BasicGravityModel

January 24, 2021

[1]:
```
%matplotlib inline
import numpy as np
import math
from matplotlib import pyplot as plt
from numpy import random
import numpy as np
from scipy import stats
plt.style.use('seaborn-whitegrid')

#Defined Functions: for Plotting observed and Predicted Model Results on the␣
↪Grid,
#the Friction of Distance Parameter, and the Location-Interactions Plots for␣
↪Correlations

def friction(parameter,dis):
    frict=math.exp(parameter*dis)
    return frict

def locintplot(obs,pred,activities, M):
    maxo=np.max(obs); maxop=np.max(pred)
    if maxo>maxop:
        maxv=maxo
    else:
        maxv=maxop
    maxv=maxv*(1.1)
    plt.axis([0,maxv,0,maxv])
    plt.xlabel("Observed" + activities)
    plt.ylabel("Predicted" + activities)
    plt.title(activities + " Activity")
    plt.scatter(pred, obs, s=10,c='black')
    flatobs = np.reshape(obs, M)
    flatpred = np.reshape(pred, M)
    print("Correlation and its p-Test",stats.pearsonr(flatobs, flatpred))
    return

def scattergraph(soutput,dataname,colours):
    plt.show()
```

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    sizes=soutput**2
    plt.axis([0,n,0,n])
    plt.xlabel("x coordinate")
    plt.ylabel("y coordinate")
    plt.title(dataname + ' Activity')
    plt.scatter(xcoord, ycoord, c=sizes, s=sizes, alpha=0.75, cmap=colours)
    return

#Defining the Hypothetical Spatial System

xcoord=np.array([])
ycoord=np.array([])

n=input("Enter the Grid Size: The Number of Squares Along One Side of a Square␣
 ↪Grid, 5 or 10, say --- ")
n=int(n); N=n*n
print("The Size of the Hypothetical Spatial System is",n, "Zones by", n,"Zones,␣
 ↪Making", N,"in All")
print()

distance=np.full((N,N), 1.0)

n=n+1
for y in range(1,n):
    for x in range(1,n):
        xcoord = np.append(xcoord,[x])
        ycoord = np.append(ycoord,[y])

#for i in range(0,N):
#        print(i, xcoord[i], ycoord[i])

input()
ij=0
for i in range (0,N):
    xi=xcoord[i]
    yi=ycoord[i]
    for j in range (0,N):
        ij=ij+1
        xj=xcoord[j]
        yj=ycoord[j]
        dis=math.sqrt((((xi-xj)**2)+((yi-yj)**2)))
        distance[i][j]=dis
        if distance[i][j]==0:
            distance[i][j]=0.5
        #print(i+1,j+1,distance[i][j])

#Defining the Hypothetical Trip, Origin and Destination Data
```

```
tobs=np.full((N,N), 1.0)
origins=np.full((N),1.0)
destinations=np.full((N),1.0)
differences=np.full((N),1.0)

for i in range (0,N):
    for j in range (0,N):
        tobs[i][j]=1.0/(distance[i][j]*(0.1+random.rand()))
Tobs = np.sum(tobs)
CMean=0.0
for i in range (0,N):
    for j in range(0,N):
        ij=ij+1
        tobs[i][j]=1000*(tobs[i][j]/Tobs)
        CMean=CMean+tobs[i,j]*distance[i][j]

origins = np.sum(tobs, axis = 1)
destinations = np.sum(tobs, axis = 0)

To=np.sum(origins)
Td=np.sum(destinations)
Tobs = np.sum(tobs)
CMean=CMean/Tobs


print("Mean Trip Length of the Hypothetical Data ", CMean)
print()
#Defining and Running th Unconstrained Gravity Model

beta=input("Enter the Parameter Value on Distance - beta - that You Think Best␣
 ↪Fits the Data: It should be greater than 0 and less than 1 ---- ")
beta=float(beta)
print()
trips=np.full((N,N),1.0)
OPred=np.full((N),1.0)
DPred=np.full((N), 1.0)
trips1=np.full((N,N),1.0)
tobs1=np.full((N,N),1.0)

total=1000
for i in range(0,N):
    for j in range(0,N):
        trips[i][j]=origins[i]*destinations[j]/(friction(beta, distance[i][j]))
Ttrip=np.sum(trips)
CCMean=0.0
for i in range(0,N):
```

```
    for j in range(0,N):
        trips[i][j]=total*((origins[i]*destinations[j])/(friction(beta,␣
 ↪distance[i][j])))/Ttrip
        CCMean=CCMean+trips[i][j]*distance[i][j]
#Printing the Predictions

Ttrip=np.sum(trips)
CCMean=CCMean/Ttrip
print()
print("Mean Trip Length of the Model ", CCMean)
print()
OPred = np.sum(trips, axis = 1)
DPred = np.sum(trips, axis = 0)

print("Zone","\t","ObsO","\t","ObsD","\t","PredO","\t","PredD")
print()
for i in range(0,N):
    print(i+1, "\t","{:.2f}".format(origins[i]), "\t","{:.2f}".
 ↪format(destinations[i]),"\t","{:.2f}".format(OPred[i]),"\t","{:.2f}".
 ↪format(DPred[i]))

#Comparing Observed with Predicted Origin Activity Using Scattergraphs

input()
locintplot(origins, OPred, 'Origins',N)
plt.savefig('OriginOutputs.png', dpi=300, bbox_inches='tight')
plt.show()

input()
locintplot(destinations, DPred, 'Destinations',N)
plt.savefig('DestOutputs.png', dpi=300, bbox_inches='tight')
plt.show()

input()
M=N*N
locintplot(tobs, trips, 'Trips',M)
plt.savefig('TripOutputs.png', dpi=300, bbox_inches='tight')
plt.show()

rng = np.random.RandomState(0)
colors = rng.rand(N)

#Plotting Observed and Predicted Locations on the Hypothetical Grid

input()
scattergraph(origins, 'Observed Origin','winter')
plt.savefig('ObsOrigins.png', dpi=300, bbox_inches='tight')
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```python
plt.colorbar()
plt.show()

input()
scattergraph(OPred, 'Predicted Origin','winter')
plt.savefig('PredOrigins.png', dpi=300, bbox_inches='tight')
plt.colorbar()
plt.show()

input()
scattergraph(destinations, 'Observed Destination','winter')
plt.savefig('ObsDestinations.png', dpi=300, bbox_inches='tight')
plt.colorbar()
plt.show()

input()
scattergraph(DPred, 'Predicted Destination','winter')
plt.savefig('PredDestinations.png', dpi=300, bbox_inches='tight')
plt.colorbar()
plt.show()

#Measuring the Differences Between Predictions and Observations

for i in range(0,N):
    differences[i]=(origins[i]-OPred[i])*6
input()

scattergraph(differences, 'Differences in Origin ','autumn')
plt.savefig('Odifferences.png', dpi=300, bbox_inches='tight')
plt.colorbar()
plt.show()

for i in range(0,N):
    differences[i]=(destinations[i]-DPred[i])*6
input()
scattergraph(differences, 'Differences in Destination ','autumn')
plt.savefig('Ddifferences.png', dpi=300, bbox_inches='tight')
plt.colorbar()
plt.show()

print("The model and its outputs are now complete")
print()
```

```
Enter the Grid Size: The Number of Squares Along One Side of a Square Grid, 5 or
10, say ---  5
```

```
The Size of the Hypothetical Spatial System is 5 Zones by 5 Zones, Making 25 in
All
```

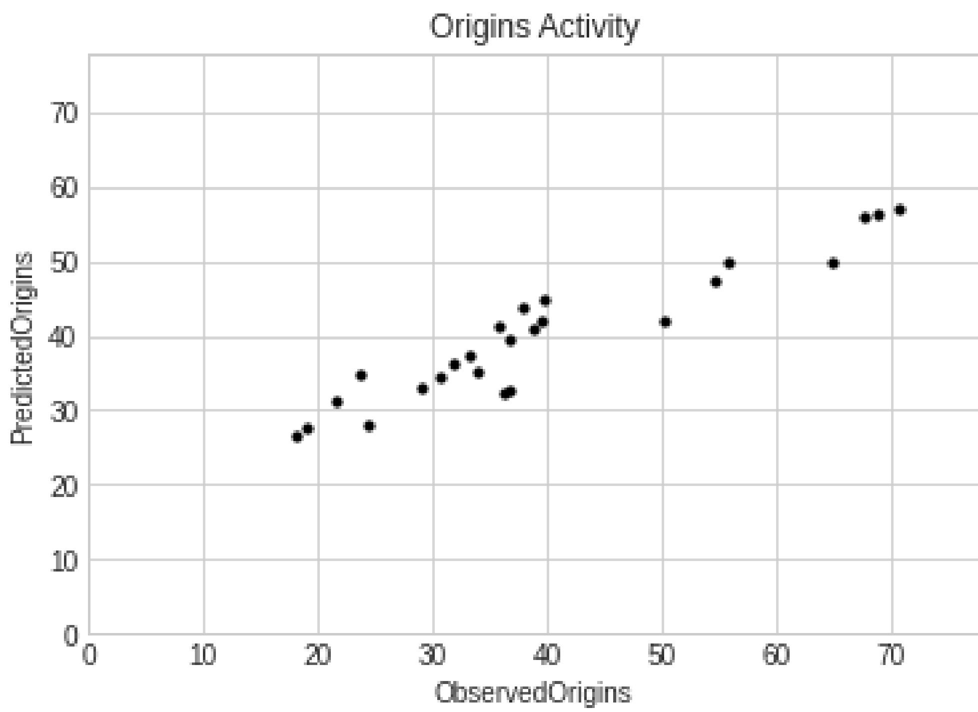
Mean Trip Length of the Hypothetical Data 1.8421047015914735

Enter the Parameter Value on Distance - beta - that You Think Best Fits the Data: It should be greater than 0 and less than 1 ---- 0.7

Mean Trip Length of the Model 1.680976386709437

Zone	ObsO	ObsD	PredO	PredD
1	34.69	22.36	23.66	15.51
2	34.39	38.23	30.75	33.71
3	35.16	41.09	33.97	38.78
4	44.78	39.31	39.79	34.17
5	31.40	31.17	21.55	20.93
6	33.04	36.12	29.10	32.06
7	47.25	58.68	54.66	67.24
8	57.12	56.12	70.73	68.65
9	32.54	45.67	36.74	50.63
10	27.97	32.34	24.32	27.43
11	41.93	35.27	39.42	33.75
12	56.20	53.89	68.80	66.56
13	49.71	42.68	64.93	56.50
14	41.96	36.24	50.24	43.80
15	39.39	45.58	36.72	42.42
16	41.40	34.50	35.87	30.34
17	32.42	37.86	36.37	42.87
18	56.10	48.49	67.70	59.74
19	50.00	41.45	55.82	47.43
20	43.64	34.02	37.88	30.13
21	26.45	30.24	18.05	20.52
22	36.23	43.27	31.84	37.76
23	40.92	38.64	38.80	36.84
24	37.49	45.94	33.14	40.87
25	27.83	30.84	19.14	21.37

Correlation and its p-Test (0.9463462980624612, 9.010111738368429e-13)

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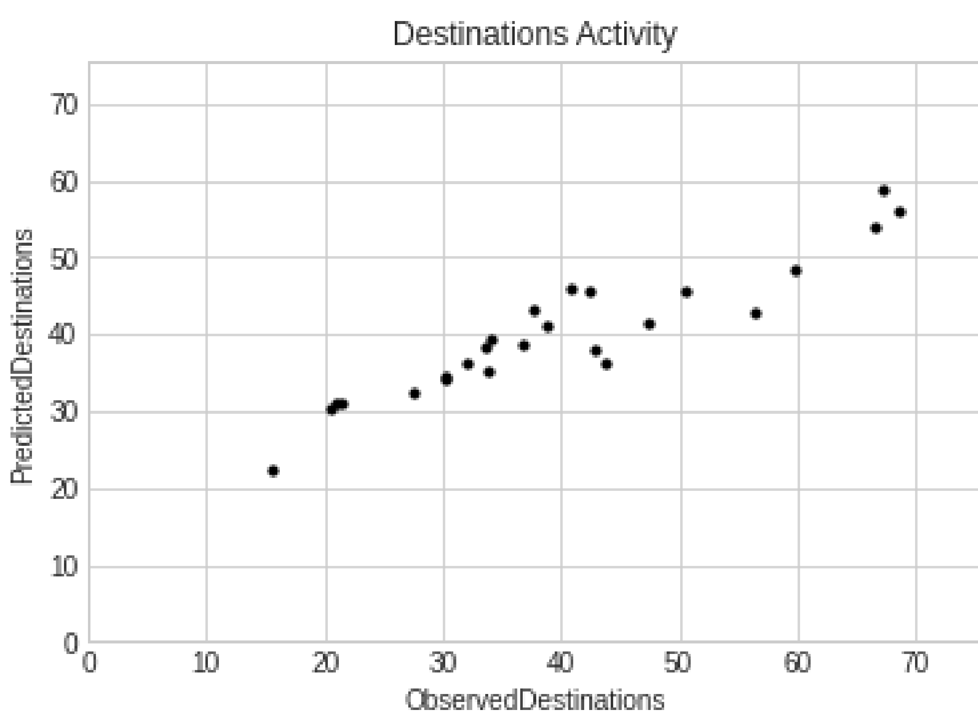
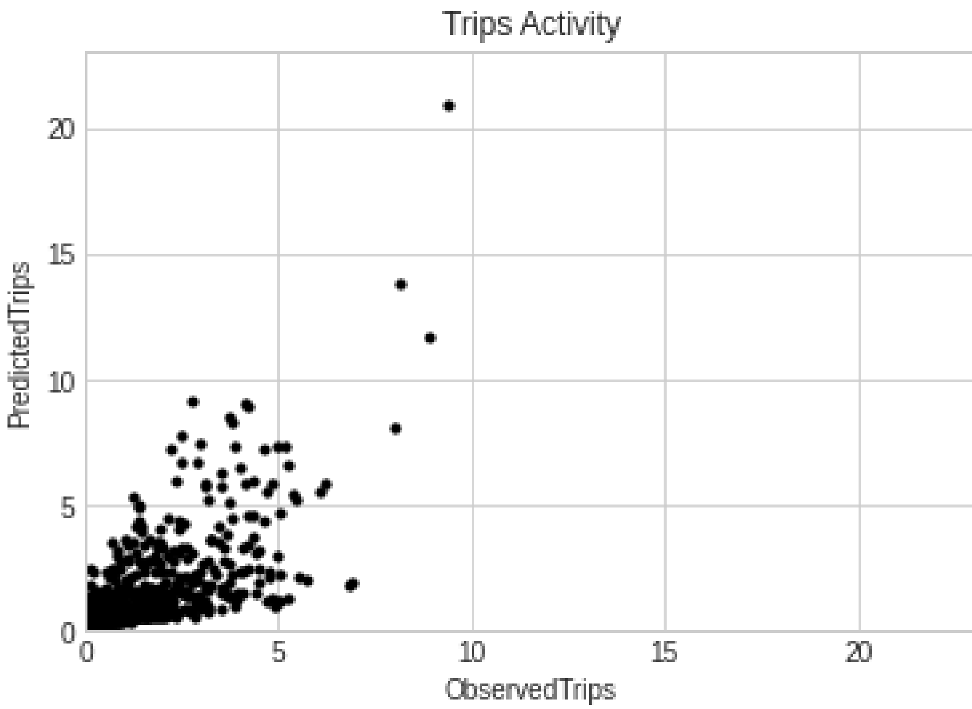
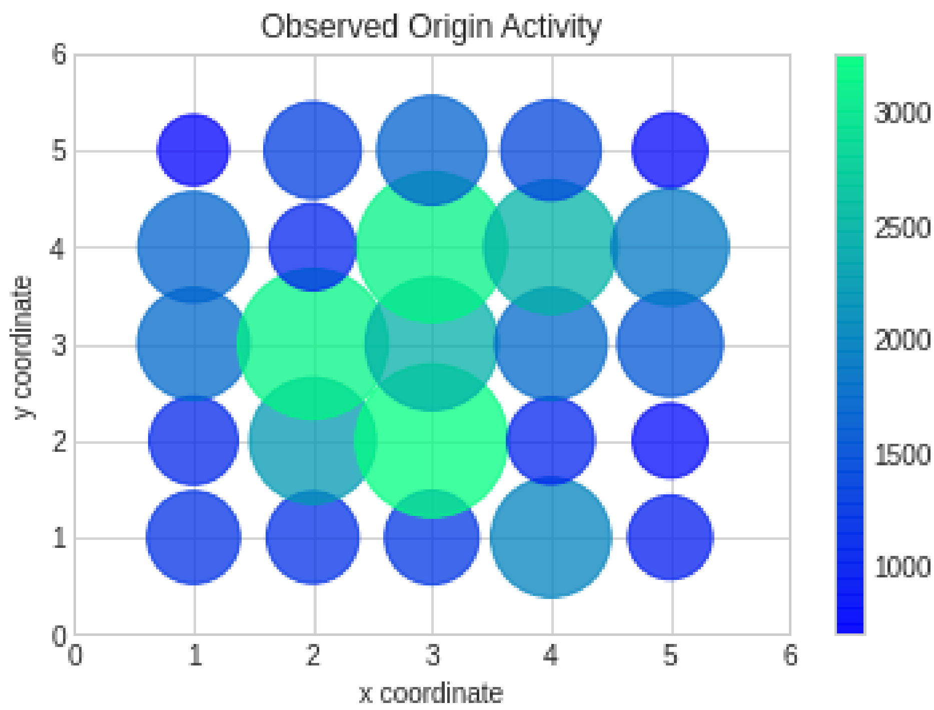
Correlation and its p-Test (0.9348721930594136, 7.905834041303546e-12)
```

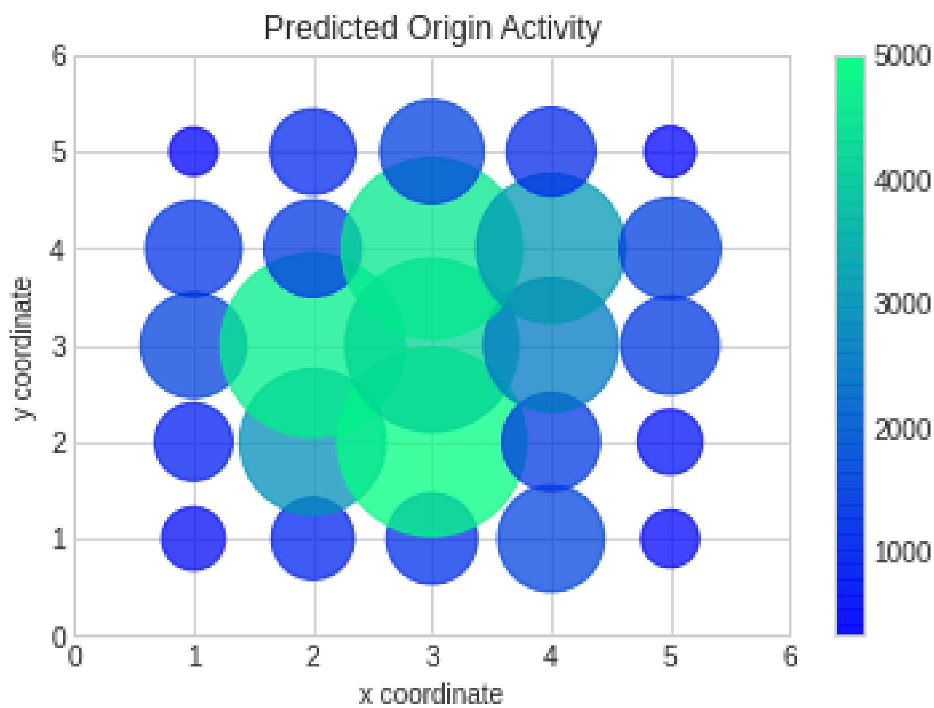


```
Correlation and its p-Test (0.6618862637107212, 5.049203442161058e-80)
```

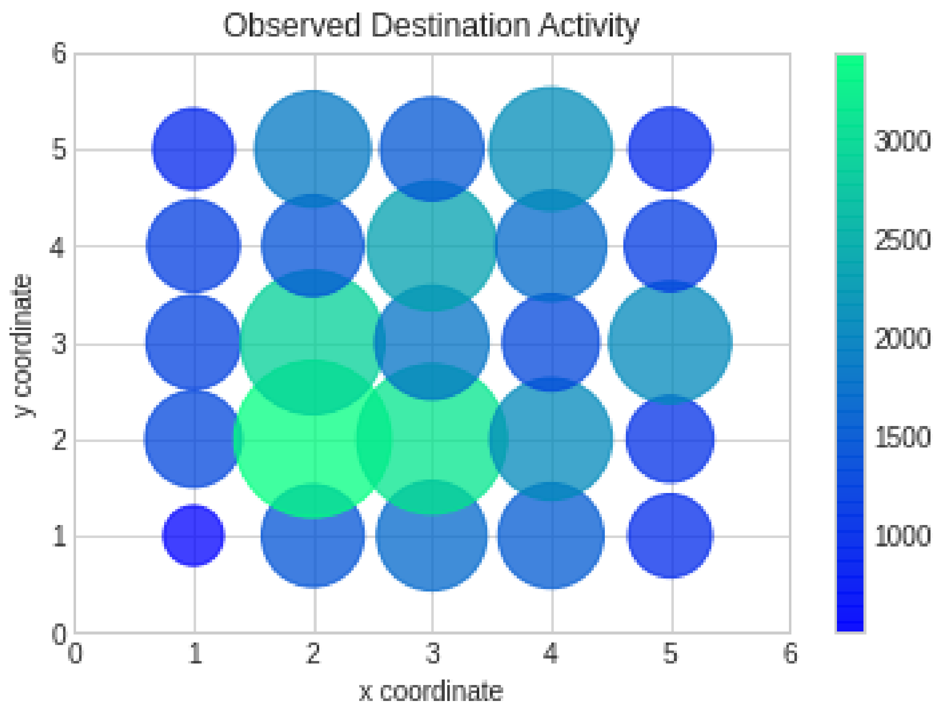


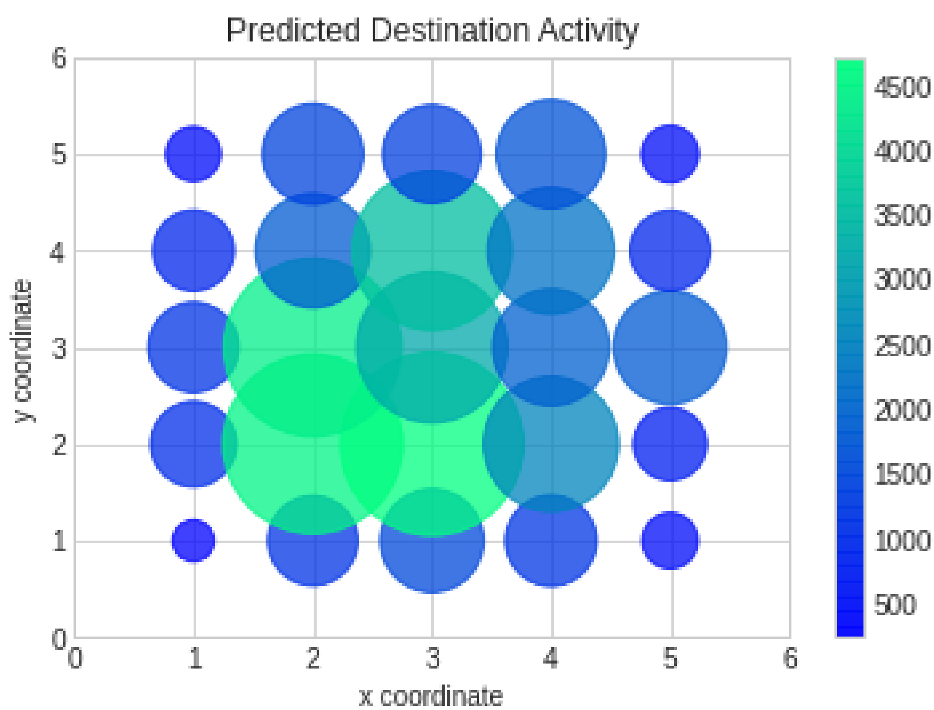


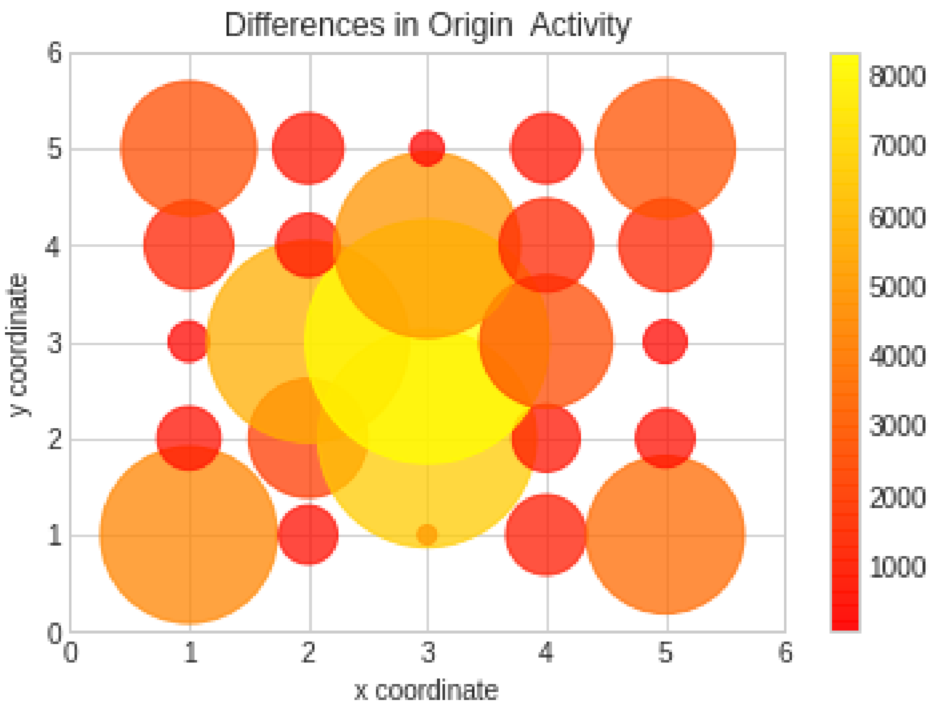
Observed Origin Activity
y coordinate
x coordinate
0
1
2
3
4
5
6
3000
2500
2000
1500
1000

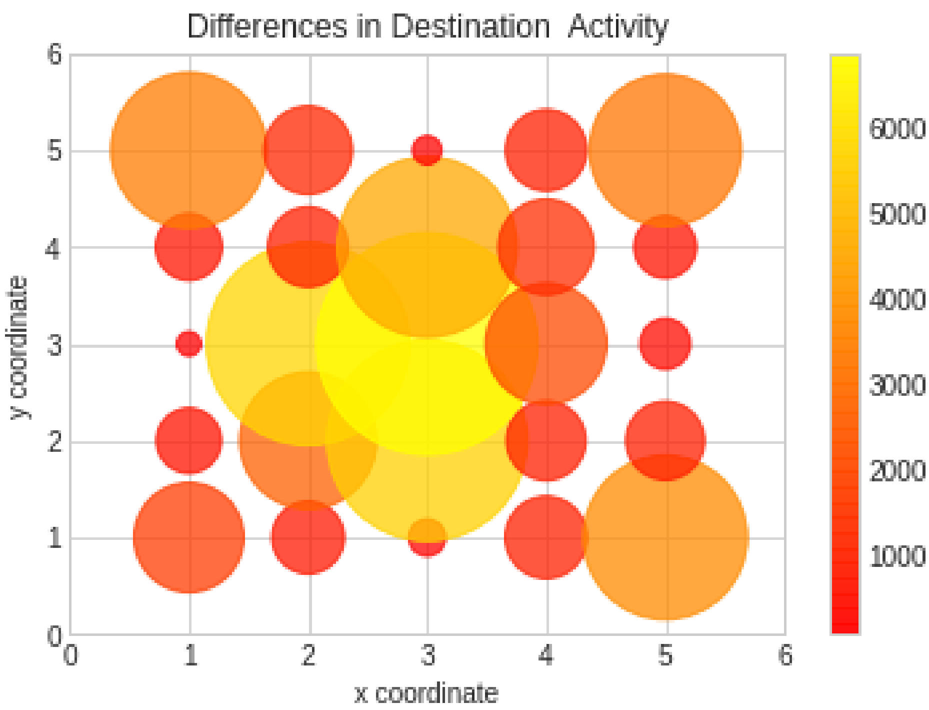


Predicted Origin Activity
y coordinate
x coordinate
0
1
2
3
4
5
6
5000
4000
3000
2000
1000


Observed Destination Activity
y coordinate
x coordinate
0
1
2
3
4
5
6
1000
1500
2000
2500
3000


Predicted Destination Activity
y coordinate
x coordinate
0
1
2
3
4
5
6
500
1000
1500
2000
2500
3000
3500
4000
4500


Differences in Origin Activity
y coordinate
x coordinate
0
1
2
3
4
5
6
1000
2000
3000
4000
5000
6000
7000
8000



The model and its outputs are now complete

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[ ]:
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