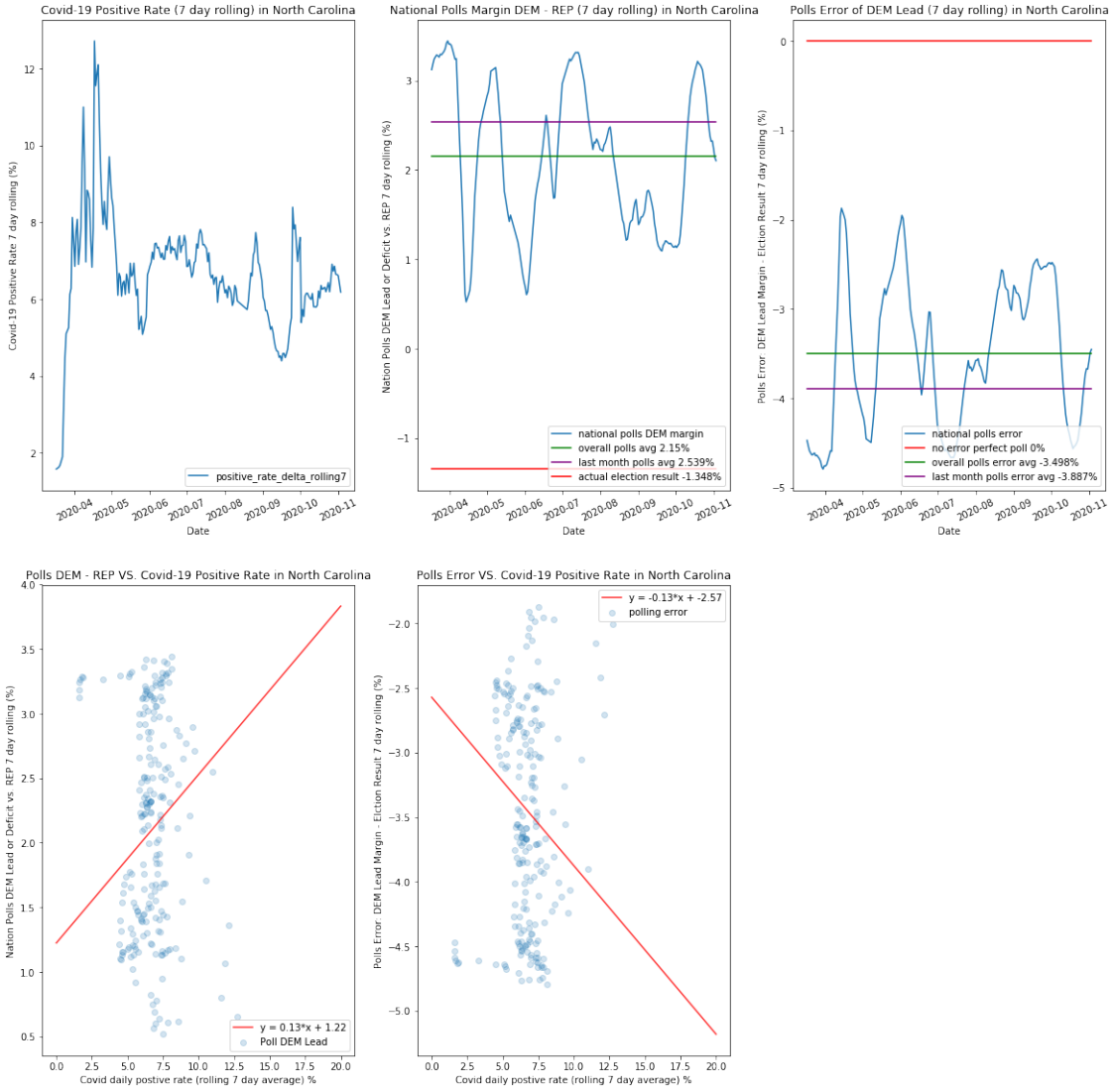


[199]:
```
poll_cov(poll_covid, "North Carolina")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))
```

```
                            WLS Regression Results
==============================================================================
```

```
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.032
Model:                                 WLS   Adj. R-squared:
0.028
Method:                      Least Squares   F-statistic:
7.444
Date:                     Sat, 12 Dec 2020   Prob (F-statistic):
0.00687
Time:                             15:30:45   Log-Likelihood:
-inf
No. Observations:                      225   AIC:
inf
Df Residuals:                          223   BIC:
inf
Df Model:                                1
Covariance Type:                 nonrobust
==============================================================================
================
                                   coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
const                            -2.5721      0.313     -8.227      0.000
-3.188      -1.956
positive_rate_delta_rolling7     -0.1304      0.048     -2.728      0.007
-0.225      -0.036
==============================================================================
Omnibus:                       15.067   Durbin-Watson:                   0.034
Prob(Omnibus):                  0.001   Jarque-Bera (JB):                6.072
Skew:                          -0.090   Prob(JB):                       0.0480
Kurtosis:                       2.215   Cond. No.                         42.2
==============================================================================

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

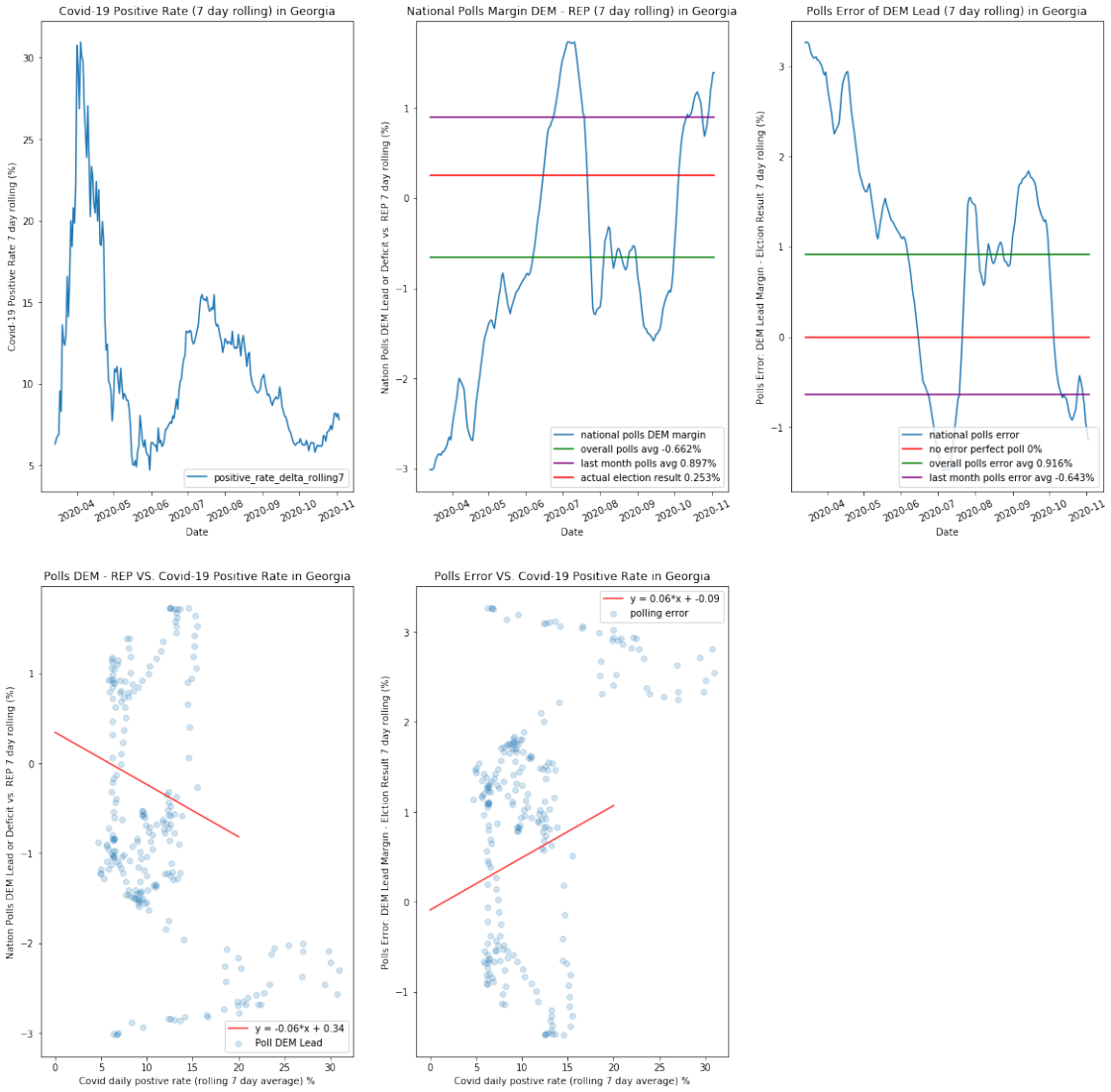


[200]:
```
poll_cov(poll_covid, "Georgia")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))
```

```
                            WLS Regression Results
==============================================================================
```

```
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.036
Model:                                 WLS   Adj. R-squared:
0.032
Method:                      Least Squares   F-statistic:
8.702
Date:                     Sat, 12 Dec 2020   Prob (F-statistic):
0.00350
Time:                             15:30:48   Log-Likelihood:
-inf
No. Observations:                      235   AIC:
inf
Df Residuals:                          233   BIC:
inf
Df Model:                                1
Covariance Type:                 nonrobust
==============================================================================
================
                                   coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
const                            -0.0901      0.201     -0.448      0.654
-0.486       0.306
positive_rate_delta_rolling7      0.0580      0.020      2.950      0.004
0.019       0.097
==============================================================================
Omnibus:                       25.616   Durbin-Watson:                   0.011
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               24.861
Skew:                          -0.732   Prob(JB):                     3.99e-06
Kurtosis:                       2.372   Cond. No.                         29.2
==============================================================================

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

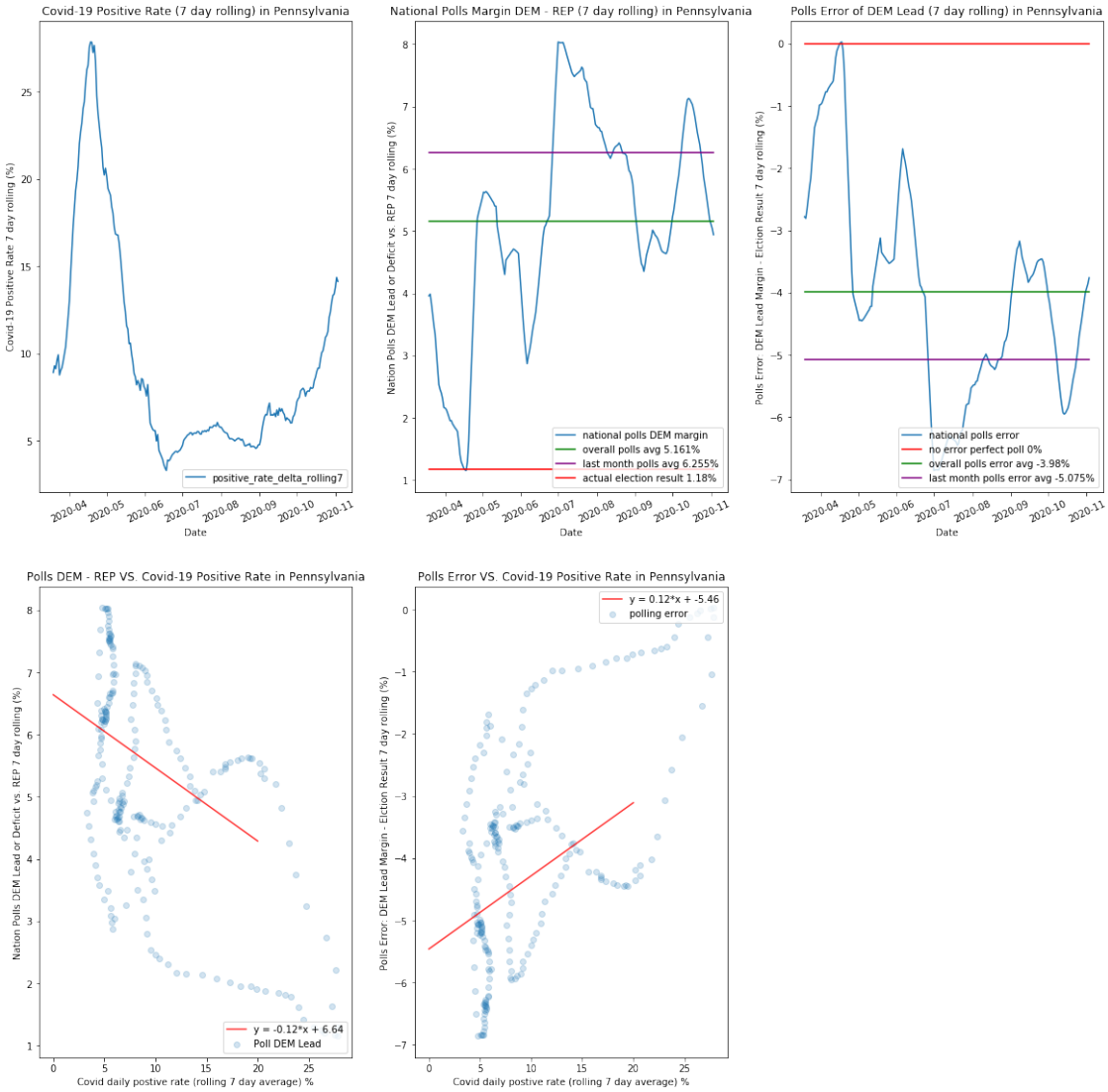


[201]:
```
poll_cov(poll_covid, "Pennsylvania")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))
```

```
                            WLS Regression Results
==============================================================================
```

```
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.142
Model:                                 WLS   Adj. R-squared:
0.138
Method:                      Least Squares   F-statistic:
37.81
Date:                     Sat, 12 Dec 2020   Prob (F-statistic):
3.46e-09
Time:                             15:30:51   Log-Likelihood:
-inf
No. Observations:                      230   AIC:
inf
Df Residuals:                          228   BIC:
inf
Df Model:                                1
Covariance Type:                 nonrobust
==============================================================================
================
                                   coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
const                            -5.4597      0.168    -32.460      0.000
-5.791      -5.128
positive_rate_delta_rolling7      0.1176      0.019      6.149      0.000
0.080       0.155
==============================================================================
Omnibus:                       37.028   Durbin-Watson:                   0.014
Prob(Omnibus):                  0.000   Jarque-Bera (JB):                9.461
Skew:                          -0.083   Prob(JB):                      0.00882
Kurtosis:                       2.020   Cond. No.                         19.1
==============================================================================

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

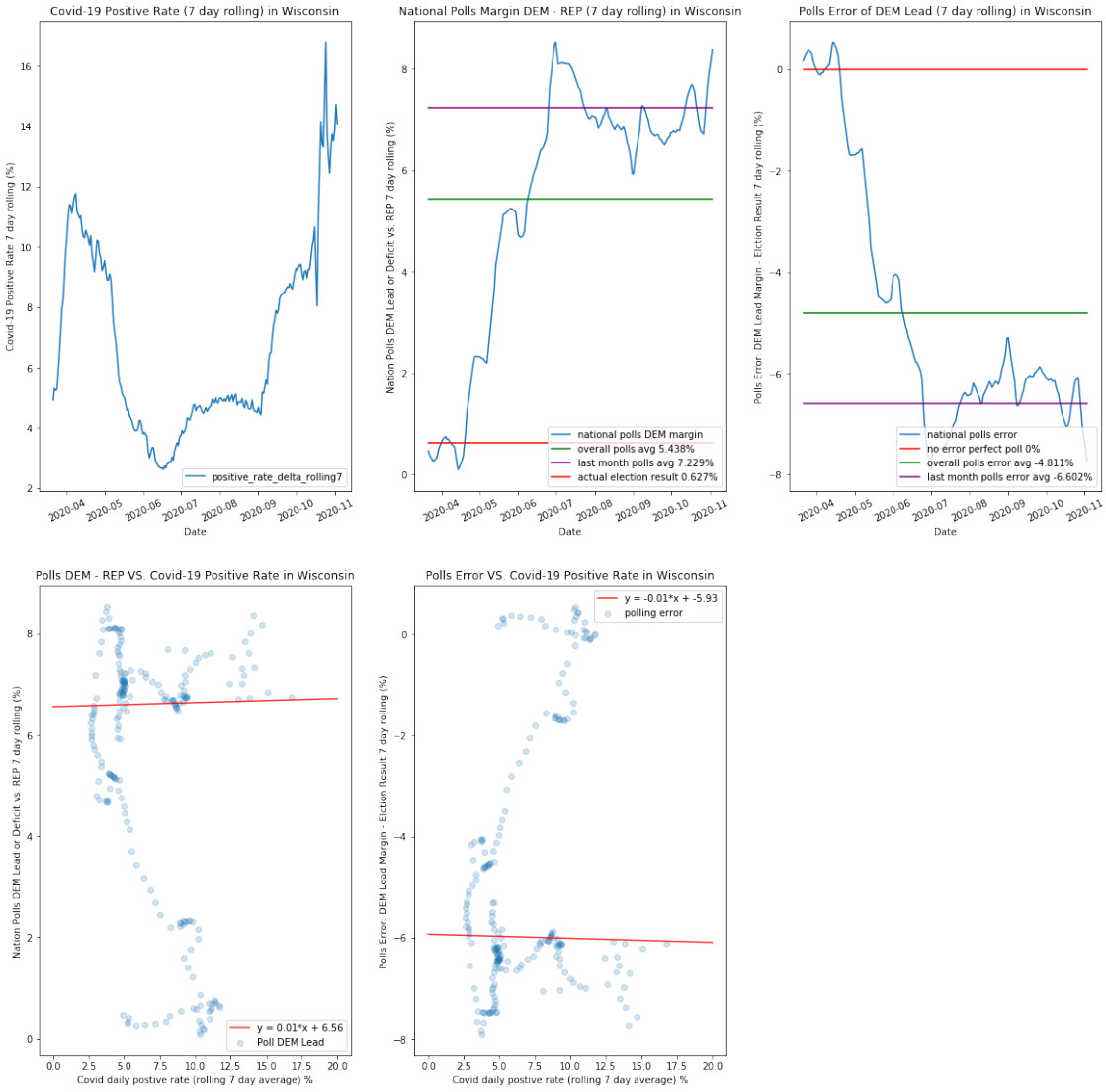


[202]:
```
poll_cov(poll_covid, "Wisconsin")
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2580:
FutureWarning: Method .ptp is deprecated and will be removed in a future
version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
/anaconda3/lib/python3.6/site-
packages/statsmodels/regression/linear_model.py:764: RuntimeWarning: divide by
zero encountered in log
  llf += 0.5 * np.sum(np.log(self.weights))
```

```
                            WLS Regression Results
==============================================================================
```

```
===
Dep. Variable:     dem_lead_rolling_7_diff   R-squared:
0.000
Model:                                 WLS   Adj. R-squared:
-0.004
Method:                      Least Squares   F-statistic:
0.08258
Date:                     Sat, 12 Dec 2020   Prob (F-statistic):
0.774
Time:                             15:30:54   Log-Likelihood:
-inf
No. Observations:                      228   AIC:
inf
Df Residuals:                          226   BIC:
inf
Df Model:                                1
Covariance Type:                 nonrobust
================================================================================
================
                                   coef    std err          t      P>|t|
[0.025      0.975]
--------------------------------------------------------------------------------
----------------
const                            -5.9343      0.221    -26.841      0.000
-6.370      -5.499
positive_rate_delta_rolling7     -0.0080      0.028     -0.287      0.774
-0.063       0.047
==============================================================================
Omnibus:                       26.382   Durbin-Watson:                   0.009
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               13.913
Skew:                           0.435   Prob(JB):                     0.000952
Kurtosis:                       2.160   Cond. No.                         18.9
==============================================================================

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



[145]:
```
poll_covid_election_day = poll_covid[poll_covid['date']=='2020-11-03']
```

[147]:
```
poll_covid_election_day.head()
```

[147]:

	state	date	rep_poll_2020	dem_poll_2020	dem_lead	\
226	Alabama	2020-11-03	57.36126	37.82732	-19.53394	
344	Alaska	2020-11-03	51.23236	43.57005	-7.66231	
579	Arizona	2020-11-03	46.10181	48.70539	2.60358	
726	Arkansas	2020-11-03	58.94886	36.17764	-22.77122	
962	California	2020-11-03	32.43615	61.62459	29.18844	

	dem_lead_rolling_7	usa_state_code	usa_state_latitude	\
226	-19.027321	AL	32.318231	
344	-7.500766	AK	63.588753	
579	2.992987	AZ	34.048928	

```
726          -23.458171             AR           35.201050
962           28.638266             CA           36.778261

     usa_state_longitude  dem_lead_rolling_30  ... negative_delta  \
226           -86.902298           -18.194698  ...         5986.0
344          -154.493062            -5.668142  ...         4202.0
579          -111.093731             3.547420  ...         9071.0
726           -91.831833           -18.147534  ...         4936.0
962          -119.417932            30.125426  ...       158376.0

     totalTestResults_delta  death_delta  positive_rate_delta  \
226                  6629.0         14.0            15.643385
344                  4585.0          0.0             8.353326
579                 10633.0         38.0            15.790464
726                  5456.0         18.0            16.092375
962                162420.0         14.0             2.489841

     positive_negative_ratio_delta  positive_delta_rolling7  \
226                      17.323755              1356.000000
344                       9.114707               373.000000
579                      18.509536              1385.142857
726                      17.787682               977.142857
962                       2.553417              4353.428571

     negative_delta_rolling7  totalTestResults_delta_rolling7  \
226              6139.142857                      7166.000000
344              6387.857143                      6760.857143
579              9916.142857                     11226.857143
726              8641.000000                      9378.428571
962            131056.857143                    135410.285714

     death_delta_rolling7 positive_rate_delta_rolling7
226             13.571429                   18.922690
344              2.000000                    5.517052
579             18.428571                   12.337761
726             20.857143                   10.419047
962             40.857143                    3.214991

[5 rows x 41 columns]
```

[233]:
```
covid_positive_election_day =␣
 ↪poll_covid_election_day['positive_rate_delta_rolling7'].tolist()

poll_dem_margin = poll_covid_election_day['dem_lead_rolling_7'].tolist()

poll_error_election_day = poll_covid_election_day['dem_lead_rolling_7_diff'].
 ↪tolist()
```

```
states_election_day = poll_covid_election_day['state_code'].tolist()

result_election_day = poll_covid_election_day['dem_2020_margin'].tolist()

# margin_shift = poll_covid_election_day['margin_shift'].tolist()
```

[220]:
```
battleground_states = ['Florida', 'Georgia', 'Arizona',
                       'Wisconsin', 'Pennsylvania', 'Nevada',
                       'Michigan', 'Minnesota', 'North Carolina',
                       'Texas', 'Ohio', 'Iowa'
                      ]

poll_covid_election_battleground = poll_covid_election_day.
 ↪loc[poll_covid_election_day['state'].isin(battleground_states)]

poll_covid_election_battleground.head()
```

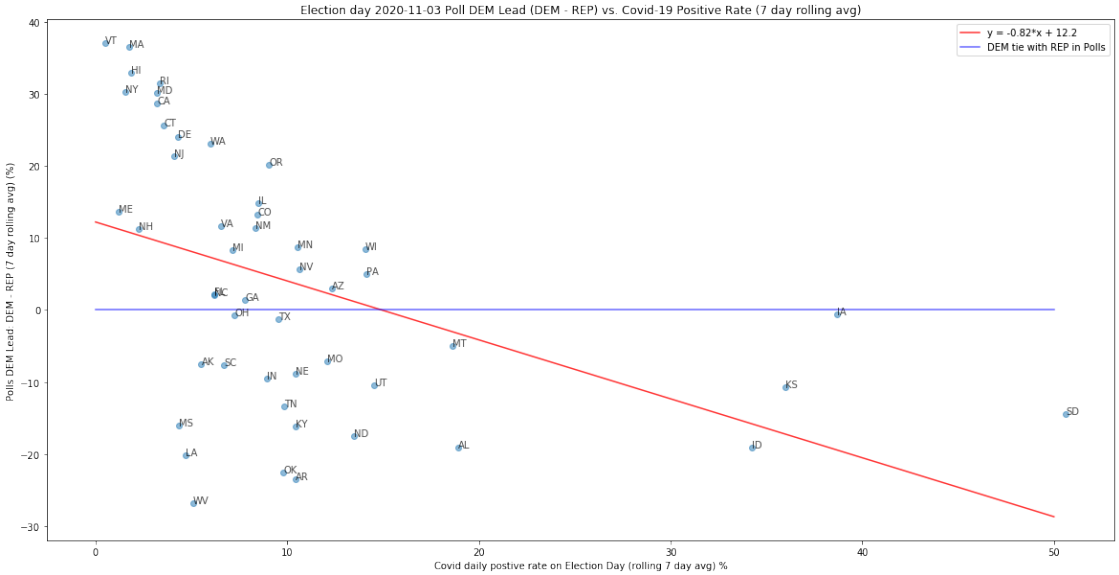
[220]:
```
        state       date  rep_poll_2020  dem_poll_2020  dem_lead  \
579    Arizona 2020-11-03       46.10181       48.70539   2.60358
1903   Florida 2020-11-03       46.61909       49.08035   2.46126
2138   Georgia 2020-11-03       47.36694       48.54042   1.17348
2752      Iowa 2020-11-03       47.59527       46.31091  -1.28436
4098  Michigan 2020-11-03       43.23326       51.15482   7.92156

      dem_lead_rolling_7 usa_state_code  usa_state_latitude  \
579             2.992987             AZ           34.048928
1903            2.151427             FL           27.664827
2138            1.386774             GA           32.157435
2752           -0.553669             IA           41.878003
4098            8.275706             MI           44.314844

      usa_state_longitude  dem_lead_rolling_30  ... negative_delta  \
579          -111.093731             3.547420  ...         9071.0
1903          -81.515754             3.323476  ...        20822.0
2138          -82.907123             1.029727  ...        20462.0
2752          -93.097702             0.395159  ...         1050.0
4098          -85.602364             7.993318  ...        38754.0

      totalTestResults_delta  death_delta  positive_rate_delta  \
579                  10633.0         38.0            15.790464
1903                 55696.0         56.0             8.174734
2138                 22130.0        480.0             7.537280
2752                  2142.0         22.0            50.980392
4098                 42191.0         45.0             8.146287

      positive_negative_ratio_delta  positive_delta_rolling7  \
579                       18.509536              1385.142857
```

```
1903                     21.866295                4244.142857
2138                      8.151696                1602.428571
2752                    104.000000                1886.142857
4098                      8.868762                3631.285714

      negative_delta_rolling7  totalTestResults_delta_rolling7  \
579               9916.142857                     11226.857143
1903             29201.857143                     68424.142857
2138             18960.285714                     20562.714286
2752              2987.571429                      4873.714286
4098             47371.571429                     51002.857143

      death_delta_rolling7 positive_rate_delta_rolling7
579              18.428571                    12.337761
1903             55.714286                     6.202698
2138             90.714286                     7.792884
2752             14.571429                    38.700317
4098             25.142857                     7.119769

[5 rows x 41 columns]
```

[221]:
```
covid_positive_election_day_battleground =␣
 ↪poll_covid_election_battleground['positive_rate_delta_rolling7'].tolist()

poll_dem_margin_battleground =␣
 ↪poll_covid_election_battleground['dem_lead_rolling_7'].tolist()

poll_error_election_day_battleground =␣
 ↪poll_covid_election_battleground['dem_lead_rolling_7_diff'].tolist()

states_election_day_battleground =␣
 ↪poll_covid_election_battleground['state_code'].tolist()

result_election_day_battleground =␣
 ↪poll_covid_election_battleground['dem_2020_margin'].tolist()
```

[218]:
```
# plt.scatter(covid_positive_election_day, poll_dem_margin, alpha=0.5)

fig, ax = plt.subplots(figsize = (20,10))

ax.scatter(covid_positive_election_day, poll_dem_margin, alpha=0.5)

for i, txt in enumerate(states_election_day):
    ax.annotate(txt, (covid_positive_election_day[i], poll_dem_margin[i]),␣
 ↪alpha =0.7)
```

```
results = sm.OLS(poll_dem_margin, sm.add_constant(covid_positive_election_day)).
 ↪fit()

X_plot = np.linspace(0, 50, 501)
a = results.params[1]
b = results.params[0]
Y_plot = X_plot*a + b
Y_flat = [0]*len(X_plot)

plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a,2)}*x + {np.
 ↪round(b,2)}", alpha=0.8)
plt.plot(X_plot, Y_flat, 'b-', label="DEM tie with REP in Polls", alpha=0.6)


plt.legend(loc="upper right")
plt.xlabel("Covid daily postive rate on Election Day (rolling 7 day avg) %")
plt.ylabel("Polls DEM Lead: DEM - REP (7 day rolling avg) (%)")
plt.title("Election day 2020-11-03 Poll DEM Lead (DEM - REP) vs. Covid-19␣
 ↪Positive Rate (7 day rolling avg)")

plt.show()

print(results.params)
print(results.summary())
```



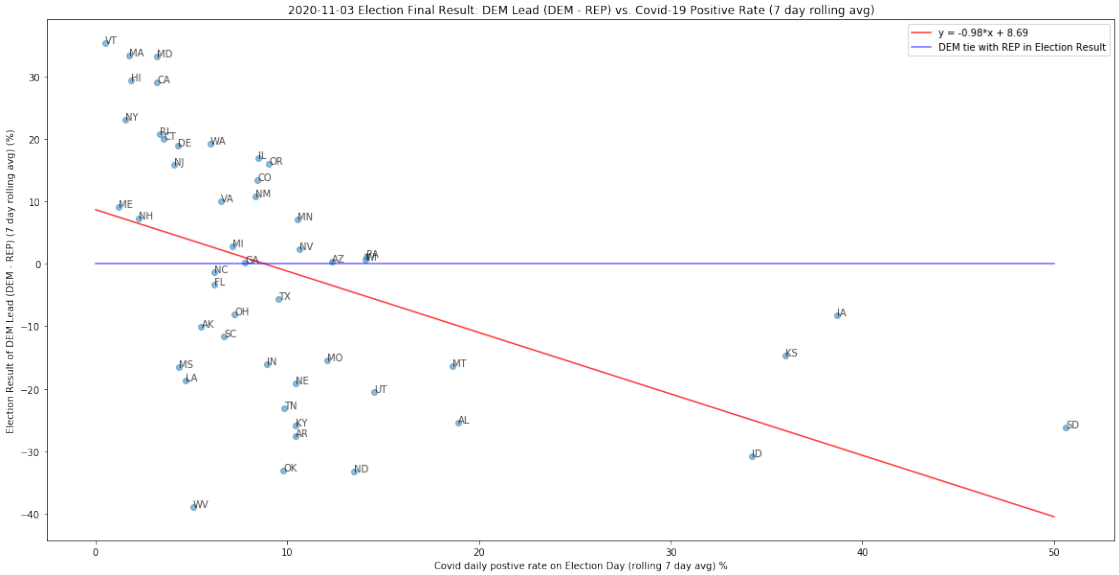

```
[12.20121706 -0.8172465 ]
```

OLS Regression Results

```
==============================================================================
Dep. Variable:                      y   R-squared:                       0.211
Model:                            OLS   Adj. R-squared:                  0.195
Method:                 Least Squares   F-statistic:                     12.60
Date:                Sat, 12 Dec 2020   Prob (F-statistic):           0.000888
Time:                        16:27:22   Log-Likelihood:                -204.44
No. Observations:                  49   AIC:                             412.9
Df Residuals:                      47   BIC:                             416.7
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         12.2012      3.303      3.694      0.001       5.557      18.846
x1            -0.8172      0.230     -3.550      0.001      -1.280      -0.354
==============================================================================
Omnibus:                        3.383   Durbin-Watson:                   2.051
Prob(Omnibus):                  0.184   Jarque-Bera (JB):                2.036
Skew:                          -0.263   Prob(JB):                        0.361
Kurtosis:                       2.151   Cond. No.                         20.8
==============================================================================

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

[223]:
```
# plt.scatter(covid_positive_election_day, dem_2020_margin, alpha=0.5)

# result_election_day

fig, ax = plt.subplots(figsize = (20,10))

ax.scatter(covid_positive_election_day, result_election_day, alpha=0.5)

for i, txt in enumerate(states_election_day):
    ax.annotate(txt, (covid_positive_election_day[i], result_election_day[i]),␣
 ↪alpha =0.7)


results = sm.OLS(result_election_day, sm.
 ↪add_constant(covid_positive_election_day)).fit()

X_plot = np.linspace(0, 50, 501)
a = results.params[1]
b = results.params[0]
Y_plot = X_plot*a + b
Y_flat = [0]*len(X_plot)
```

```
plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a,2)}*x + {np.
 ↪round(b,2)}", alpha=0.8)
plt.plot(X_plot, Y_flat, 'b-', label="DEM tie with REP in Election Result",␣
 ↪alpha=0.6)


plt.legend(loc="upper right")
plt.xlabel("Covid daily postive rate on Election Day (rolling 7 day avg) %")
plt.ylabel("Election Result of DEM Lead (DEM - REP) (7 day rolling avg) (%)")
plt.title("2020-11-03 Election Final Result: DEM Lead (DEM - REP) vs. Covid-19␣
 ↪Positive Rate (7 day rolling avg)")

plt.show()

print(results.params)
print(results.summary())
```




```
[ 8.69332029 -0.9842113 ]
```

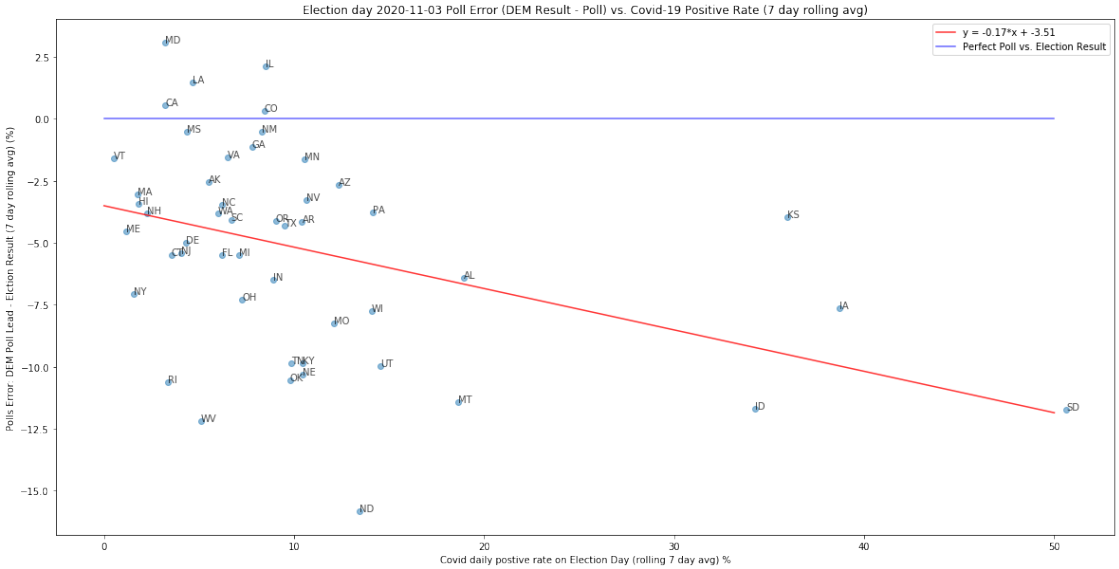
OLS Regression Results

Dep. Variable:	y	R-squared:	0.242
Model:	OLS	Adj. R-squared:	0.226
Method:	Least Squares	F-statistic:	15.03
Date:	Sat, 12 Dec 2020	Prob (F-statistic):	0.000328
Time:	16:39:10	Log-Likelihood:	-209.23
No. Observations:	49	AIC:	422.5

```
Df Residuals:                       47   BIC:                             426.2
Df Model:                            1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          8.6933      3.642      2.387      0.021       1.367      16.020
x1            -0.9842      0.254     -3.877      0.000      -1.495      -0.473
==============================================================================
Omnibus:                        2.862   Durbin-Watson:                   2.015
Prob(Omnibus):                  0.239   Jarque-Bera (JB):                2.162
Skew:                          -0.356   Prob(JB):                        0.339
Kurtosis:                       2.257   Cond. No.                         20.8
==============================================================================

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

[214]:
```
fig, ax = plt.subplots(figsize = (20,10))

ax.scatter(covid_positive_election_day, poll_error_election_day, alpha=0.5)

for i, txt in enumerate(states_election_day):
    ax.annotate(txt, (covid_positive_election_day[i],␣
 ↪poll_error_election_day[i]), alpha =0.7)


results2 = sm.OLS(poll_error_election_day, sm.
 ↪add_constant(covid_positive_election_day)).fit()

X_plot = np.linspace(0, 50, 501)
a2 = results2.params[1]
b2 = results2.params[0]
Y_plot = X_plot*a2 + b2
Y_flat = [0]*len(X_plot)

plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a2,2)}*x + {np.
 ↪round(b2,2)}", alpha=0.8)
plt.plot(X_plot, Y_flat, 'b-', label="Perfect Poll on Election Result", alpha=0.
 ↪6)


plt.legend(loc="upper right")
plt.xlabel("Covid daily postive rate on Election Day (rolling 7 day avg) %")
plt.ylabel("Polls Error: DEM Poll Lead - Elction Result (7 day rolling avg)␣
 ↪(%)")
```

```
plt.title("Election day 2020-11-03 Poll Error (DEM Result - Poll) vs. Covid-19␣
 ↪Positive Rate (7 day rolling avg)")

plt.show()

print(results2.params)
print(results2.summary())
```



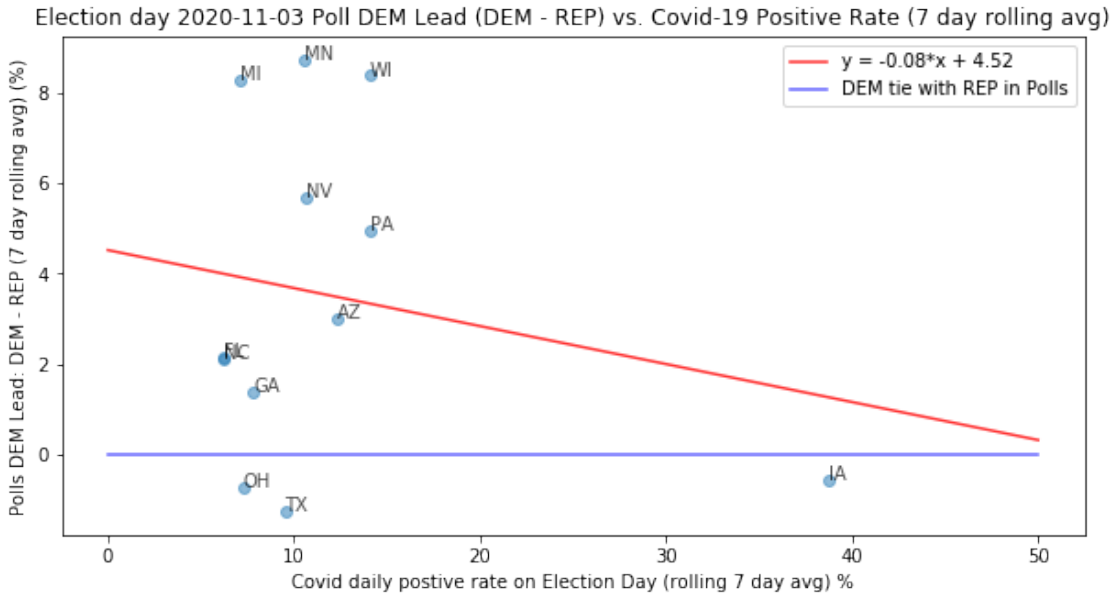

```
[-3.50789677 -0.1669648 ]
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.161
Model:                            OLS   Adj. R-squared:                  0.143
Method:                 Least Squares   F-statistic:                     9.021
Date:                Sat, 12 Dec 2020   Prob (F-statistic):            0.00427
Time:                        16:24:38   Log-Likelihood:                -134.80
No. Observations:                  49   AIC:                             273.6
Df Residuals:                      47   BIC:                             277.4
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -3.5079      0.797     -4.399      0.000      -5.112      -1.904
x1            -0.1670      0.056     -3.004      0.004      -0.279      -0.055
==============================================================================
Omnibus:                        1.199   Durbin-Watson:                   2.088
Prob(Omnibus):                  0.549   Jarque-Bera (JB):                1.012
```

```
Skew:                          -0.345   Prob(JB):                         0.603
Kurtosis:                       2.858   Cond. No.                         20.8
==============================================================================

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

[224]:
```
covid_positive_election_day_battleground =␣
 ↪poll_covid_election_battleground['positive_rate_delta_rolling7'].tolist()

poll_dem_margin_battleground =␣
 ↪poll_covid_election_battleground['dem_lead_rolling_7'].tolist()

poll_error_election_day_battleground =␣
 ↪poll_covid_election_battleground['dem_lead_rolling_7_diff'].tolist()

states_election_day_battleground =␣
 ↪poll_covid_election_battleground['state_code'].tolist()

result_election_day_battleground =␣
 ↪poll_covid_election_battleground['dem_2020_margin'].tolist()
```

[229]:
```
# plt.scatter(covid_positive_election_day_battleground,␣
 ↪poll_dem_margin_battleground, alpha=0.5)

fig, ax = plt.subplots(figsize = (10,5))

ax.scatter(covid_positive_election_day_battleground,␣
 ↪poll_dem_margin_battleground, alpha=0.5)

for i, txt in enumerate(states_election_day_battleground):
    ax.annotate(txt, (covid_positive_election_day_battleground[i],␣
 ↪poll_dem_margin_battleground[i]), alpha =0.7)


results = sm.OLS(poll_dem_margin_battleground, sm.
 ↪add_constant(covid_positive_election_day_battleground)).fit()

X_plot = np.linspace(0, 50, 501)
a = results.params[1]
b = results.params[0]
Y_plot = X_plot*a + b
Y_flat = [0]*len(X_plot)

plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a,2)}*x + {np.
 ↪round(b,2)}", alpha=0.8)
```

```
plt.plot(X_plot, Y_flat, 'b-', label="DEM tie with REP in Polls", alpha=0.6)


plt.legend(loc="upper right")
plt.xlabel("Covid daily postive rate on Election Day (rolling 7 day avg) %")
plt.ylabel("Polls DEM Lead: DEM - REP (7 day rolling avg) (%)")
plt.title("Election day 2020-11-03 Poll DEM Lead (DEM - REP) vs. Covid-19␣
 ↪Positive Rate (7 day rolling avg)")

plt.show()

print(results.params)
print(results.summary())
```

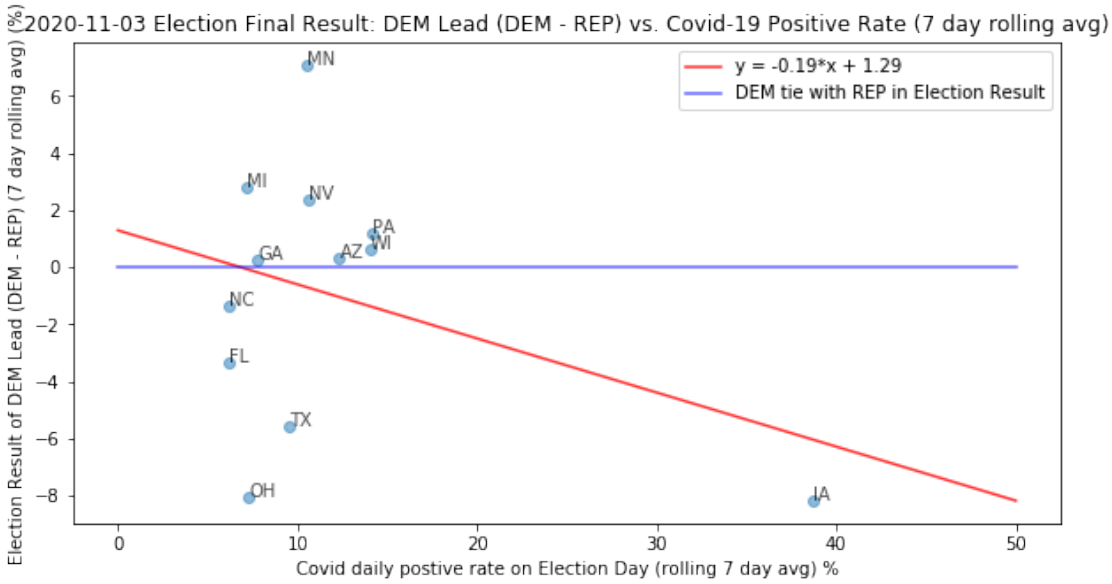



```
[ 4.51640353 -0.08388989]
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.042
Model:                            OLS   Adj. R-squared:                 -0.054
Method:                 Least Squares   F-statistic:                    0.4334
Date:                Sat, 12 Dec 2020   Prob (F-statistic):              0.525
Time:                        17:19:55   Log-Likelihood:                -31.776
No. Observations:                  12   AIC:                             67.55
Df Residuals:                      10   BIC:                             68.52
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
```

```
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          4.5164      1.877      2.406      0.037       0.334       8.698
x1            -0.0839      0.127     -0.658      0.525      -0.368       0.200
==============================================================================
Omnibus:                        1.681   Durbin-Watson:                   1.831
Prob(Omnibus):                  0.432   Jarque-Bera (JB):                0.871
Skew:                           0.203   Prob(JB):                        0.647
Kurtosis:                       1.744   Cond. No.                         25.7
==============================================================================

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

/anaconda3/lib/python3.6/site-packages/scipy/stats/stats.py:1604: UserWarning:
kurtosistest only valid for n>=20 ... continuing anyway, n=12
  "anyway, n=%i" % int(n))
```

[230]:
```
# plt.scatter(covid_positive_election_day_battleground,␣
 ↪result_election_day_battleground, alpha=0.5)

# result_election_day

fig, ax = plt.subplots(figsize = (10,5))

ax.scatter(covid_positive_election_day_battleground,␣
 ↪result_election_day_battleground, alpha=0.5)

for i, txt in enumerate(states_election_day_battleground):
    ax.annotate(txt, (covid_positive_election_day_battleground[i],␣
 ↪result_election_day_battleground[i]), alpha =0.7)


results = sm.OLS(result_election_day_battleground, sm.
 ↪add_constant(covid_positive_election_day_battleground)).fit()

X_plot = np.linspace(0, 50, 501)
a = results.params[1]
b = results.params[0]
Y_plot = X_plot*a + b
Y_flat = [0]*len(X_plot)

plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a,2)}*x + {np.
 ↪round(b,2)}", alpha=0.8)
plt.plot(X_plot, Y_flat, 'b-', label="DEM tie with REP in Election Result",␣
 ↪alpha=0.6)
```

```
plt.legend(loc="upper right")
plt.xlabel("Covid daily postive rate on Election Day (rolling 7 day avg) %")
plt.ylabel("Election Result of DEM Lead (DEM - REP) (7 day rolling avg) (%)")
plt.title("2020-11-03 Election Final Result: DEM Lead (DEM - REP) vs. Covid-19␣
 ↪Positive Rate (7 day rolling avg)")

plt.show()

print(results.params)
print(results.summary())
```

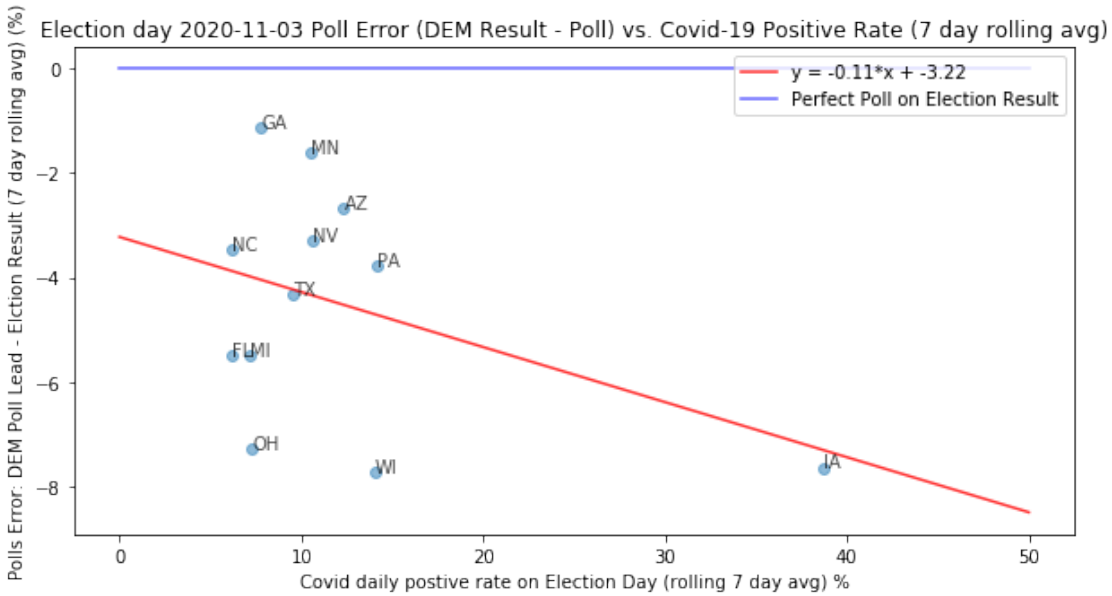



```
[ 1.2931866  -0.18947101]
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.135
Model:                            OLS   Adj. R-squared:                  0.048
Method:                 Least Squares   F-statistic:                     1.556
Date:                Sat, 12 Dec 2020   Prob (F-statistic):              0.241
Time:                        17:20:04   Log-Likelihood:                -33.883
No. Observations:                  12   AIC:                             71.77
Df Residuals:                      10   BIC:                             72.74
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
```

```
------------------------------------------------------------------------------
const          1.2932      2.237      0.578      0.576      -3.692       6.278
x1            -0.1895      0.152     -1.247      0.241      -0.528       0.149
==============================================================================
Omnibus:                        0.228   Durbin-Watson:                   2.003
Prob(Omnibus):                  0.892   Jarque-Bera (JB):                0.111
Skew:                          -0.160   Prob(JB):                        0.946
Kurtosis:                       2.654   Cond. No.                         25.7
==============================================================================

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

/anaconda3/lib/python3.6/site-packages/scipy/stats/stats.py:1604: UserWarning:
kurtosistest only valid for n>=20 ... continuing anyway, n=12
  "anyway, n=%i" % int(n))
```

[231]:
```
fig, ax = plt.subplots(figsize = (10,5))

ax.scatter(covid_positive_election_day_battleground,␣
 ↪poll_error_election_day_battleground, alpha=0.5)

for i, txt in enumerate(states_election_day_battleground):
    ax.annotate(txt, (covid_positive_election_day_battleground[i],␣
 ↪poll_error_election_day_battleground[i]), alpha =0.7)


results2 = sm.OLS(poll_error_election_day_battleground, sm.
 ↪add_constant(covid_positive_election_day_battleground)).fit()

X_plot = np.linspace(0, 50, 501)
a2 = results2.params[1]
b2 = results2.params[0]
Y_plot = X_plot*a2 + b2
Y_flat = [0]*len(X_plot)

plt.plot(X_plot, Y_plot, 'r-', label=f"y = {np.round(a2,2)}*x + {np.
 ↪round(b2,2)}", alpha=0.8)
plt.plot(X_plot, Y_flat, 'b-', label="Perfect Poll on Election Result", alpha=0.
 ↪6)


plt.legend(loc="upper right")
plt.xlabel("Covid daily postive rate on Election Day (rolling 7 day avg) %")
plt.ylabel("Polls Error: DEM Poll Lead - Elction Result (7 day rolling avg)␣
 ↪(%)")
```

```
plt.title("Election day 2020-11-03 Poll Error (DEM Result - Poll) vs. Covid-19␣
 ↪Positive Rate (7 day rolling avg)")

plt.show()

print(results2.params)
print(results2.summary())
```




```
[-3.22321693 -0.10558112]
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.171
Model:                            OLS   Adj. R-squared:                  0.088
Method:                 Least Squares   F-statistic:                     2.062
Date:                Sat, 12 Dec 2020   Prob (F-statistic):              0.182
Time:                        17:20:12   Log-Likelihood:                -25.178
No. Observations:                  12   AIC:                             54.36
Df Residuals:                      10   BIC:                             55.33
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -3.2232      1.083     -2.976      0.014      -5.636      -0.810
x1            -0.1056      0.074     -1.436      0.182      -0.269       0.058
==============================================================================
Omnibus:                        0.711   Durbin-Watson:                   2.303
```

```
Prob(Omnibus):                  0.701   Jarque-Bera (JB):                 0.621
Skew:                          -0.204   Prob(JB):                         0.733
Kurtosis:                       1.963   Cond. No.                         25.7
==============================================================================

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

/anaconda3/lib/python3.6/site-packages/scipy/stats/stats.py:1604: UserWarning:
kurtosistest only valid for n>=20 ... continuing anyway, n=12
  "anyway, n=%i" % int(n))
```

[789]:
```
demographic_tigeryi.head()
```

[789]:

	county	state_code	percentage16_Donald_Trump	\
0	Abbeville	SC	62.868333	
1	Acadia	LA	77.262105	
2	Accomack	VA	54.471596	
3	Ada	ID	47.931611	
4	Adair	IA	65.336526	

	percentage16_Hillary_Clinton	total_votes16	votes16_Donald_Trump	\
0	34.613950	10724.0	6742.0	
1	20.587161	27386.0	21159.0	
2	42.761028	15755.0	8582.0	
3	38.691733	195587.0	93748.0	
4	29.981378	3759.0	2456.0	

	votes16_Hillary_Clinton	percentage20_Donald_Trump	percentage20_Joe_Biden	\
0	3712.0	66.074157	32.984799	
1	5638.0	79.493404	19.148637	
2	6737.0	54.150431	44.739639	
3	75676.0	50.387256	46.470359	
4	1127.0	69.734640	28.615826	

	total_votes20	...	state	cases	deaths	dem_16_margin	\
0	12433.0	...	South Carolina	808.0	18.0	-28.254383	
1	28425.0	...	Louisiana	3291.0	103.0	-56.674943	
2	16938.0	...	Virginia	1229.0	19.0	-11.710568	
3	259389.0	...	Idaho	17828.0	184.0	-9.239878	
4	4183.0	...	Iowa	250.0	1.0	-35.355148	

	dem_20_margin	dem_margin_shift	cases_rate	deaths_rate	men_percent	\
0	-33.089359	-4.834976	3.259642	0.072616	48.588026	
1	-60.344767	-3.669824	5.256601	0.164518	48.609580	
2	-9.410792	2.299776	3.742387	0.057856	48.961632	
3	-3.916897	5.322981	4.097289	0.042287	50.101237	

```
4     -41.118814         -5.763667    3.476085     0.013904    49.388209

   women_percent
0      51.411974
1      51.390420
2      51.038368
3      49.898763
4      50.611791

[5 rows x 58 columns]
```

[238]:
```
scaler = MinMaxScaler()
```

[796]:
```
vars_to_merge = [x for x in demographic_tigeryi.columns if x not in ['state',␣
 ↪'county','state_code']]

df = pd.DataFrame(demographic_tigeryi.groupby(['state',␣
 ↪'county'])[vars_to_merge].sum())

df.head(5)
```

[796]:
```
                percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                 73.435789                     23.956855
        Baldwin                 77.351472                     19.565310
        Barbour                 52.271415                     46.660250
        Bibb                    76.966164                     21.422039
        Blount                  89.851875                      8.469902

                total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga       24661.0               18110.0                   5908.0
        Baldwin       94090.0               72780.0                  18409.0
        Barbour       10390.0                5431.0                   4848.0
        Bibb           8748.0                6733.0                   1874.0
        Blount        25384.0               22808.0                   2150.0

                percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                 71.507652               26.954666
        Baldwin                 76.235715               22.345220
        Barbour                 53.600459               45.634503
        Bibb                    78.428915               20.704064
        Blount                  89.569904                9.566991

                total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                           ...
Alabama Autauga       27639.0               19764.0             7450.0  ...
```

```
         Baldwin       108945.0              83055.0            24344.0  ...
         Barbour        10457.0               5605.0             4772.0  ...
         Bibb            9573.0               7508.0             1982.0  ...
         Blount         27459.0              24595.0             2627.0  ...

                  Unemployment   cases  deaths  dem_16_margin  dem_20_margin  \
state   county
Alabama Autauga           5.2  2210.0    31.0     -49.478934     -44.552987
        Baldwin           5.5  7054.0    74.0     -57.786162     -53.890495
        Barbour          12.4  1077.0     9.0      -5.611165      -7.965956
        Bibb              8.2   900.0    15.0     -55.544124     -57.724851
        Blount            4.9  2204.0    25.0     -81.381973     -80.002913

                  dem_margin_shift  cases_rate  deaths_rate  men_percent  \
state   county
Alabama Autauga           4.925948    4.015553     0.056327    48.875282
        Baldwin           3.895667    3.468725     0.036389    48.941286
        Barbour          -2.354791    4.110530     0.034350    53.341476
        Bibb             -2.180727    3.985828     0.066430    54.255979
        Blount            1.379059    3.821943     0.043352    49.404339

                  women_percent
state   county
Alabama Autauga       51.124718
        Baldwin       51.058714
        Barbour       46.658524
        Bibb          45.744021
        Blount        50.595661

[5 rows x 55 columns]
```

[797]:
```
df = df.drop(['dem_16_margin', 'dem_20_margin', 'dem_margin_shift'], axis=1)
df.head()
```

[797]:
```
                  percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                   73.435789                     23.956855
        Baldwin                   77.351472                     19.565310
        Barbour                   52.271415                     46.660250
        Bibb                      76.966164                     21.422039
        Blount                    89.851875                      8.469902

                  total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga         24661.0               18110.0                   5908.0
        Baldwin         94090.0               72780.0                  18409.0
        Barbour         10390.0                5431.0                   4848.0
        Bibb             8748.0                6733.0                   1874.0
```

```
        Blount         25384.0              22808.0                   2150.0

                percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                 71.507652               26.954666
        Baldwin                 76.235715               22.345220
        Barbour                 53.600459               45.634503
        Bibb                    78.428915               20.704064
        Blount                  89.569904                9.566991

                total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                           ...
Alabama Autauga       27639.0               19764.0             7450.0  ...
        Baldwin      108945.0               83055.0            24344.0  ...
        Barbour       10457.0                5605.0             4772.0  ...
        Bibb           9573.0                7508.0             1982.0  ...
        Blount        27459.0               24595.0             2627.0  ...

                PublicWork  SelfEmployed  FamilyWork  Unemployment   cases  \
state   county
Alabama Autauga        20.2           5.6         0.1           5.2  2210.0
        Baldwin        12.9           6.3         0.1           5.5  7054.0
        Barbour        19.1           6.5         0.3          12.4  1077.0
        Bibb           17.4           6.3         0.3           8.2   900.0
        Blount         11.9           4.0         0.1           4.9  2204.0

                deaths  cases_rate  deaths_rate  men_percent  women_percent
state   county
Alabama Autauga   31.0    4.015553     0.056327    48.875282      51.124718
        Baldwin   74.0    3.468725     0.036389    48.941286      51.058714
        Barbour    9.0    4.110530     0.034350    53.341476      46.658524
        Bibb      15.0    3.985828     0.066430    54.255979      45.744021
        Blount    25.0    3.821943     0.043352    49.404339      50.595661

[5 rows x 52 columns]
```

[798]:
```
df = df.drop(['lat', 'long'], axis=1)

df.head()
```

[798]:
```
                percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                 73.435789                     23.956855
        Baldwin                 77.351472                     19.565310
        Barbour                 52.271415                     46.660250
        Bibb                    76.966164                     21.422039
        Blount                  89.851875                      8.469902
```

```
                 total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga        24661.0               18110.0                   5908.0
        Baldwin        94090.0               72780.0                  18409.0
        Barbour        10390.0                5431.0                   4848.0
        Bibb            8748.0                6733.0                   1874.0
        Blount         25384.0               22808.0                   2150.0

                 percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                  71.507652               26.954666
        Baldwin                  76.235715               22.345220
        Barbour                  53.600459               45.634503
        Bibb                     78.428915               20.704064
        Blount                   89.569904                9.566991

                 total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                            ...
Alabama Autauga        27639.0               19764.0             7450.0  ...
        Baldwin       108945.0               83055.0            24344.0  ...
        Barbour        10457.0                5605.0             4772.0  ...
        Bibb            9573.0                7508.0             1982.0  ...
        Blount         27459.0               24595.0             2627.0  ...

                 PublicWork  SelfEmployed  FamilyWork  Unemployment   cases  \
state   county
Alabama Autauga        20.2           5.6         0.1           5.2  2210.0
        Baldwin        12.9           6.3         0.1           5.5  7054.0
        Barbour        19.1           6.5         0.3          12.4  1077.0
        Bibb           17.4           6.3         0.3           8.2   900.0
        Blount         11.9           4.0         0.1           4.9  2204.0

                 deaths  cases_rate  deaths_rate  men_percent  women_percent
state   county
Alabama Autauga    31.0    4.015553     0.056327    48.875282      51.124718
        Baldwin    74.0    3.468725     0.036389    48.941286      51.058714
        Barbour     9.0    4.110530     0.034350    53.341476      46.658524
        Bibb       15.0    3.985828     0.066430    54.255979      45.744021
        Blount     25.0    3.821943     0.043352    49.404339      50.595661

[5 rows x 50 columns]
```

[799]:
```
df = df.drop(["Men", "Women", "VotingAgeCitizen", "Employed",
 "Income","IncomeErr","IncomePerCap", "IncomePerCapErr",
 "cases", "deaths", "TotalPop", "VotingAgeCitizen", "Employed"], axis=1)
df.head()
```

[799]:

state	county	percentage16_Donald_Trump	percentage16_Hillary_Clinton	\
Alabama	Autauga	73.435789	23.956855	
	Baldwin	77.351472	19.565310	
	Barbour	52.271415	46.660250	
	Bibb	76.966164	21.422039	
	Blount	89.851875	8.469902	

state	county	total_votes16	votes16_Donald_Trump	votes16_Hillary_Clinton	\
Alabama	Autauga	24661.0	18110.0	5908.0	
	Baldwin	94090.0	72780.0	18409.0	
	Barbour	10390.0	5431.0	4848.0	
	Bibb	8748.0	6733.0	1874.0	
	Blount	25384.0	22808.0	2150.0	

state	county	percentage20_Donald_Trump	percentage20_Joe_Biden	\
Alabama	Autauga	71.507652	26.954666	
	Baldwin	76.235715	22.345220	
	Barbour	53.600459	45.634503	
	Bibb	78.428915	20.704064	
	Blount	89.569904	9.566991	

state	county	total_votes20	votes20_Donald_Trump	votes20_Joe_Biden	...	\
					...	
Alabama	Autauga	27639.0	19764.0	7450.0	...	
	Baldwin	108945.0	83055.0	24344.0	...	
	Barbour	10457.0	5605.0	4772.0	...	
	Bibb	9573.0	7508.0	1982.0	...	
	Blount	27459.0	24595.0	2627.0	...	

state	county	MeanCommute	PrivateWork	PublicWork	SelfEmployed	\
Alabama	Autauga	25.8	74.1	20.2	5.6	
	Baldwin	27.0	80.7	12.9	6.3	
	Barbour	23.4	74.1	19.1	6.5	
	Bibb	30.0	76.0	17.4	6.3	
	Blount	35.0	83.9	11.9	4.0	

state	county	FamilyWork	Unemployment	cases_rate	deaths_rate	\
Alabama	Autauga	0.1	5.2	4.015553	0.056327	
	Baldwin	0.1	5.5	3.468725	0.036389	
	Barbour	0.3	12.4	4.110530	0.034350	
	Bibb	0.3	8.2	3.985828	0.066430	
	Blount	0.1	4.9	3.821943	0.043352	

```
                men_percent  women_percent
state   county
Alabama Autauga    48.875282      51.124718
        Baldwin    48.941286      51.058714
        Barbour    53.341476      46.658524
        Bibb       54.255979      45.744021
        Blount     49.404339      50.595661

[5 rows x 39 columns]
```

[800]:
```
df.to_csv("df_tigeryi.csv", index=False)
```

[605]:
```
# df = pd.read_csv("df_tigeryi.csv", index_col=False)
```

[801]:
```
df.head()
```

[801]:
```
                percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                 73.435789                     23.956855
        Baldwin                 77.351472                     19.565310
        Barbour                 52.271415                     46.660250
        Bibb                    76.966164                     21.422039
        Blount                  89.851875                      8.469902

                total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga       24661.0               18110.0                   5908.0
        Baldwin       94090.0               72780.0                  18409.0
        Barbour       10390.0                5431.0                   4848.0
        Bibb           8748.0                6733.0                   1874.0
        Blount        25384.0               22808.0                   2150.0

                percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                 71.507652               26.954666
        Baldwin                 76.235715               22.345220
        Barbour                 53.600459               45.634503
        Bibb                    78.428915               20.704064
        Blount                  89.569904                9.566991

                total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                           ...
Alabama Autauga       27639.0               19764.0             7450.0  ...
        Baldwin      108945.0               83055.0            24344.0  ...
        Barbour       10457.0                5605.0             4772.0  ...
        Bibb           9573.0                7508.0             1982.0  ...
        Blount        27459.0               24595.0             2627.0  ...
```

```
                MeanCommute  PrivateWork  PublicWork  SelfEmployed  \
state   county
Alabama Autauga         25.8         74.1        20.2           5.6
        Baldwin         27.0         80.7        12.9           6.3
        Barbour         23.4         74.1        19.1           6.5
        Bibb            30.0         76.0        17.4           6.3
        Blount          35.0         83.9        11.9           4.0

                FamilyWork  Unemployment  cases_rate  deaths_rate  \
state   county
Alabama Autauga         0.1           5.2    4.015553     0.056327
        Baldwin         0.1           5.5    3.468725     0.036389
        Barbour         0.3          12.4    4.110530     0.034350
        Bibb            0.3           8.2    3.985828     0.066430
        Blount          0.1           4.9    3.821943     0.043352

                men_percent  women_percent
state   county
Alabama Autauga    48.875282      51.124718
        Baldwin    48.941286      51.058714
        Barbour    53.341476      46.658524
        Bibb       54.255979      45.744021
        Blount     49.404339      50.595661

[5 rows x 39 columns]
```

[802]:
```
# min max scaling
df_final = minmax_scaling(df, columns=df.columns)
df_final.head()
```

[802]:
```
                percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                   0.748799                      0.241484
        Baldwin                   0.793843                      0.190529
        Barbour                   0.505335                      0.504911
        Bibb                      0.789411                      0.212072
        Blount                    0.937641                      0.061789

                total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga      0.010629              0.030577                 0.003568
        Baldwin      0.040630              0.123174                 0.011123
        Barbour      0.004462              0.009102                 0.002928
        Bibb         0.003752              0.011307                 0.001130
        Blount       0.010941              0.038534                 0.001297

                percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
```

```
Alabama Autauga                  0.717614                0.275705
        Baldwin                  0.771725                0.222451
        Barbour                  0.512673                0.491519
        Bibb                     0.796825                0.203490
        Blount                   0.924329                0.074820

                total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                           ...
Alabama Autauga      0.006660              0.017799           0.002526  ...
        Baldwin      0.026300              0.074971           0.008258  ...
        Barbour      0.002510              0.005009           0.001618  ...
        Bibb         0.002296              0.006728           0.000671  ...
        Blount       0.006617              0.022163           0.000890  ...

                MeanCommute  PrivateWork  PublicWork  SelfEmployed  \
state   county
Alabama Autauga     0.483957     0.740741    0.293135      0.147368
        Baldwin     0.516043     0.857143    0.157699      0.165789
        Barbour     0.419786     0.740741    0.272727      0.171053
        Bibb        0.596257     0.774250    0.241187      0.165789
        Blount      0.729947     0.913580    0.139147      0.105263

                FamilyWork  Unemployment  cases_rate  deaths_rate  \
state   county
Alabama Autauga      0.0125      0.181185    0.194740     0.088130
        Baldwin      0.0125      0.191638    0.168221     0.056934
        Barbour      0.0375      0.432056    0.199346     0.053744
        Bibb         0.0375      0.285714    0.193298     0.103938
        Blount       0.0125      0.170732    0.185351     0.067830

                men_percent  women_percent
state   county
Alabama Autauga     0.147038       0.852962
        Baldwin     0.148800       0.851200
        Barbour     0.266240       0.733760
        Bibb        0.290647       0.709353
        Blount      0.161159       0.838841

[5 rows x 39 columns]
```

[803]:
```
votes_perc = df[['percentage20_Donald_Trump', 'percentage20_Joe_Biden',
                 'votes20_Donald_Trump', 'votes20_Joe_Biden']].columns
```

[804]:
```
PearsonCorr = df_final.corr(method="pearson")
```

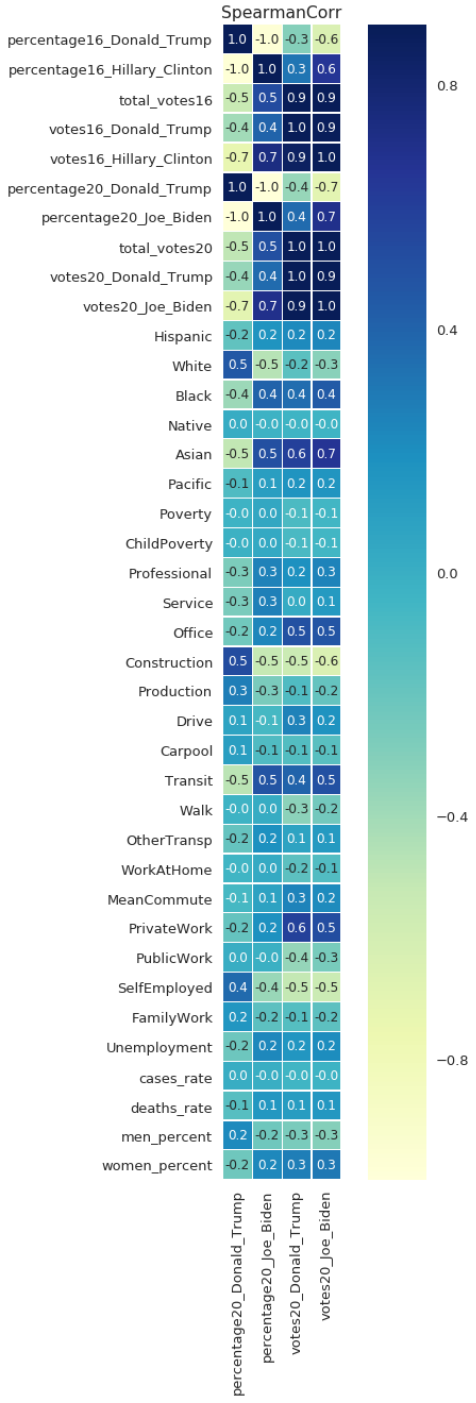
[805]:
```
Pearson = PearsonCorr[votes_perc]
```

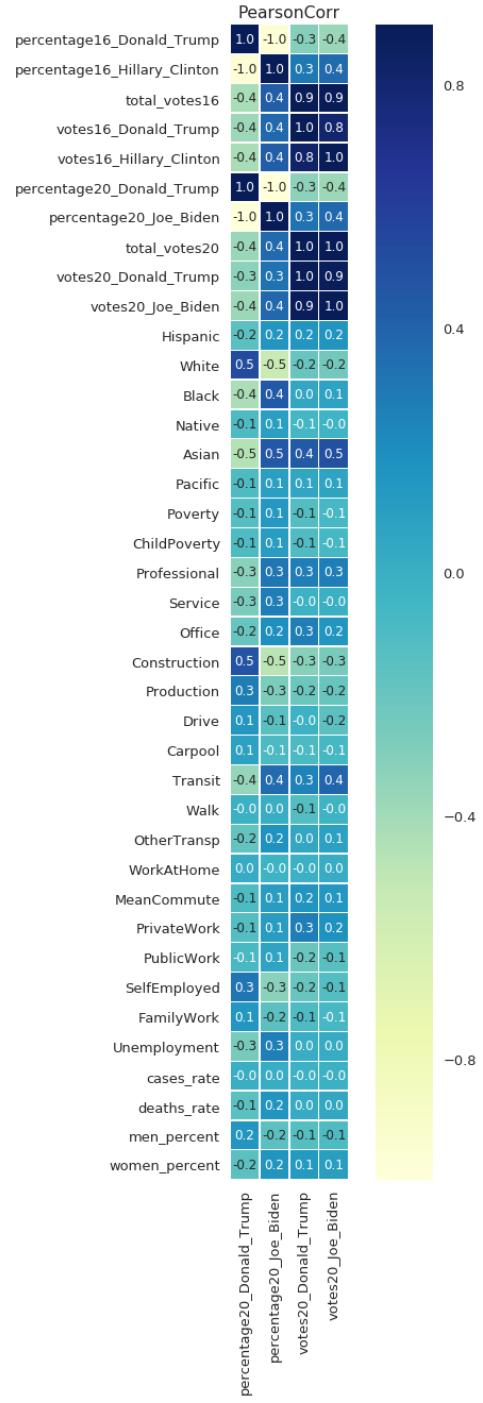
[806]:
```
SpearmanCorr = df_final.corr(method="spearman")
```

[807]:
```
Spear = SpearmanCorr[votes_perc]
```

[808]:
```
# Correlation Diagram

plt.subplots(figsize = (20,20))

plt.subplot(1,2,1)

plt.title("SpearmanCorr")

ax1 = sns.heatmap(Spear, vmax=.9, square=True, annot=True, linewidths=.3,␣
 ↪cmap="YlGnBu", fmt='.1f')

plt.subplot(1,2,2)

plt.title("PearsonCorr")

ax2 = sns.heatmap(Pearson, vmax=.9, square=True, annot=True, linewidths=.3,␣
 ↪cmap="YlGnBu", fmt='.1f')

plt.show()
```

```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```





[809]:
```
votes = df_final.iloc[:,0:10].columns
votes
```

[809]:
```
Index(['percentage16_Donald_Trump', 'percentage16_Hillary_Clinton',
       'total_votes16', 'votes16_Donald_Trump', 'votes16_Hillary_Clinton',
       'percentage20_Donald_Trump', 'percentage20_Joe_Biden', 'total_votes20',
```

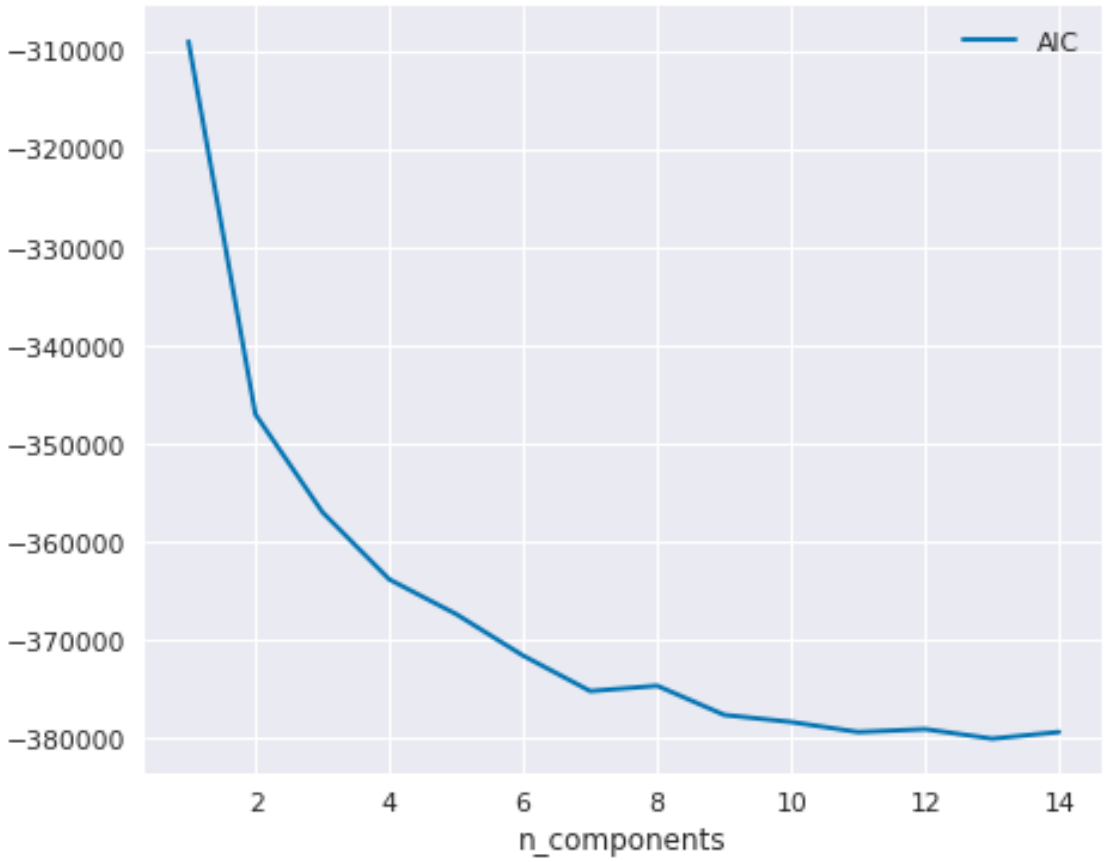
```
       'votes20_Donald_Trump', 'votes20_Joe_Biden'],
      dtype='object')
```

[810]:
```
factors =  [x for x in df.columns if x not in votes]
```

[811]:
```
# GM clustering

X = df_final[factors].values

GM_n_components = np.arange(1, 15)
GM_models = [GaussianMixture(n, covariance_type='full', random_state=0).fit(X)␣
 ↪for n in GM_n_components]

plt.figure(num=None, figsize=(8, 6), dpi=60, facecolor='w', edgecolor='r')
plt.plot(GM_n_components, [m.aic(X) for m in GM_models], label='AIC')
plt.tight_layout()
plt.legend(loc='best')
plt.xlabel('n_components')
```

```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```

[811]:
```
Text(0.5,24.0833,'n_components')
```



[812]:
```
# GM clustering - Gaussian Mixture Model

GM_n_classes = 2

GMcluster = GaussianMixture(n_components=GM_n_classes,␣
 ↪covariance_type='full',random_state = 0)

GMcluster_fit = GMcluster.fit(df_final)

GMlabels = GMcluster_fit.predict(df_final)

print('Number of clusters: ' + format(len(np.unique(GMlabels))))
```

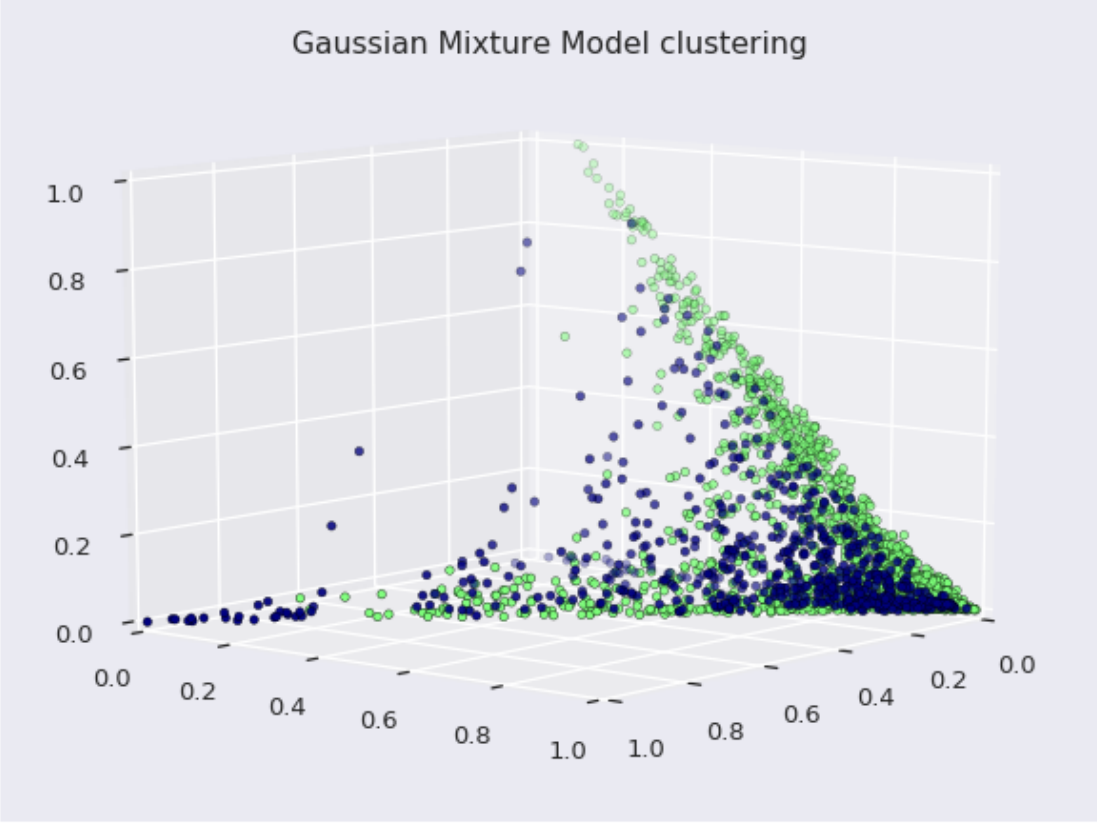
```
Number of clusters: 2
```

[813]:
```
unique, counts = np.unique(GMlabels, return_counts=True)
dict(zip(unique, counts))
```

[813]:
```
{0: 652, 1: 2303}
```

[822]:
```
# GM clustering - Gaussian Mixture Model

fig = plt.figure(figsize=(8, 6),facecolor='w', edgecolor='r')
ax = Axes3D(fig, rect = (1, 1, 1, 1))
ax.set_xlim3d(0, 1)
ax.set_ylim3d(0, 1)
ax.set_zlim3d(0, 1)
ax.view_init(10, 40)
for l in np.unique(GMlabels):
    ax.scatter(X[GMlabels == l, 0], X[GMlabels == l, 1], X[GMlabels == l, 2],
               color=plt.cm.jet(float(l) / np.max(GMlabels + 1)),s=20,␣
 ↪edgecolor='k')
plt.title('Gaussian Mixture Model clustering' )

plt.show()
```

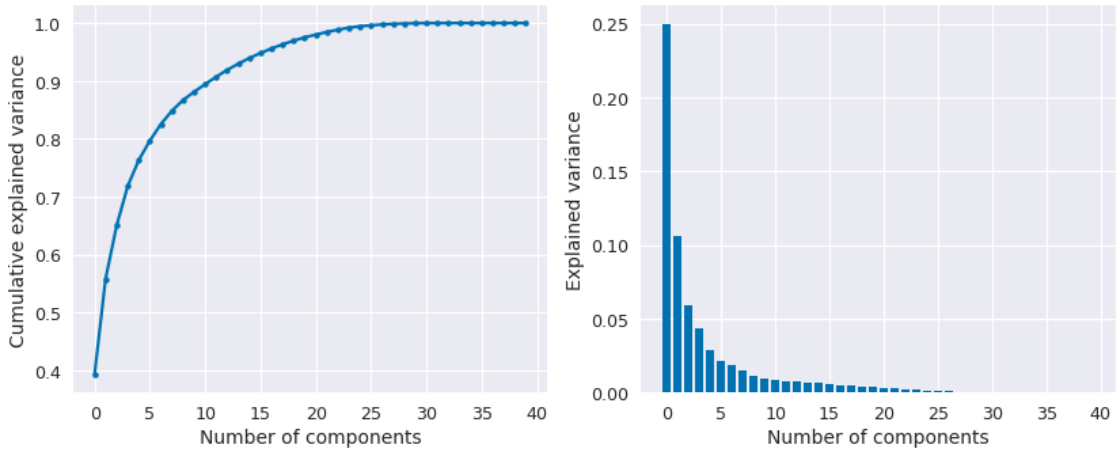
```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```



[823]:
```
df_final['Party_Cluster'] = GMlabels
```

[824]:
```
pca = PCA().fit(df_final)

fig, axes = plt.subplots(nrows=1, ncols=2, figsize=(12, 5), dpi=70,␣
 ↪facecolor='w', edgecolor='k')
ax0, ax1 = axes.flatten()

sns.set('talk', palette='colorblind')

font = {'family' : 'normal',
        'weight' : 'normal',
        'size'   : 12}

matplotlib.rc('font', **font)

ax0.plot(np.cumsum(pca.explained_variance_ratio_), marker='.')
ax0.set_xlabel('Number of components')
ax0.set_ylabel('Cumulative explained variance');

ax1.bar(range(df_final.shape[1]),pca.explained_variance_)
ax1.set_xlabel('Number of components')
ax1.set_ylabel('Explained variance');

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

```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```

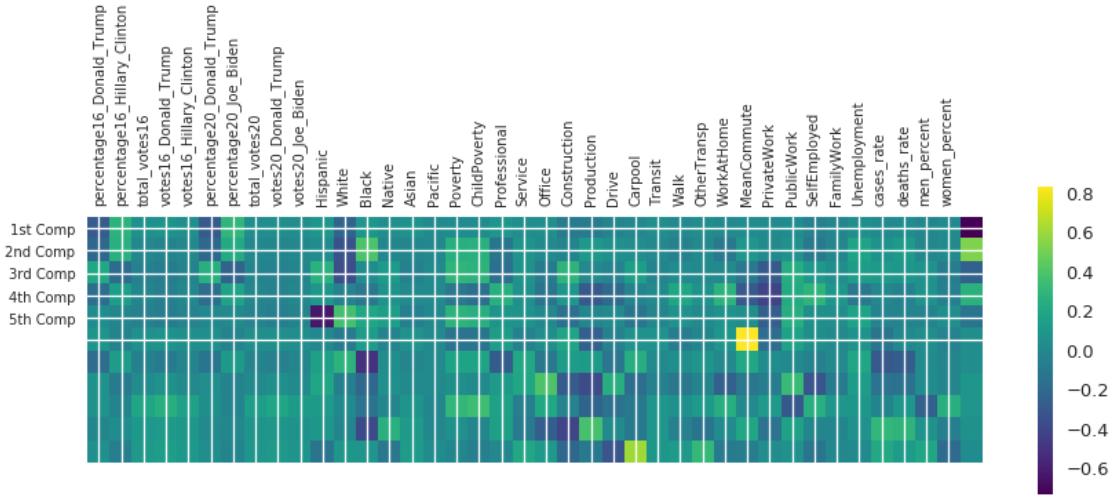


[825]:
```
n_PCA_90 = np.size(np.cumsum(pca.explained_variance_ratio_)>0.9) - np.
 ↪count_nonzero(np.cumsum(pca.explained_variance_ratio_)>0.9)

print("Need: " + format(n_PCA_90) + " components to cover 90% of variance.")
```

```
Need: 11 components to cover 90% of variance.
```

[826]:
```
pca = PCA(11).fit(df_final)

X_pca=pca.transform(df_final)

plt.matshow(pca.components_,cmap='viridis')
plt.yticks([0,1,2,3,4,5],['1st Comp','2nd Comp','3rd Comp','4th Comp','5th␣
 ↪Comp'],fontsize=10)
plt.colorbar()
plt.xticks(range(len(df.columns)),df.columns,fontsize=10,rotation=90)
plt.tight_layout()
plt.show()
```

```
/anaconda3/lib/python3.6/site-packages/matplotlib/figure.py:2022: UserWarning:
This figure includes Axes that are not compatible with tight_layout, so results
might be incorrect.
  warnings.warn("This figure includes Axes that are not compatible "
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```



[827]:
```
PCA_vars = [0]*len(df_final.columns)

def ExtractColumn(lst,j):
    return [item[j] for item in lst]

for i, feature in zip(range(len(df.columns)),df.columns):
    x = ExtractColumn(pca.components_,i-1)
    if ((max(x) > 0.2) | (min(x) < -0.2)):
        if abs(max(x)) > abs(min(x)):
            PCA_vars[i] = max(x)
        else:
            PCA_vars[i] = min(x)
    else:
        PCA_vars[i] = 0

PCA_vars = pd.DataFrame(list(zip(df_final.
 ↪columns,PCA_vars)),columns=('Name','Max absolute␣
 ↪contribution'),index=range(1,41,1))
PCA_vars = (PCA_vars[(PCA_vars['Max absolute contribution']!=0)]).
 ↪sort_values(by='Max absolute contribution',ascending=False)
PCA_vars
```

[827]:

	Name	Max absolute contribution
31	PrivateWork	0.828690
26	Transit	0.605653
22	Construction	0.393574
24	Drive	0.373126
13	Black	0.369373
19	Professional	0.341196
33	SelfEmployed	0.317437
29	WorkAtHome	0.304277
37	deaths_rate	0.302476
18	ChildPoverty	0.302208
8	total_votes20	0.294081
38	men_percent	0.279977
3	total_votes16	0.278326
30	MeanCommute	0.274190
15	Asian	0.257044
5	votes16_Hillary_Clinton	0.248183
21	Office	0.203204
39	women_percent	-0.252851
20	Service	-0.275662
2	percentage16_Hillary_Clinton	-0.289022
7	percentage20_Joe_Biden	-0.294472
34	FamilyWork	-0.323693
25	Carpool	-0.323823
23	Production	-0.406732

```
32                    PublicWork                -0.413831
14                        Native                -0.514235
12                         White                -0.636059
1       percentage16_Donald_Trump                -0.735241
```

[828]:
```
df_final.head()
```

[828]:
```
                 percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                   0.748799                      0.241484
        Baldwin                   0.793843                      0.190529
        Barbour                   0.505335                      0.504911
        Bibb                      0.789411                      0.212072
        Blount                    0.937641                      0.061789

                 total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga       0.010629              0.030577                 0.003568
        Baldwin       0.040630              0.123174                 0.011123
        Barbour       0.004462              0.009102                 0.002928
        Bibb          0.003752              0.011307                 0.001130
        Blount        0.010941              0.038534                 0.001297

                 percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                   0.717614                0.275705
        Baldwin                   0.771725                0.222451
        Barbour                   0.512673                0.491519
        Bibb                      0.796825                0.203490
        Blount                    0.924329                0.074820

                 total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                            ...
Alabama Autauga       0.006660              0.017799           0.002526  ...
        Baldwin       0.026300              0.074971           0.008258  ...
        Barbour       0.002510              0.005009           0.001618  ...
        Bibb          0.002296              0.006728           0.000671  ...
        Blount        0.006617              0.022163           0.000890  ...

                 PrivateWork  PublicWork  SelfEmployed  FamilyWork  \
state   county
Alabama Autauga     0.740741    0.293135      0.147368      0.0125
        Baldwin     0.857143    0.157699      0.165789      0.0125
        Barbour     0.740741    0.272727      0.171053      0.0375
        Bibb        0.774250    0.241187      0.165789      0.0375
        Blount      0.913580    0.139147      0.105263      0.0125

                 Unemployment  cases_rate  deaths_rate  men_percent  \
```

```
state   county
Alabama Autauga      0.181185    0.194740     0.088130     0.147038
        Baldwin      0.191638    0.168221     0.056934     0.148800
        Barbour      0.432056    0.199346     0.053744     0.266240
        Bibb         0.285714    0.193298     0.103938     0.290647
        Blount       0.170732    0.185351     0.067830     0.161159

                women_percent  Party_Cluster
state   county
Alabama Autauga       0.852962             1
        Baldwin       0.851200             0
        Barbour       0.733760             1
        Bibb          0.709353             1
        Blount        0.838841             1

[5 rows x 40 columns]
```

[829]:
```
df.head()
```

[829]:
```
                percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                 73.435789                     23.956855
        Baldwin                 77.351472                     19.565310
        Barbour                 52.271415                     46.660250
        Bibb                    76.966164                     21.422039
        Blount                  89.851875                      8.469902

                total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga       24661.0               18110.0                   5908.0
        Baldwin       94090.0               72780.0                  18409.0
        Barbour       10390.0                5431.0                   4848.0
        Bibb           8748.0                6733.0                   1874.0
        Blount        25384.0               22808.0                   2150.0

                percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                 71.507652               26.954666
        Baldwin                 76.235715               22.345220
        Barbour                 53.600459               45.634503
        Bibb                    78.428915               20.704064
        Blount                  89.569904                9.566991

                total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                           ...
Alabama Autauga       27639.0               19764.0             7450.0  ...
        Baldwin      108945.0               83055.0            24344.0  ...
        Barbour       10457.0                5605.0             4772.0  ...
```

```
        Bibb            9573.0                7508.0             1982.0  ...
        Blount         27459.0               24595.0             2627.0  ...

                  MeanCommute  PrivateWork  PublicWork  SelfEmployed  \
state   county
Alabama Autauga          25.8         74.1        20.2           5.6
        Baldwin          27.0         80.7        12.9           6.3
        Barbour          23.4         74.1        19.1           6.5
        Bibb             30.0         76.0        17.4           6.3
        Blount           35.0         83.9        11.9           4.0

                  FamilyWork  Unemployment  cases_rate  deaths_rate  \
state   county
Alabama Autauga          0.1           5.2    4.015553     0.056327
        Baldwin          0.1           5.5    3.468725     0.036389
        Barbour          0.3          12.4    4.110530     0.034350
        Bibb             0.3           8.2    3.985828     0.066430
        Blount           0.1           4.9    3.821943     0.043352

                  men_percent  women_percent
state   county
Alabama Autauga     48.875282      51.124718
        Baldwin     48.941286      51.058714
        Barbour     53.341476      46.658524
        Bibb        54.255979      45.744021
        Blount      49.404339      50.595661

[5 rows x 39 columns]
```

[830]:
```
df_null = df[df.isnull().any(axis=1)]
Null_county = np.array(df_null.index.get_level_values('county'))
```

[831]:
```
df_estimation = df.drop(Null_county, level='county')

df_estimation.head()
```

[831]:
```
                  percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                   73.435789                     23.956855
        Baldwin                   77.351472                     19.565310
        Barbour                   52.271415                     46.660250
        Bibb                      76.966164                     21.422039
        Blount                    89.851875                      8.469902

                  total_votes16  votes16_Donald_Trump  votes16_Hillary_Clinton  \
state   county
Alabama Autauga         24661.0               18110.0                   5908.0
        Baldwin         94090.0               72780.0                  18409.0
```

```
        Barbour        10390.0               5431.0                   4848.0
        Bibb            8748.0               6733.0                   1874.0
        Blount         25384.0              22808.0                   2150.0

                 percentage20_Donald_Trump  percentage20_Joe_Biden  \
state   county
Alabama Autauga                  71.507652               26.954666
        Baldwin                  76.235715               22.345220
        Barbour                  53.600459               45.634503
        Bibb                     78.428915               20.704064
        Blount                   89.569904                9.566991

                 total_votes20  votes20_Donald_Trump  votes20_Joe_Biden  ...  \
state   county                                                            ...
Alabama Autauga        27639.0               19764.0             7450.0  ...
        Baldwin       108945.0               83055.0            24344.0  ...
        Barbour        10457.0                5605.0             4772.0  ...
        Bibb            9573.0                7508.0             1982.0  ...
        Blount         27459.0               24595.0             2627.0  ...

                 MeanCommute  PrivateWork  PublicWork  SelfEmployed  \
state   county
Alabama Autauga         25.8         74.1        20.2           5.6
        Baldwin         27.0         80.7        12.9           6.3
        Barbour         23.4         74.1        19.1           6.5
        Bibb            30.0         76.0        17.4           6.3
        Blount          35.0         83.9        11.9           4.0

                 FamilyWork  Unemployment  cases_rate  deaths_rate  \
state   county
Alabama Autauga         0.1           5.2    4.015553     0.056327
        Baldwin         0.1           5.5    3.468725     0.036389
        Barbour         0.3          12.4    4.110530     0.034350
        Bibb            0.3           8.2    3.985828     0.066430
        Blount          0.1           4.9    3.821943     0.043352

                 men_percent  women_percent
state   county
Alabama Autauga    48.875282      51.124718
        Baldwin    48.941286      51.058714
        Barbour    53.341476      46.658524
        Bibb       54.255979      45.744021
        Blount     49.404339      50.595661

[5 rows x 39 columns]
```

[832]:
```
df_final_estimation = df_final.drop(Null_county, level='county')
df_final_estimation.head()
```

[832]:

state	county	percentage16_Donald_Trump	percentage16_Hillary_Clinton	\
Alabama	Autauga	0.748799	0.241484	
	Baldwin	0.793843	0.190529	
	Barbour	0.505335	0.504911	
	Bibb	0.789411	0.212072	
	Blount	0.937641	0.061789	

state	county	total_votes16	votes16_Donald_Trump	votes16_Hillary_Clinton	\
Alabama	Autauga	0.010629	0.030577	0.003568	
	Baldwin	0.040630	0.123174	0.011123	
	Barbour	0.004462	0.009102	0.002928	
	Bibb	0.003752	0.011307	0.001130	
	Blount	0.010941	0.038534	0.001297	

state	county	percentage20_Donald_Trump	percentage20_Joe_Biden	\
Alabama	Autauga	0.717614	0.275705	
	Baldwin	0.771725	0.222451	
	Barbour	0.512673	0.491519	
	Bibb	0.796825	0.203490	
	Blount	0.924329	0.074820	

state	county	total_votes20	votes20_Donald_Trump	votes20_Joe_Biden	...	\
					...	
Alabama	Autauga	0.006660	0.017799	0.002526	...	
	Baldwin	0.026300	0.074971	0.008258	...	
	Barbour	0.002510	0.005009	0.001618	...	
	Bibb	0.002296	0.006728	0.000671	...	
	Blount	0.006617	0.022163	0.000890	...	

state	county	PrivateWork	PublicWork	SelfEmployed	FamilyWork	\
Alabama	Autauga	0.740741	0.293135	0.147368	0.0125	
	Baldwin	0.857143	0.157699	0.165789	0.0125	
	Barbour	0.740741	0.272727	0.171053	0.0375	
	Bibb	0.774250	0.241187	0.165789	0.0375	
	Blount	0.913580	0.139147	0.105263	0.0125	

state	county	Unemployment	cases_rate	deaths_rate	men_percent	\
Alabama	Autauga	0.181185	0.194740	0.088130	0.147038	
	Baldwin	0.191638	0.168221	0.056934	0.148800	

```
          Barbour      0.432056    0.199346     0.053744     0.266240
          Bibb         0.285714    0.193298     0.103938     0.290647
          Blount       0.170732    0.185351     0.067830     0.161159

                   women_percent  Party_Cluster
state   county
Alabama Autauga         0.852962              1
        Baldwin         0.851200              0
        Barbour         0.733760              1
        Bibb            0.709353              1
        Blount          0.838841              1

[5 rows x 40 columns]
```

[833]:
```
Response_origin = pd.DataFrame(df_estimation['percentage20_Donald_Trump'])

Response_origin.head()
```

[833]:
```
                 percentage20_Donald_Trump
state   county
Alabama Autauga                  71.507652
        Baldwin                  76.235715
        Barbour                  53.600459
        Bibb                     78.428915
        Blount                   89.569904
```

[834]:
```
Response = pd.DataFrame(df_final_estimation['percentage20_Donald_Trump'])
            # + df_final_estimation['percentage16_Donald_Trump']
             #, columns=["Response"])

Response = minmax_scaling(Response, columns=Response.columns)
```

[835]:
```
Response.head()
```

[835]:
```
                 percentage20_Donald_Trump
state   county
Alabama Autauga                   0.717614
        Baldwin                   0.771725
        Barbour                   0.512673
        Bibb                      0.796825
        Blount                    0.924329
```

[836]:
```
votes = df_final.iloc[:,2:10].columns
votes
```

[836]:
```
Index(['total_votes16', 'votes16_Donald_Trump', 'votes16_Hillary_Clinton',
       'percentage20_Donald_Trump', 'percentage20_Joe_Biden', 'total_votes20',
       'votes20_Donald_Trump', 'votes20_Joe_Biden'],
      dtype='object')
```

[837]:
```
df_estimation = df_estimation.drop(votes, axis=1)

df_estimation.head()
```

[837]:

state	county	percentage16_Donald_Trump	percentage16_Hillary_Clinton	Hispanic	White	Black	Native	Asian	Pacific	Poverty	ChildPoverty	...	MeanCommute	PrivateWork	PublicWork	SelfEmployed	FamilyWork	Unemployment	cases_rate	deaths_rate	men_percent	women_percent
Alabama	Autauga	73.435789	23.956855	2.7	75.4	18.9	0.3	0.9	0.0	13.7	20.1	...	25.8	74.1	20.2	5.6	0.1	5.2	4.015553	0.056327	48.875282	51.124718
	Baldwin	77.351472	19.565310	4.4	83.1	9.5	0.8	0.7	0.0	11.8	16.1	...	27.0	80.7	12.9	6.3	0.1	5.5	3.468725	0.036389	48.941286	51.058714
	Barbour	52.271415	46.660250	4.2	45.7	47.8	0.2	0.6	0.0	27.2	44.9	...	23.4	74.1	19.1	6.5	0.3	12.4	4.110530	0.034350	53.341476	46.658524
	Bibb	76.966164	21.422039	2.4	74.6	22.0	0.4	0.0	0.0	15.2	26.6	...	30.0	76.0	17.4	6.3	0.3	8.2	3.985828	0.066430	54.255979	45.744021
	Blount	89.851875	8.469902	9.0	87.4	1.5	0.3	0.1	0.0	15.6	25.4	...	35.0	83.9	11.9	4.0	0.1	4.9	3.821943	0.043352	49.404339	50.595661

[5 rows x 31 columns]

[838]:
```
df_final_estimation = df_final_estimation.drop(votes, axis=1)
```

```
df_final_estimation.head()
```

[838]:
```
                percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state   county
Alabama Autauga                  0.748799                      0.241484
        Baldwin                  0.793843                      0.190529
        Barbour                  0.505335                      0.504911
        Bibb                     0.789411                      0.212072
        Blount                   0.937641                      0.061789

                Hispanic     White     Black    Native     Asian  Pacific  \
state   county
Alabama Autauga  0.027218  0.752515  0.217491  0.003676  0.021531      0.0
        Baldwin  0.044355  0.829980  0.109321  0.009804  0.016746      0.0
        Barbour  0.042339  0.453722  0.550058  0.002451  0.014354      0.0
        Bibb     0.024194  0.744467  0.253165  0.004902  0.000000      0.0
        Blount   0.090726  0.873239  0.017261  0.003676  0.002392      0.0

                 Poverty  ChildPoverty  ...  PrivateWork  PublicWork  \
state   county                          ...
Alabama Autauga  0.227823      0.262745  ...     0.740741    0.293135
        Baldwin  0.189516      0.210458  ...     0.857143    0.157699
        Barbour  0.500000      0.586928  ...     0.740741    0.272727
        Bibb     0.258065      0.347712  ...     0.774250    0.241187
        Blount   0.266129      0.332026  ...     0.913580    0.139147

                SelfEmployed  FamilyWork  Unemployment  cases_rate  \
state   county
Alabama Autauga      0.147368      0.0125      0.181185    0.194740
        Baldwin      0.165789      0.0125      0.191638    0.168221
        Barbour      0.171053      0.0375      0.432056    0.199346
        Bibb         0.165789      0.0375      0.285714    0.193298
        Blount       0.105263      0.0125      0.170732    0.185351

                deaths_rate  men_percent  women_percent  Party_Cluster
state   county
Alabama Autauga     0.088130     0.147038       0.852962              1
        Baldwin     0.056934     0.148800       0.851200              0
        Barbour     0.053744     0.266240       0.733760              1
        Bibb        0.103938     0.290647       0.709353              1
        Blount      0.067830     0.161159       0.838841              1

[5 rows x 32 columns]
```

[839]:
```
x_train,x_test,y_train,y_test = train_test_split(df_final_estimation,␣
↪Response,test_size=0.2,random_state=0)
```

[840]:
```
x_train_origin,x_test_origin,y_train_origin,y_test_origin =␣
↪train_test_split(df_estimation, Response_origin,test_size=0.2,random_state=0)
```

[841]:
```
ModelAverage = y_train.mean()
print(str(round(ModelAverage,5)))
```

```
percentage20_Donald_Trump    0.64985
dtype: float64
```

[842]:
```
ModelAverage_origin = y_train_origin.mean()
print(str(round(ModelAverage,5)))
```

```
percentage20_Donald_Trump    0.64985
dtype: float64
```

[843]:
```
RMSE = y_test
RMSE.insert(1, "Model_Average_Trump", ModelAverage.values[0], True)
y_test=y_test.drop(['Model_Average_Trump'], axis=1)
RMSE.head(5)
```

[843]:

		percentage20_Donald_Trump	Model_Average_Trump
state	county		
New Mexico	De Baca	0.732496	0.649853
Illinois	Saline	0.735554	0.649853
Arkansas	Lafayette	0.649822	0.649853
Colorado	Lincoln	0.820898	0.649853
Minnesota	Martin	0.674376	0.649853

[844]:
```
RMSE_origin = y_test_origin
RMSE_origin.insert(1, "Model_Average_Trump", ModelAverage_origin.values[0],␣
↪True)
y_test_origin=y_test_origin.drop(['Model_Average_Trump'], axis=1)
RMSE_origin.head()
```

[844]:

		percentage20_Donald_Trump	Model_Average_Trump
state	county		
New Mexico	De Baca	72.807991	65.586883
Illinois	Saline	73.075187	65.586883
Arkansas	Lafayette	65.584173	65.586883
Colorado	Lincoln	80.532319	65.586883
Minnesota	Martin	67.729661	65.586883

[845]:
```
y_train.head()
```

[845]:

		percentage20_Donald_Trump
state	county	
Tennessee	Trousdale	0.739445
Missouri	Webster	0.805858
Arkansas	Lawrence	0.792022
Texas	Victoria	0.680401

```
Missouri  Camden                     0.768877
```

[846]:
```
x_train.head()
```

[846]:
```
                    percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state     county
Tennessee Trousdale                  0.672517                      0.311750
Missouri  Webster                    0.788263                      0.184102
Arkansas  Lawrence                   0.726374                      0.221289
Texas     Victoria                   0.691875                      0.294156
Missouri  Camden                     0.771175                      0.209675

                    Hispanic     White     Black    Native     Asian  \
state     county
Tennessee Trousdale  0.011089  0.848089  0.131185  0.001225  0.007177
Missouri  Webster    0.020161  0.944668  0.013809  0.003676  0.007177
Arkansas  Lawrence   0.013105  0.957746  0.010357  0.006127  0.002392
Texas     Victoria   0.463710  0.450704  0.066743  0.001225  0.026316
Missouri  Camden     0.027218  0.944668  0.008055  0.007353  0.014354

                     Pacific   Poverty  ChildPoverty  ...  PrivateWork  \
state     county                                       ...
Tennessee Trousdale  0.000000  0.219758      0.193464  ...     0.779541
Missouri  Webster    0.017544  0.322581      0.333333  ...     0.843034
Arkansas  Lawrence   0.000000  0.322581      0.274510  ...     0.724868
Texas     Victoria   0.000000  0.250000      0.271895  ...     0.853616
Missouri  Camden     0.000000  0.304435      0.372549  ...     0.832451

                    PublicWork  SelfEmployed  FamilyWork  Unemployment  \
state     county
Tennessee Trousdale    0.217069      0.200000      0.0000      0.285714
Missouri  Webster      0.118738      0.242105      0.0125      0.167247
Arkansas  Lawrence     0.282004      0.184211      0.0250      0.285714
Texas     Victoria     0.129870      0.205263      0.0375      0.177700
Missouri  Camden       0.133581      0.236842      0.0125      0.278746

                    cases_rate  deaths_rate  men_percent  women_percent  \
state     county
Tennessee Trousdale    1.000000     0.178344     0.258437       0.741563
Missouri  Webster      0.163471     0.070820     0.204842       0.795158
Arkansas  Lawrence     0.260736     0.205171     0.160591       0.839409
Texas     Victoria     0.229134     0.167543     0.148797       0.851203
Missouri  Camden       0.185639     0.125574     0.170422       0.829578

                    Party_Cluster
state     county
Tennessee Trousdale              1
Missouri  Webster                1
```

```
Arkansas  Lawrence               1
Texas     Victoria               1
Missouri  Camden                 1

[5 rows x 32 columns]
```

[847]:
```
Model_GLM = sm.GLM(y_train, x_train,family=sm.families.Gaussian())

Model_GLM_fit = Model_GLM.fit()
```

[848]:
```
print(Model_GLM_fit.summary())
```

```
                 Generalized Linear Model Regression Results
==============================================================================
=====
Dep. Variable:     percentage20_Donald_Trump   No. Observations:
2364
Model:                                 GLM   Df Residuals:
2332
Model Family:                     Gaussian   Df Model:
31
Link Function:                    identity   Scale:
0.00097887
Method:                               IRLS   Log-Likelihood:
4851.9
Date:                     Sun, 13 Dec 2020   Deviance:
2.2827
Time:                             13:04:33   Pearson chi2:
2.28
No. Iterations:                          3
Covariance Type:                 nonrobust
==============================================================================
================
                                 coef    std err          z      P>|z|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
percentage16_Donald_Trump        0.4892      0.026     19.017      0.000
0.439       0.540
percentage16_Hillary_Clinton    -0.4747      0.027    -17.465      0.000
-0.528      -0.421
Hispanic                         0.0943      0.047      2.012      0.044
0.002       0.186
White                            0.0556      0.047      1.175      0.240
-0.037       0.148
Black                            0.0270      0.042      0.645      0.519
-0.055       0.109
Native                          -0.0064      0.042     -0.154      0.878
```

```
-0.088       0.076
Asian                          -0.0326      0.027     -1.205      0.228
-0.086       0.020
Pacific                         0.0633      0.025      2.510      0.012
0.014       0.113
Poverty                         0.0408      0.015      2.691      0.007
0.011       0.071
ChildPoverty                    0.0019      0.014      0.136      0.892
-0.026       0.030
Professional                   -0.2235      0.567     -0.394      0.693
-1.334       0.888
Service                        -0.1431      0.457     -0.313      0.754
-1.038       0.752
Office                         -0.1084      0.319     -0.340      0.734
-0.733       0.517
Construction                   -0.0678      0.337     -0.201      0.840
-0.728       0.592
Production                     -0.0808      0.479     -0.169      0.866
-1.020       0.859
Drive                          -0.3347      0.858     -0.390      0.696
-2.016       1.346
Carpool                        -0.1261      0.276     -0.457      0.647
-0.667       0.414
Transit                        -0.1564      0.581     -0.269      0.788
-1.296       0.983
Walk                           -0.1470      0.399     -0.369      0.712
-0.928       0.634
OtherTransp                    -0.0788      0.130     -0.607      0.544
-0.333       0.176
WorkAtHome                     -0.1782      0.310     -0.574      0.566
-0.787       0.430
MeanCommute                     0.0145      0.006      2.538      0.011
0.003       0.026
PrivateWork                     0.4182      0.637      0.656      0.512
-0.831       1.667
PublicWork                      0.4304      0.606      0.710      0.478
-0.757       1.618
SelfEmployed                    0.3602      0.427      0.844      0.399
-0.477       1.197
FamilyWork                      0.0704      0.090      0.779      0.436
-0.107       0.248
Unemployment                   -0.0108      0.010     -1.133      0.257
-0.029       0.008
cases_rate                      0.0192      0.010      1.965      0.049
4.84e-05       0.038
deaths_rate                     0.0234      0.009      2.589      0.010
0.006       0.041
men_percent                     0.5352      1.395      0.384      0.701
```

```
-2.199       3.270
women_percent                    0.5200      1.395      0.373      0.709
-2.214       3.254
Party_Cluster                    0.0013      0.002      0.603      0.546
-0.003       0.006
==============================================================================
================
```

[849]:
```
x_test.head()
```

[849]:
```
                       percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state      county
New Mexico De Baca                      0.688302                      0.209676
Illinois   Saline                       0.748617                      0.226992
Arkansas   Lafayette                    0.611379                      0.382623
Colorado   Lincoln                      0.801035                      0.156252
Minnesota  Martin                       0.680014                      0.266416

                       Hispanic     White     Black    Native     Asian  \
state      county
New Mexico De Baca     0.463710  0.519115  0.017261  0.000000  0.000000
Illinois   Saline      0.017137  0.915493  0.039125  0.001225  0.016746
Arkansas   Lafayette   0.012097  0.590543  0.434983  0.003676  0.009569
Colorado   Lincoln     0.228831  0.661972  0.103567  0.012255  0.004785
Minnesota  Martin      0.041331  0.935614  0.003452  0.001225  0.021531

                        Pacific   Poverty  ChildPoverty  ...  PrivateWork  \
state      county                                        ...
New Mexico De Baca     0.000000  0.409274      0.292810  ...     0.499118
Illinois   Saline      0.000000  0.366935      0.352941  ...     0.774250
Arkansas   Lafayette   0.000000  0.431452      0.422222  ...     0.673721
Colorado   Lincoln     0.026316  0.233871      0.197386  ...     0.412698
Minnesota  Martin      0.000000  0.179435      0.198693  ...     0.883598

                       PublicWork  SelfEmployed  FamilyWork  Unemployment  \
state      county
New Mexico De Baca       0.578850      0.105263      0.0000      0.229965
Illinois   Saline        0.241187      0.163158      0.0625      0.393728
Arkansas   Lafayette     0.300557      0.215789      0.1125      0.289199
Colorado   Lincoln       0.458256      0.381579      0.1125      0.128920
Minnesota  Martin        0.081633      0.231579      0.0375      0.108014

                       cases_rate  deaths_rate  men_percent  women_percent  \
state      county
New Mexico De Baca       0.007217     0.000000     0.068498       0.931502
Illinois   Saline        0.133598     0.070449     0.156627       0.843373
Arkansas   Lafayette     0.142374     0.066570     0.152263       0.847737
Colorado   Lincoln       0.021964     0.000000     0.545490       0.454510
```

```
Minnesota  Martin       0.159127     0.140226     0.173469       0.826531

                     Party_Cluster
state      county
New Mexico De Baca               1
Illinois   Saline                1
Arkansas   Lafayette             1
Colorado   Lincoln               1
Minnesota  Martin                1

[5 rows x 32 columns]
```

[850]:
```
y_test.head()
```

[850]:
```
                     percentage20_Donald_Trump
state      county
New Mexico De Baca                    0.732496
Illinois   Saline                     0.735554
Arkansas   Lafayette                  0.649822
Colorado   Lincoln                    0.820898
Minnesota  Martin                     0.674376
```

[851]:
```
RMSE.insert(2, "Model_GLM_Trump", Model_GLM_fit.predict(x_test).values, True)
```

[852]:
```
RMSE.head()
```

[852]:
```
                     percentage20_Donald_Trump  Model_Average_Trump  \
state      county
New Mexico De Baca                    0.732496             0.649853
Illinois   Saline                     0.735554             0.649853
Arkansas   Lafayette                  0.649822             0.649853
Colorado   Lincoln                    0.820898             0.649853
Minnesota  Martin                     0.674376             0.649853

                     Model_GLM_Trump
state      county
New Mexico De Baca          0.737774
Illinois   Saline           0.757657
Arkansas   Lafayette        0.627183
Colorado   Lincoln          0.808537
Minnesota  Martin           0.688849
```

[859]:
```
Model_RLM = sm.RLM(y_train, x_train)

Model_RLM_fit = Model_RLM.fit()
```

[860]:
```
print(Model_RLM_fit.summary())
```

```
                    Robust linear Model Regression Results
==============================================================================
=====
```

```
Dep. Variable:     percentage20_Donald_Trump   No. Observations:
2364
Model:                                 RLM   Df Residuals:
2332
Method:                               IRLS   Df Model:
31
Norm:                              HuberT
Scale Est.:                           mad
Cov Type:                              H1
Date:                  Sun, 13 Dec 2020
Time:                          13:18:53
No. Iterations:                       50
==============================================================================
================
                                 coef    std err          z      P>|z|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
percentage16_Donald_Trump        0.5202      0.017     29.981      0.000
0.486       0.554
percentage16_Hillary_Clinton    -0.4550      0.018    -24.815      0.000
-0.491      -0.419
Hispanic                         0.0097      0.032      0.307      0.758
-0.052       0.072
White                           -0.0070      0.032     -0.218      0.827
-0.069       0.056
Black                           -0.0170      0.028     -0.603      0.546
-0.072       0.038
Native                          -0.0449      0.028     -1.592      0.111
-0.100       0.010
Asian                           -0.0481      0.018     -2.635      0.008
-0.084      -0.012
Pacific                          0.0416      0.017      2.448      0.014
0.008       0.075
Poverty                          0.0226      0.010      2.207      0.027
0.003       0.043
ChildPoverty                     0.0064      0.010      0.661      0.509
-0.012       0.025
Professional                    -0.0436      0.382     -0.114      0.909
-0.793       0.706
Service                          0.0135      0.308      0.044      0.965
-0.590       0.617
Office                          -0.0115      0.215     -0.054      0.957
-0.433       0.410
Construction                     0.0407      0.227      0.179      0.858
-0.404       0.486
Production                       0.0685      0.323      0.212      0.832
-0.565       0.702
```

```
Drive                          -0.3161      0.578     -0.546      0.585
-1.450       0.818
Carpool                        -0.1245      0.186     -0.669      0.503
-0.489       0.240
Transit                        -0.1279      0.392     -0.326      0.744
-0.897       0.641
Walk                           -0.1475      0.269     -0.548      0.583
-0.675       0.380
OtherTransp                    -0.0688      0.088     -0.786      0.432
-0.240       0.103
WorkAtHome                     -0.1633      0.209     -0.780      0.435
-0.574       0.247
MeanCommute                     0.0127      0.004      3.308      0.001
0.005       0.020
PrivateWork                    -0.0477      0.430     -0.111      0.912
-0.890       0.795
PublicWork                     -0.0155      0.409     -0.038      0.970
-0.817       0.786
SelfEmployed                    0.0378      0.288      0.131      0.895
-0.527       0.602
FamilyWork                      0.0110      0.061      0.181      0.856
-0.108       0.131
Unemployment                   -0.0105      0.006     -1.639      0.101
-0.023       0.002
cases_rate                      0.0152      0.007      2.309      0.021
0.002       0.028
deaths_rate                     0.0164      0.006      2.703      0.007
0.005       0.028
men_percent                     0.8277      0.941      0.880      0.379
-1.017       2.672
women_percent                   0.8072      0.941      0.858      0.391
-1.037       2.651
Party_Cluster                   0.0020      0.001      1.345      0.179
-0.001       0.005
==============================================================================
================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[861]:
```
RMSE.insert(3, "Model_RLM_Trump", Model_RLM_fit.predict(x_test).values, True)
```

[862]:
```
RMSE.head()
```

[862]:

state	county	percentage20_Donald_Trump	Model_Average_Trump	\
New Mexico	De Baca	0.732496	0.649853	
Illinois	Saline	0.735554	0.649853	

```
Arkansas    Lafayette                 0.649822            0.649853
Colorado    Lincoln                   0.820898            0.649853
Minnesota   Martin                    0.674376            0.649853
```

```
                      Model_GLM_Trump  Model_RLM_Trump
state       county
New Mexico  De Baca          0.737774         0.728339
Illinois    Saline           0.757657         0.758150
Arkansas    Lafayette        0.627183         0.627234
Colorado    Lincoln          0.808537         0.808237
Minnesota   Martin           0.688849         0.689165
```

[881]:
```
rmse1 = mean_squared_error(RMSE['Model_Average_Trump'],␣
 ↪RMSE['percentage20_Donald_Trump'] ,squared=False)

print("Root mean square error for the average response is: ", rmse1)
```

```
Root mean square error for the average response is:  0.17618438429977545
```

[882]:
```
rmse2 = mean_squared_error(RMSE['Model_GLM_Trump'],␣
 ↪RMSE['percentage20_Donald_Trump'] ,squared=False)


print("Root mean square error by using Generalized Linear Regression Model is:␣
 ↪", rmse2)
```

```
Root mean square error by using Generalized Linear Regression Model is:
0.02857160110101859
```

[899]:
```
rmse3 = mean_squared_error(RMSE['Model_RLM_Trump'],␣
 ↪RMSE['percentage20_Donald_Trump'] ,squared=False)


print("Root mean square error by using Robust Linear Regression Model is: ",␣
 ↪rmse3)
```

```
Root mean square error by using Robust Linear Regression Model is:
0.02850639358265002
```

0.0.1 Not Scaled Model below

[869]:
```
y_train_origin.head()
```

[869]:
```
                     percentage20_Donald_Trump
state      county
Tennessee  Trousdale                  73.415184
Missouri   Webster                    79.218151
```

```
Arkansas  Lawrence                 78.009220
Texas     Victoria                 68.256103
Missouri  Camden                   75.986922
```

[870]:
```
x_train_origin.head()
```

[870]:
```
                   percentage16_Donald_Trump  percentage16_Hillary_Clinton  \
state     county
Tennessee Trousdale                 66.804583                     30.012731
Missouri  Webster                   76.866387                     19.011384
Arkansas  Lawrence                  71.486368                     22.216359
Texas     Victoria                  68.487368                     28.496391
Missouri  Camden                    75.380940                     21.215400

                   Hispanic  White  Black  Native  Asian  Pacific  Poverty  \
state     county
Tennessee Trousdale       1.1   84.9   11.4     0.1    0.3      0.0     13.3
Missouri  Webster         2.0   94.5    1.2     0.3    0.3      0.2     18.4
Arkansas  Lawrence        1.3   95.8    0.9     0.5    0.1      0.0     18.4
Texas     Victoria       46.0   45.4    5.8     0.1    1.1      0.0     14.8
Missouri  Camden          2.7   94.5    0.7     0.6    0.6      0.0     17.5

                   ChildPoverty  ...  MeanCommute  PrivateWork  PublicWork  \
state     county                 ...
Tennessee Trousdale          14.8  ...         29.2         76.3        16.1
Missouri  Webster            25.5  ...         28.9         79.9        10.8
Arkansas  Lawrence           21.0  ...         26.1         73.2        19.6
Texas     Victoria           20.8  ...         20.0         80.5        11.4
Missouri  Camden             28.5  ...         22.4         79.3        11.6

                   SelfEmployed  FamilyWork  Unemployment  cases_rate  \
state     county
Tennessee Trousdale           7.6         0.0           8.2   20.620084
Missouri  Webster             9.2         0.1           4.8    3.370787
Arkansas  Lawrence            7.0         0.2           8.2    5.376408
Texas     Victoria            7.8         0.3           5.1    4.724754
Missouri  Camden              9.0         0.1           8.0    3.827890

                   deaths_rate  men_percent  women_percent
state     county
Tennessee Trousdale     0.113986    53.049128      46.950872
Missouri  Webster       0.045263    51.041056      48.958944
Arkansas  Lawrence      0.131132    49.383084      50.616916
Texas     Victoria      0.107083    48.941192      51.058808
Missouri  Camden        0.080259    49.751421      50.248579

[5 rows x 31 columns]
```

[871]:
```
Model_GLM_origin = sm.GLM(y_train_origin, x_train_origin,family=sm.families.
↪Gaussian())

Model_GLM_fit_origin = Model_GLM_origin.fit()
```

[872]:
```
print(Model_GLM_fit_origin.summary())
```

```
                 Generalized Linear Model Regression Results
==============================================================================
=====
Dep. Variable:     percentage20_Donald_Trump   No. Observations:
2364
Model:                                 GLM   Df Residuals:
2333
Model Family:                     Gaussian   Df Model:
30
Link Function:                    identity   Scale:
7.4715
Method:                               IRLS   Log-Likelihood:
-5715.9
Date:                     Sun, 13 Dec 2020   Deviance:
17431.
Time:                             13:27:32   Pearson chi2:
1.74e+04
No. Iterations:                          3
Covariance Type:                 nonrobust
==============================================================================
===============
                                 coef    std err          z      P>|z|
[0.025      0.975]
------------------------------------------------------------------------------
---------------
percentage16_Donald_Trump        0.4948      0.025     19.524      0.000
0.445       0.544
percentage16_Hillary_Clinton    -0.4789      0.027    -17.559      0.000
-0.532      -0.425
Hispanic                         0.0875      0.041      2.153      0.031
0.008       0.167
White                            0.0539      0.041      1.325      0.185
-0.026       0.134
Black                            0.0323      0.041      0.785      0.433
-0.048       0.113
Native                          -0.0036      0.044     -0.082      0.935
-0.091       0.083
Asian                           -0.0656      0.056     -1.163      0.245
-0.176       0.045
Pacific                          0.4954      0.192      2.575      0.010
0.118       0.872
```

```
Poverty                         0.0721      0.027      2.697      0.007
0.020       0.125
ChildPoverty                    0.0020      0.016      0.123      0.902
-0.030       0.034
Professional                   -0.3270      0.860     -0.380      0.704
-2.012       1.358
Service                        -0.2563      0.859     -0.298      0.766
-1.941       1.428
Office                         -0.2805      0.860     -0.326      0.744
-1.965       1.404
Construction                   -0.1602      0.860     -0.186      0.852
-1.845       1.525
Production                     -0.1313      0.860     -0.153      0.879
-1.816       1.553
Drive                          -0.3105      0.821     -0.378      0.705
-1.920       1.299
Carpool                        -0.3661      0.822     -0.445      0.656
-1.977       1.245
Transit                        -0.2120      0.822     -0.258      0.796
-1.823       1.399
Walk                           -0.2929      0.821     -0.357      0.721
-1.903       1.317
OtherTransp                    -0.4887      0.821     -0.595      0.552
-2.099       1.121
WorkAtHome                     -0.4619      0.822     -0.562      0.574
-2.072       1.148
MeanCommute                     0.0333      0.013      2.508      0.012
0.007       0.059
PrivateWork                     0.6257      0.982      0.637      0.524
-1.298       2.550
PublicWork                      0.6799      0.982      0.693      0.489
-1.244       2.604
SelfEmployed                    0.8103      0.981      0.826      0.409
-1.113       2.733
FamilyWork                      0.7534      0.987      0.763      0.445
-1.181       2.688
Unemployment                   -0.0331      0.029     -1.144      0.253
-0.090       0.024
cases_rate                      0.0802      0.041      1.942      0.052
-0.001       0.161
deaths_rate                     3.1912      1.233      2.588      0.010
0.774       5.608
men_percent                     0.3593      1.546      0.232      0.816
-2.671       3.390
women_percent                   0.3238      1.546      0.209      0.834
-2.706       3.353
==============================================================================
================
```

[873]:
```
x_test_origin.head()
```

[873]:

state	county	percentage16_Donald_Trump	percentage16_Hillary_Clinton	\
New Mexico	De Baca	68.176796	21.215470	
Illinois	Saline	73.419975	22.707851	
Arkansas	Lafayette	61.489810	36.120871	
Colorado	Lincoln	77.976686	16.611157	
Minnesota	Martin	67.456300	26.105645	

state	county	Hispanic	White	Black	Native	Asian	Pacific	Poverty	\
New Mexico	De Baca	46.0	52.2	1.5	0.0	0.0	0.0	22.7	
Illinois	Saline	1.7	91.6	3.4	0.1	0.7	0.0	20.6	
Arkansas	Lafayette	1.2	59.3	37.8	0.3	0.4	0.0	23.8	
Colorado	Lincoln	22.7	66.4	9.0	1.0	0.2	0.3	14.0	
Minnesota	Martin	4.1	93.6	0.3	0.1	0.9	0.0	11.3	

state	county	ChildPoverty	...	MeanCommute	PrivateWork	PublicWork	\
			...				
New Mexico	De Baca	22.4	...	10.3	60.4	35.6	
Illinois	Saline	27.0	...	23.1	76.0	17.4	
Arkansas	Lafayette	32.3	...	25.1	70.3	20.6	
Colorado	Lincoln	15.1	...	17.3	55.5	29.1	
Minnesota	Martin	15.2	...	17.0	82.2	8.8	

state	county	SelfEmployed	FamilyWork	Unemployment	cases_rate	\
New Mexico	De Baca	4.0	0.0	6.6	0.148810	
Illinois	Saline	6.2	0.5	11.3	2.754810	
Arkansas	Lafayette	8.2	0.9	8.3	2.935754	
Colorado	Lincoln	14.5	0.9	3.7	0.452899	
Minnesota	Martin	8.8	0.3	3.1	3.281219	

state	county	deaths_rate	men_percent	women_percent
New Mexico	De Baca	0.000000	45.932540	54.067460
Illinois	Saline	0.045027	49.234548	50.765452
Arkansas	Lafayette	0.042547	49.071054	50.928946
Colorado	Lincoln	0.000000	63.804348	36.195652
Minnesota	Martin	0.089624	49.865565	50.134435

[5 rows x 31 columns]

[874]:
```
y_test_origin.head()
```

[874]:

state	county	percentage20_Donald_Trump

```
New Mexico De Baca                    72.807991
Illinois   Saline                     73.075187
Arkansas   Lafayette                  65.584173
Colorado   Lincoln                    80.532319
Minnesota  Martin                     67.729661
```

[875]:
```
RMSE_origin.insert(2, "Model_GLM_Trump", Model_GLM_fit_origin.
↪predict(x_test_origin).values, True)
```

[876]:
```
RMSE_origin.head()
```

[876]:
```
                      percentage20_Donald_Trump  Model_Average_Trump  \
state      county
New Mexico De Baca                    72.807991            65.586883
Illinois   Saline                     73.075187            65.586883
Arkansas   Lafayette                  65.584173            65.586883
Colorado   Lincoln                    80.532319            65.586883
Minnesota  Martin                     67.729661            65.586883

                      Model_GLM_Trump
state      county
New Mexico De Baca          73.251640
Illinois   Saline           74.996622
Arkansas   Lafayette        63.610829
Colorado   Lincoln          79.452636
Minnesota  Martin           68.972087
```

[877]:
```
Model_RLM_origin = sm.RLM(y_train_origin, x_train_origin)

Model_RLM_fit_origin = Model_RLM_origin.fit()
```

[878]:
```
print(Model_RLM_fit_origin.summary())
```

```
                    Robust linear Model Regression Results
==============================================================================
=====
Dep. Variable:     percentage20_Donald_Trump   No. Observations:
2364
Model:                                 RLM   Df Residuals:
2333
Method:                               IRLS   Df Model:
30
Norm:                              HuberT
Scale Est.:                           mad
Cov Type:                              H1
Date:                  Sun, 13 Dec 2020
Time:                          13:27:59
No. Iterations:                       33
==============================================================================
================
```

```
                                 coef    std err          z      P>|z|
[0.025      0.975]
------------------------------------------------------------------------------
----------------
percentage16_Donald_Trump        0.5246      0.017     30.680      0.000
0.491       0.558
percentage16_Hillary_Clinton    -0.4604      0.018    -25.013      0.000
-0.496      -0.424
Hispanic                         0.0143      0.027      0.521      0.602
-0.039       0.068
White                            0.0006      0.027      0.020      0.984
-0.053       0.054
Black                           -0.0103      0.028     -0.371      0.710
-0.065       0.044
Native                          -0.0445      0.030     -1.485      0.137
-0.103       0.014
Asian                           -0.1020      0.038     -2.680      0.007
-0.177      -0.027
Pacific                          0.3339      0.130      2.572      0.010
0.079       0.588
Poverty                          0.0404      0.018      2.237      0.025
0.005       0.076
ChildPoverty                     0.0067      0.011      0.613      0.540
-0.015       0.028
Professional                    -0.0693      0.580     -0.120      0.905
-1.206       1.067
Service                          0.0236      0.580      0.041      0.968
-1.113       1.160
Office                          -0.0348      0.580     -0.060      0.952
-1.172       1.102
Construction                     0.1019      0.580      0.176      0.861
-1.035       1.239
Production                       0.1220      0.580      0.210      0.833
-1.015       1.259
Drive                           -0.2788      0.554     -0.503      0.615
-1.365       0.808
Carpool                         -0.3476      0.555     -0.627      0.531
-1.435       0.740
Transit                         -0.1580      0.554     -0.285      0.776
-1.245       0.929
Walk                            -0.2806      0.554     -0.506      0.613
-1.367       0.806
OtherTransp                     -0.4124      0.554     -0.744      0.457
-1.499       0.674
WorkAtHome                      -0.4085      0.554     -0.737      0.461
-1.495       0.678
MeanCommute                      0.0294      0.009      3.278      0.001
0.012       0.047
```

```
PrivateWork                     -0.0849      0.662     -0.128      0.898
-1.383       1.213
PublicWork                      -0.0350      0.662     -0.053      0.958
-1.333       1.263
SelfEmployed                     0.0767      0.662      0.116      0.908
-1.221       1.374
FamilyWork                       0.1137      0.666      0.171      0.864
-1.192       1.419
Unemployment                    -0.0322      0.020     -1.648      0.099
-0.070       0.006
cases_rate                       0.0617      0.028      2.216      0.027
0.007       0.116
deaths_rate                      2.2911      0.832      2.754      0.006
0.660       3.922
men_percent                      0.8214      1.043      0.787      0.431
-1.223       2.866
women_percent                    0.7733      1.043      0.741      0.458
-1.271       2.817
==============================================================================
================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[879]:
```
RMSE_origin.insert(3, "Model_RLM_Trump", Model_RLM_fit_origin.
↪predict(x_test_origin).values, True)
```

[884]:
```
RMSE_origin.head()
```

[884]:

		percentage20_Donald_Trump	Model_Average_Trump	Model_GLM_Trump	Model_RLM_Trump
state	county				
New Mexico	De Baca	72.807991	65.586883	73.251640	72.440118
Illinois	Saline	73.075187	65.586883	74.996622	75.035972
Arkansas	Lafayette	65.584173	65.586883	63.610829	63.616602
Colorado	Lincoln	80.532319	65.586883	79.452636	79.432277
Minnesota	Martin	67.729661	65.586883	68.972087	68.993832

[891]:
```
rmse1_origin = mean_squared_error(RMSE_origin['Model_Average_Trump'],
                                  ␣
↪RMSE_origin['percentage20_Donald_Trump'],squared=False)
```

```
print("Root mean square error for the average response is: ", rmse1_origin)
```

```
Root mean square error for the average response is:  15.394538208531928
```

[893]:
```
rmse2_origin = mean_squared_error(RMSE_origin['Model_GLM_Trump'],
                                  ␣
 ↪RMSE_origin['percentage20_Donald_Trump'],squared=False)


print("Root mean square error by using Generalized Linear Regression Model is:␣
 ↪", rmse2_origin)
```

```
Root mean square error by using Generalized Linear Regression Model is:
2.492202302942959
```

[896]:
```
rmse3_origin = mean_squared_error(RMSE_origin['Model_RLM_Trump'],
                                  ␣
 ↪RMSE_origin['percentage20_Donald_Trump'],squared=False)


print("Root mean square error by using Robust Linear Regression Model is: ",␣
 ↪rmse3_origin)
```

```
Root mean square error by using Robust Linear Regression Model is:
2.4831652243722426
```

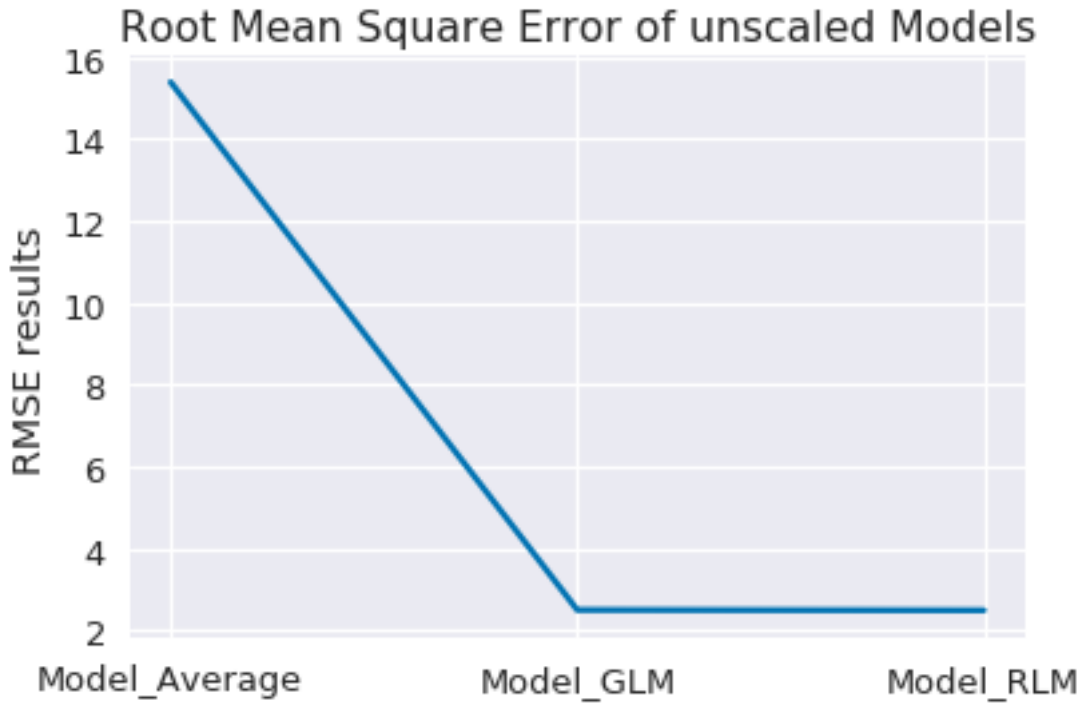
[905]:
```
d_rmse = {'models': ['Average', 'GLM', 'RLM'],
          'not_scaled': [rmse1_origin, rmse2_origin, rmse3_origin],
          'scaled': [rmse1, rmse2, rmse3]}

df_rmse = pd.DataFrame(data = d_rmse,index=None)

print(df_rmse)
```

```
    models  not_scaled    scaled
0  Average   15.394538  0.176184
1      GLM    2.492202  0.028572
2      RLM    2.483165  0.028506
```

[909]:
```
Results = pd.DataFrame({'RMSE': [rmse1_origin,rmse2_origin,rmse3_origin],
                        'Name': ['Model_Average','Model_GLM','Model_RLM']})
Results = Results.set_index('Name')


plt.plot(Results)
```

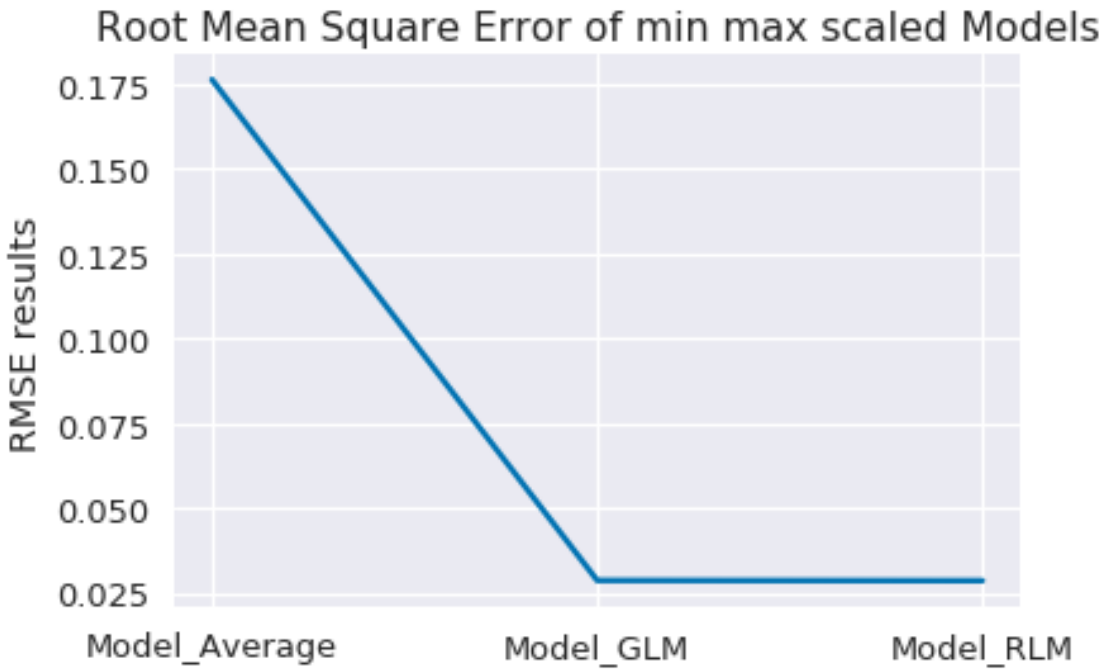
```
plt.title("Root Mean Square Error of unscaled Models")
plt.ylabel('RMSE results')
plt.show()
```

```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```



[910]:
```
Results2 = pd.DataFrame({'RMSE': [rmse1,rmse2,rmse3],
                         'Name': ['Model_Average','Model_GLM','Model_RLM']})
Results2 = Results2.set_index('Name')

plt.plot(Results2)
plt.title("Root Mean Square Error of min max scaled Models")
plt.ylabel('RMSE results')
plt.show()
```

```
/anaconda3/lib/python3.6/site-packages/matplotlib/font_manager.py:1320:
UserWarning: findfont: Font family ['normal'] not found. Falling back to DejaVu
Sans
  (prop.get_family(), self.defaultFamily[fontext]))
```


Root Mean Square Error of min max scaled Models
RMSE results
0.175
0.150
0.125
0.100
0.075
0.050
0.025
Model_Average
Model_GLM
Model_RLM

[ ]:

[ ]: