Simulated_data_example_Binomial-MGWR

May 19, 2020

Notebook Outline:

0.0.1 Set up Cells

In [1]:
```
import sys
sys.path.append("C:/Users/msachde1/Downloads/Research/Development/mgwr")
```

In [2]:
```
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import numpy as np

from mgwr.gwr import GWR
from spglm.family import Gaussian, Binomial, Poisson
from mgwr.gwr import MGWR
from mgwr.sel_bw import Sel_BW
import multiprocessing as mp
pool = mp.Pool()
from scipy import linalg
import numpy.linalg as la
from scipy import sparse as sp
from scipy.sparse import linalg as spla
from spreg.utils import spdot, spmultiply
from scipy import special
import libpysal as ps
```

```
import seaborn as sns
import matplotlib.pyplot as plt
from copy import deepcopy
import copy
from collections import namedtuple
import spglm
```

0.0.2 Global Model Example

```
In [3]: x = np.linspace(0, 25, 25)
        y = np.linspace(25, 0, 25)
        X, Y = np.meshgrid(x, y)

        lon = X.reshape(-1,1)
        lat = Y.reshape(-1,1)

        coords = np.array(list(zip(lon,lat)))
```

```
In [4]: x1=np.random.normal(0,1,625)
        x2=np.random.normal(0,1,625)
        error = np.random.normal(0,0.1,625)

        z = 1+2*x1+3*x2+error

        x1=x1.reshape(-1,1)
        x2=x2.reshape(-1,1)

        pr = 1/(1+np.exp(-z))
```

```
In [5]: y = np.random.binomial(1,pr)
        X = np.hstack([x1,x2])
        y = np.array(y).reshape((-1,1))
```

GWR

```
In [6]: bw = Sel_BW(coords,y,X,family=Binomial())
        bw=bw.search()
```

```
In [7]: gwr_mod = GWR(coords, y, X, bw,family=Binomial()).fit()
```

MGWR

```
In [8]: selector = Sel_BW(coords,y,X,multi=True,family=Binomial())
        selector.search(verbose=True,max_iter_multi=50)
```

```
Current iteration: 1 ,SOC: 0.0450537
Bandwidths: 519.0, 624.0, 183.0
Current iteration: 2 ,SOC: 0.020152
Bandwidths: 519.0, 624.0, 624.0
```

```
Current iteration: 3 ,SOC: 0.0032721
Bandwidths: 519.0, 624.0, 624.0
Current iteration: 4 ,SOC: 8.01e-05
Bandwidths: 519.0, 624.0, 624.0
Current iteration: 5 ,SOC: 9.37e-05
Bandwidths: 519.0, 624.0, 624.0
Current iteration: 6 ,SOC: 3.74e-05
Bandwidths: 519.0, 624.0, 624.0
Current iteration: 7 ,SOC: 1.87e-05
Bandwidths: 519.0, 624.0, 624.0
Current iteration: 8 ,SOC: 9e-06
Bandwidths: 519.0, 624.0, 624.0
```

```
Out[8]: array([519., 624., 624.])
```

```
In [9]: mgwr_mod = MGWR(coords, y, X, selector,family=Binomial()).fit()
```

```
HBox(children=(IntProgress(value=0, description='Inference', max=1), HTML(value='')))
```

```
In [10]: np.mean(gwr_mod.params,axis=0), np.mean(mgwr_mod.params,axis=0)
```

```
Out[10]: (array([1.16604381, 2.24362744, 3.27846807]),
          array([0.70461953, 1.78115408, 2.84722997]))
```

```
In [11]: gwr_mod.aic, mgwr_mod.aic
```

```
Out[11]: (357.9759977731823, 363.5967703986909)
```

0.0.3 Local Model Example

Create Simulated Dataset

Forming independent variables

```
In [12]: def add(a,b):
             return 1+((1/12)*(a+b))

         def con(u,v):
             return (0*(u)*(v))+1

         def sp(u,v):
             return 1+1/324*(36-(6-u/2)**2)*(36-(6-v/2)**2)

         def med(u,v):
```

```
    B = np.zeros((25,25))
    for i in range(25):
        for j in range(25):

            if u[i][j]<=8:
                B[i][j]=0.2
            elif u[i][j]>17:
                B[i][j]=0.7
            else:
                B[i][j]=0.5
    return B
```

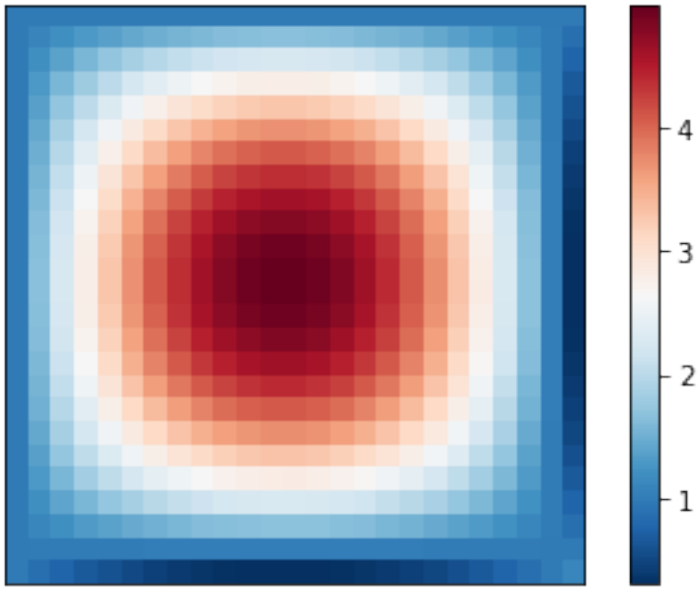
In [13]:
```
x = np.linspace(0, 25, 25)
y = np.linspace(25, 0, 25)
X, Y = np.meshgrid(x, y)
```

In [14]:
```
x1=np.random.normal(0,1,625)
x2=np.random.normal(0,1,625)
error = np.random.normal(0,0.1,625)
```

In [15]:
```
B0=con(X,Y)
B1=sp(X,Y)
B2=med(X,Y)
```

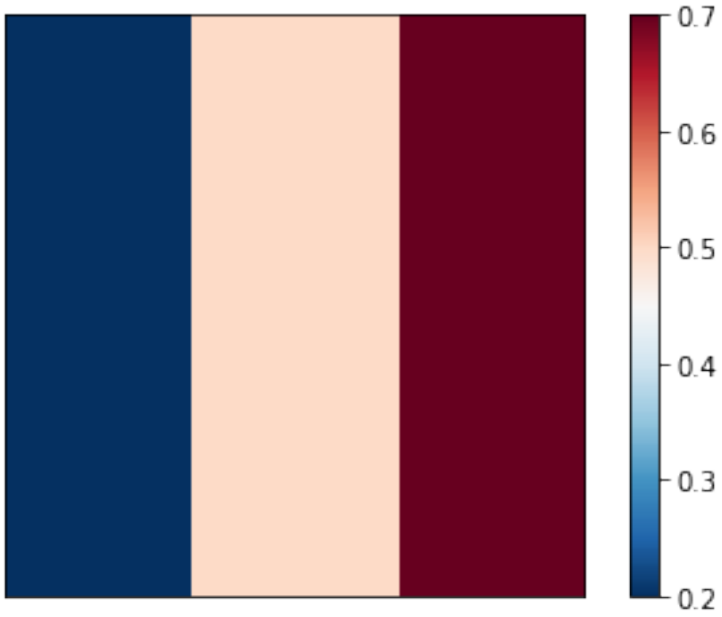
In [16]:
```
plt.imshow(B1, extent=[0,10, 0, 10], origin='lower',cmap='RdBu_r')
plt.colorbar()
plt.axis(aspect='image')
plt.xticks([])
plt.yticks([])
```

Out[16]:
```
([], <a list of 0 Text yticklabel objects>)
```



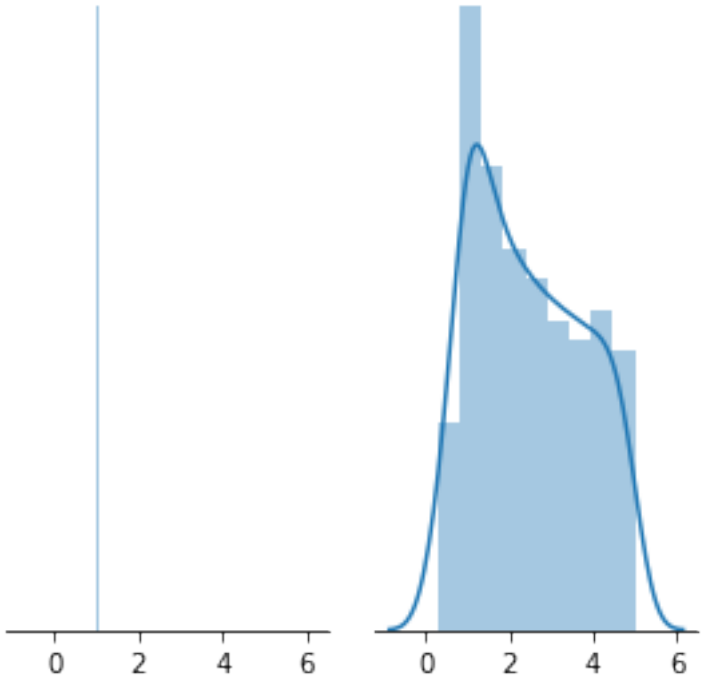
In [17]:
```
plt.imshow(B2, extent=[0,25, 0, 25], origin='lower',cmap='RdBu_r')
plt.colorbar()
plt.axis(aspect='image')
plt.xticks([])
plt.yticks([])
```

Out[17]: ([], <a list of 0 Text yticklabel objects>)



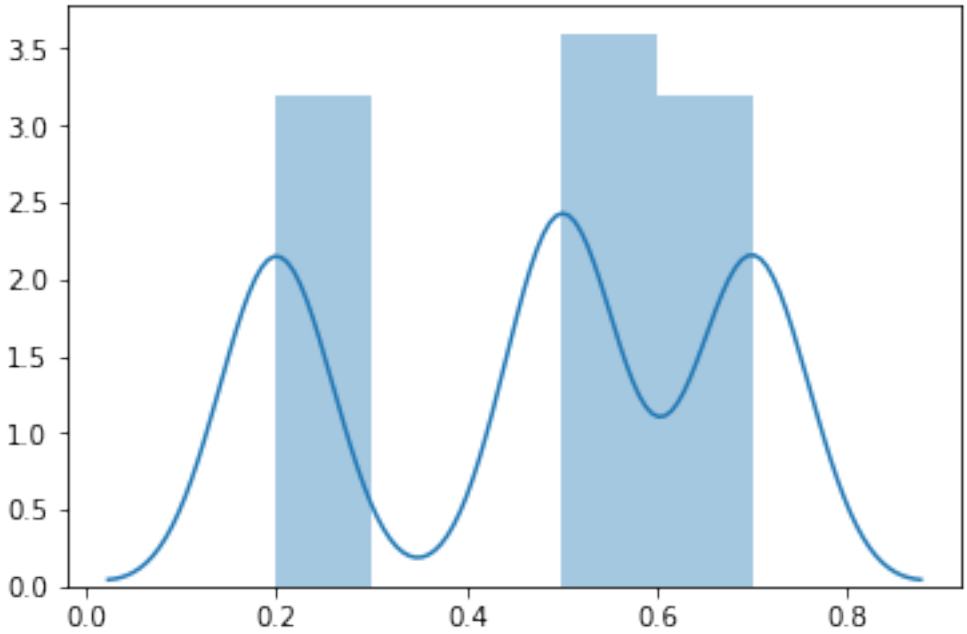
In [18]:
```
B0=B0.reshape(-1,1)
B1=B1.reshape(-1,1)
B2=B2.reshape(-1,1)
```

In [19]:
```
f, axes = plt.subplots(1, 2, figsize=(4, 4), sharex=True)
sns.despine(left=True)
sns.distplot(B0,ax=axes[0])
sns.distplot(B1,ax=axes[1])

plt.setp(axes, yticks=[])
plt.tight_layout()
```




```
In [20]: sns.distplot(B2)
```

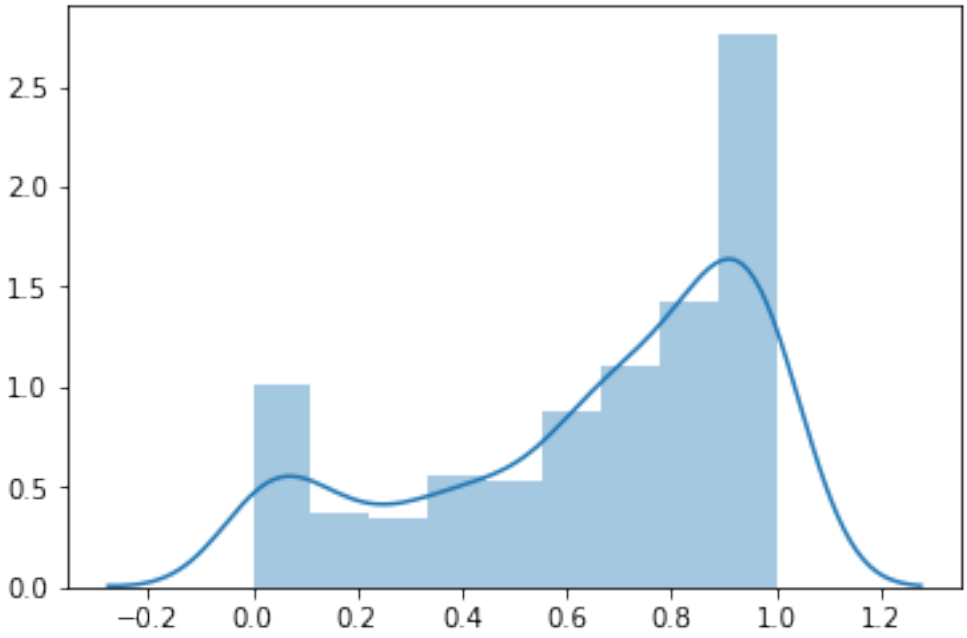
```
Out[20]: <matplotlib.axes._subplots.AxesSubplot at 0x1832f25e3c8>
```



```
In [21]: lat=Y.reshape(-1,1)
         lon=X.reshape(-1,1)

In [22]: x1=x1.reshape(-1,1)
         x2=x2.reshape(-1,1)

In [23]: param = np.hstack([B0,B1,B2])

In [24]: param.shape

Out[24]: (625, 3)

In [25]: cons=np.ones_like(x1)

In [26]: cons=cons.reshape(-1,1)

In [27]: X=np.hstack([cons,x1,x2])

In [28]: X.shape

Out[28]: (625, 3)
```

Creating y variable with Binomial distribution Incorporating step from - Chapter 6. Simulating Generalized Linear Models, p. 156

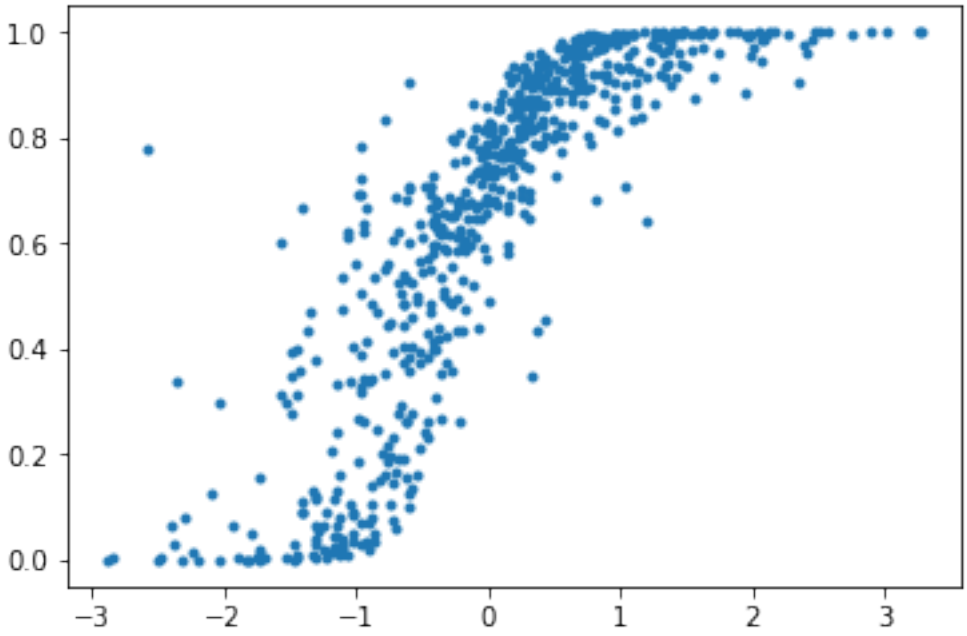
```
In [29]: #binomial y
         y_exp=((np.exp(np.sum(X * param, axis=1)+error)/(1+(np.exp(np.sum(X * param, axis=1)+e

In [30]: np.mean(y_exp)

Out[30]: 0.6510162481437103

In [31]: y_exp.shape

Out[31]: (625, 1)

In [32]: sns.distplot(y_exp)

Out[32]: <matplotlib.axes._subplots.AxesSubplot at 0x1832f17af98>
```




```
In [33]: y = np.random.binomial(1,y_exp)
```

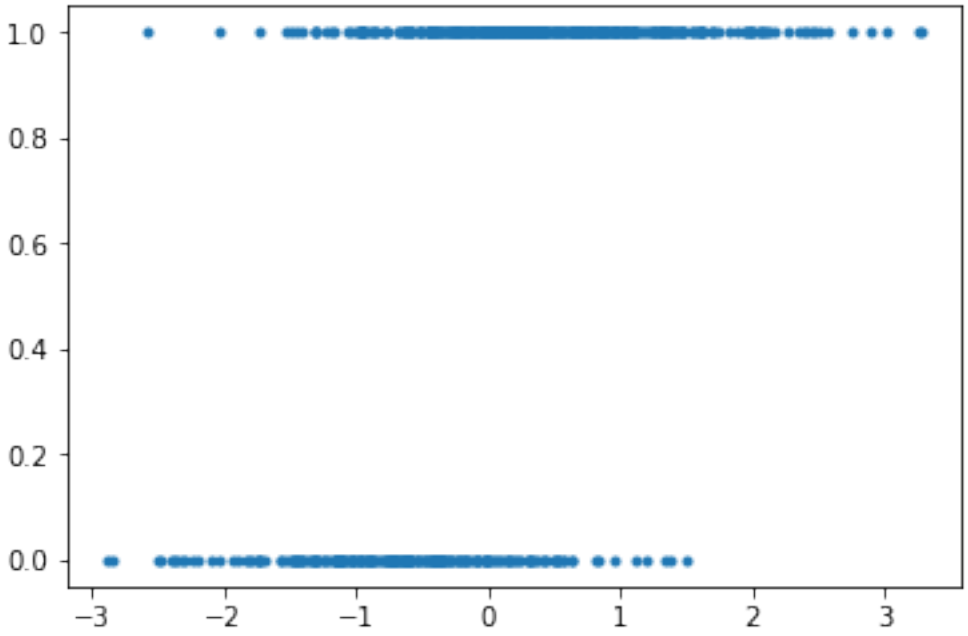
```
In [34]: pd.Series(y_exp.reshape(-1), index=x1).plot(style='.')
```

```
Out[34]: <matplotlib.axes._subplots.AxesSubplot at 0x1832ef7fe48>
```



In [35]:
```
pd.Series(y.reshape(-1), index=x1).plot(style='.')
```

Out[35]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1832ee70cc0>
```



In [36]:
```
coords = np.array(list(zip(lon,lat)))
y = np.array(y).reshape((-1,1))
```

0.0.4 Multivariate example

In [37]:
```
X=np.hstack([x1,x2])
```

In [39]:
```
bw=Sel_BW(coords,y,X,family=Binomial())
bw=bw.search()
gwr_model=GWR(coords,y,X,bw,family=Binomial()).fit()
bw
```

Out[39]:
```
172.0
```

In [40]:
```
gwr_model.aic
```

Out[40]:
```
564.9462195662602
```

Bandwidths check

```
In [42]: selector=Sel_BW(coords,y,X,multi=True,family=Binomial())
         selector.search(verbose=True)
```

```
Current iteration: 1 ,SOC: 0.0161926
Bandwidths: 622.0, 73.0, 170.0
Current iteration: 2 ,SOC: 0.0316518
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 3 ,SOC: 0.0039268
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 4 ,SOC: 0.0001849
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 5 ,SOC: 0.0001914
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 6 ,SOC: 8.61e-05
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 7 ,SOC: 4.99e-05
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 8 ,SOC: 2.72e-05
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 9 ,SOC: 1.62e-05
Bandwidths: 622.0, 181.0, 188.0
Current iteration: 10 ,SOC: 9.5e-06
Bandwidths: 622.0, 181.0, 188.0
```

```
Out[42]: array([622., 181., 188.])
```

```
In [43]: mgwr_model=MGWR(coords,y,X,selector,family=Binomial()).fit()
```

```
HBox(children=(IntProgress(value=0, description='Inference', max=1), HTML(value='')))
```

Parameters check

```
In [44]: np.mean(mgwr_model.params,axis=0),np.mean(gwr_model.params,axis=0)
```

```
Out[44]: (array([1.10211344, 2.53539688, 0.28485419]),
          array([0.90342461, 2.26934826, 0.25936595]))
```

```
In [45]: np.mean(B0),np.mean(B1),np.mean(B2)
```

```
Out[45]: (1.0, 2.471045176769571, 0.468)
```

AICc check

```
In [46]: mgwr_model.aicc,gwr_model.aicc
```

```
Out[46]: (558.2437551708874, 567.8076915280018)
```