

# Spatial Economics – Assignment 2

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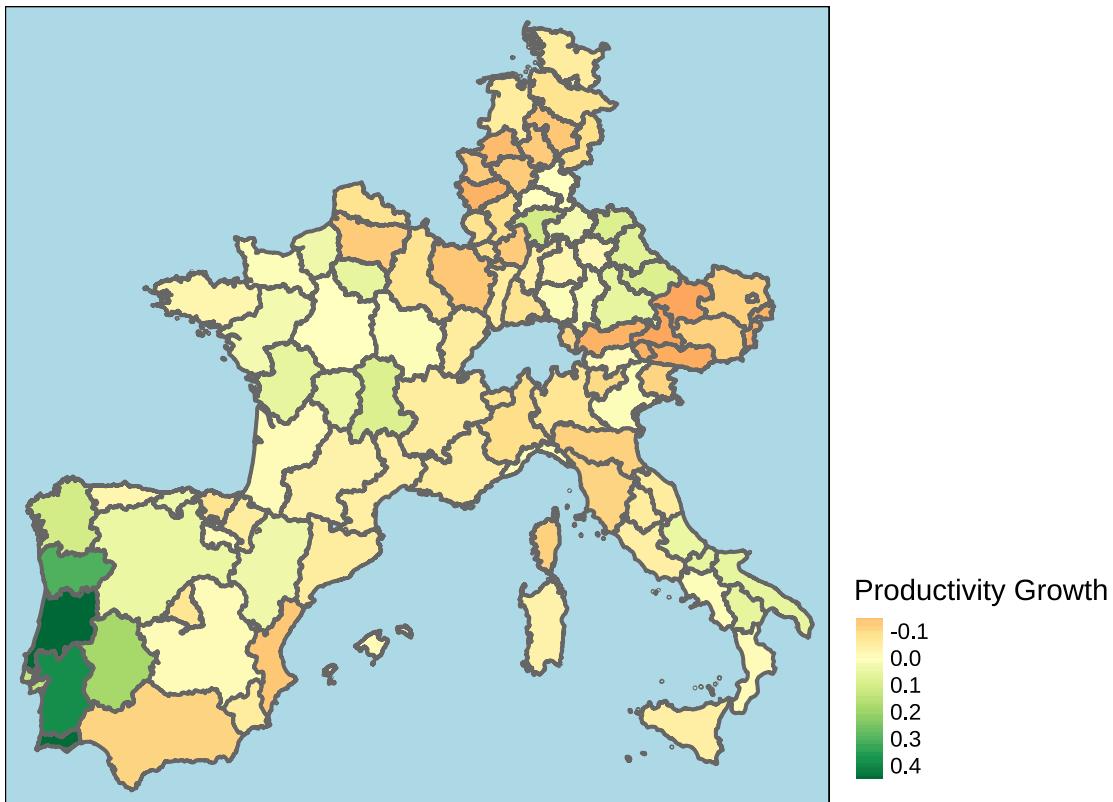
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*The code that was used in compiling the assignment is available on GitHub at  
[https://github.com/gustavpirich/spatial\\_econ/blob/main/02\\_assignment/02\\_assignmnet.Rmd](https://github.com/gustavpirich/spatial_econ/blob/main/02_assignment/02_assignmnet.Rmd).*

## Exercise A

Calculate the growth rate of productivity from 1980 to 2013 and create a map that shows the productivity growth for each region.

The map shows the productivity growth rates in the NUTS-2 regions for the selected countries. We can see that many regions especially in Germany, Austria, and France exhibited negative productivity growth over the selected time period. Notably, Portugal's productivity has been growing the fastest. We suspect that the negative growth rates can be explained by the fact that high-income countries had a high baseline productivity to begin with, while Portugal had a low baseline productivity. This could be evidence of convergence among productivity differences across Europe.



Generate three different spatial weights matrixes using (i) a distance threshold, (ii) smooth distance-decay, and iii) a contiguity-based measure.

### (i) Distance Threshold

First, we create a binary distance threshold spatial weights matrix based. Any region is being assigned a '1', if the center of any other region is less than 3 km away. Note that we have chosen this value so that every region has a neighbor. We use the nb2mat function from the 'spdep' package. We row-normalize the matrix.

```
##      Min. 1st Qu. Median   Mean 3rd Qu.   Max.
## 0.4377  0.8376 1.0191 1.1436 1.4705 2.6527
```

### (ii) Smooth-Distance Decay

Next, we create a spatial weights matrix based on a smooth distance-decay. We use the following simple distance decay function  $w_{i,j}(d) = 1/d$ . We calculate the weights for each neighboring region based on the k=1 nearest neighbors. We do not row-normalize the matrix.

### (iii) Contiguity-based measure

Finally, we calculate a contiguity based measure, which we row normalize as well.

## Compare the matrices; use your knowledge of graph theory and linear algebra

```
## Distance Threshold Graph:  
## Number of vertices: 103  
## Number of edges: 514  
## Average path length: 0.6750662  
## Graph density: 0.09784885  
## Average degree: 9.980583  
  
##  
## Smooth Distance-Decay Graph:  
## Number of vertices: 103  
## Number of edges: 40  
## Average path length: 4.531818  
## Graph density: 0.007614696  
## Average degree: 0.776699  
  
##  
## Contiguity-Based Graph:  
## Number of vertices: 103  
## Number of edges: 222  
## Average path length: 1.288804  
## Graph density: 0.04226156  
## Average degree: 4.31068
```

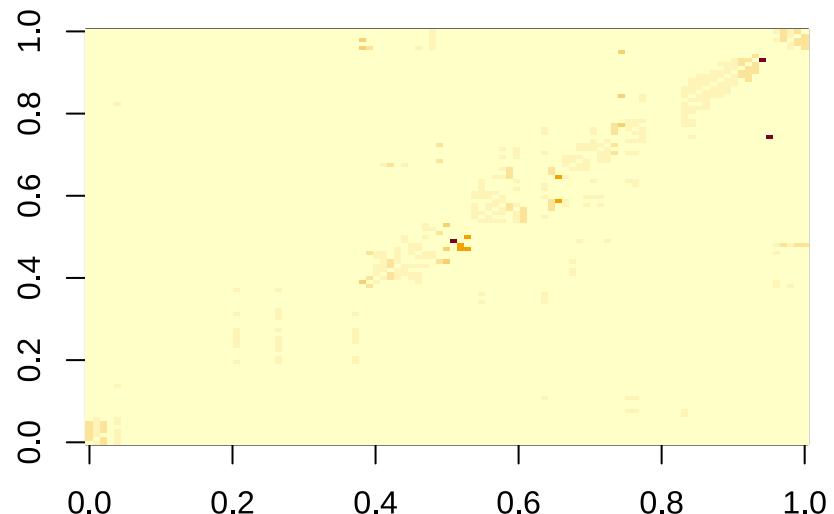
We compare the matrices based on a set of characteristics. The Distance Threshold Graph has 514 edges, indicating a higher level of connections between vertices compared to the other two. This suggests that many vertices are within the distance threshold to be considered neighbors. Smooth Distance-Decay Graph has only 40 edges, significantly fewer than the other graphs. This implies a much stricter criterion for considering two vertices to be connected, likely reflecting a much tighter control over distance decay effects. Contiguity-Based Graph strikes a balance with 222 edges, suggesting its connectivity criteria (likely based on shared boundaries or proximities) result in a moderate level of connections. Average Path Length Distance Threshold Graph shows a very low average path length (0.6750662), meaning that, on average, vertices are closely connected, allowing for short paths between them. Smooth Distance-Decay Graph has a much higher average path length (4.531818), indicating that paths between vertices are generally longer, reflecting the sparse connections. Contiguity-Based Graph has an average path length (1.288804), which is between the other two, suggesting moderate ease of movement across the graph compared to the other types. Graph Density Distance Threshold Graph has a density of 0.09784885, which is higher than the others, reflecting its higher number of edges and suggesting a relatively dense network. Smooth Distance-Decay Graph is the sparsest, with a density of 0.007614696, aligning with its fewer edges and longer path lengths. Contiguity-Based Graph has a density of 0.04226156, which, while lower than the distance threshold graph, suggests a moderately dense network, possibly due to its criteria for connections. Average Degree Distance Threshold Graph has a high average degree (9.980583), suggesting that, on average, each vertex is directly connected to about 10 other vertices, indicating a high level of connectivity. Smooth Distance-Decay Graph has a low average degree (0.776699), showing that each vertex is connected to less than one vertex on average, emphasizing its sparse nature. Contiguity-Based Graph has an average degree of 4.31068, indicating moderate connectivity among its vertices.

**Comparison Summary:**

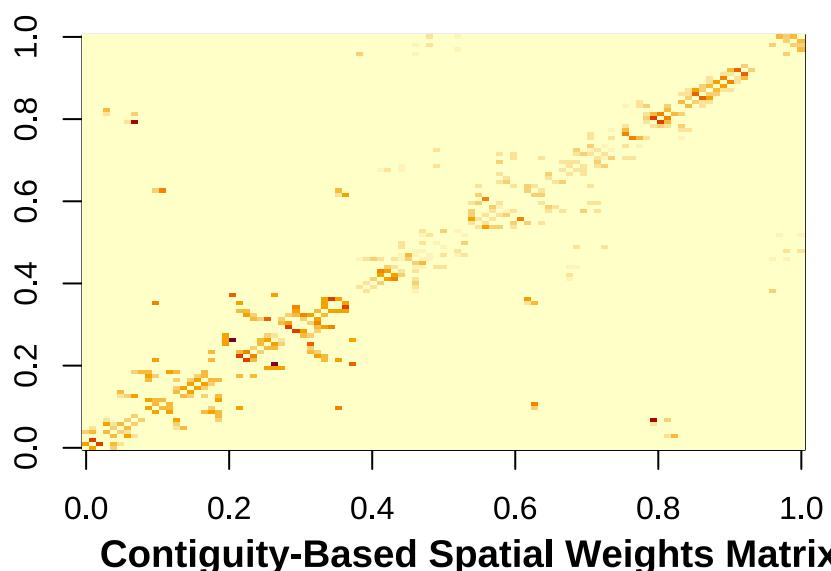
- Connectivity:** The Distance Threshold Graph is the most connected, followed by the Contiguity-Based Graph, with the Smooth Distance-Decay Graph being the least connected.
- Cohesion:** Measured by average path length and graph density, the Distance Threshold Graph shows the highest cohesion, indicating that it's easier to traverse between any two vertices. The Smooth Distance-Decay Graph has the lowest cohesion, with the Contiguity-Based Graph in the middle.
- Application Suitability:** The Distance Threshold Graph may be best suited for scenarios where the emphasis is on the close and dense connections between locations. The Smooth Distance-Decay Graph might be preferred for studies focusing on the impact of distance, favoring sparse connections that significantly weaken with distance. The Contiguity-Based Graph could be suitable for applications where geographical contiguity or proximity is a primary concern, such as regional planning. Each graph type, therefore, offers distinct advantages and drawbacks, depending on the specific requirements of your spatial analysis or modeling efforts.

Plot the matrix

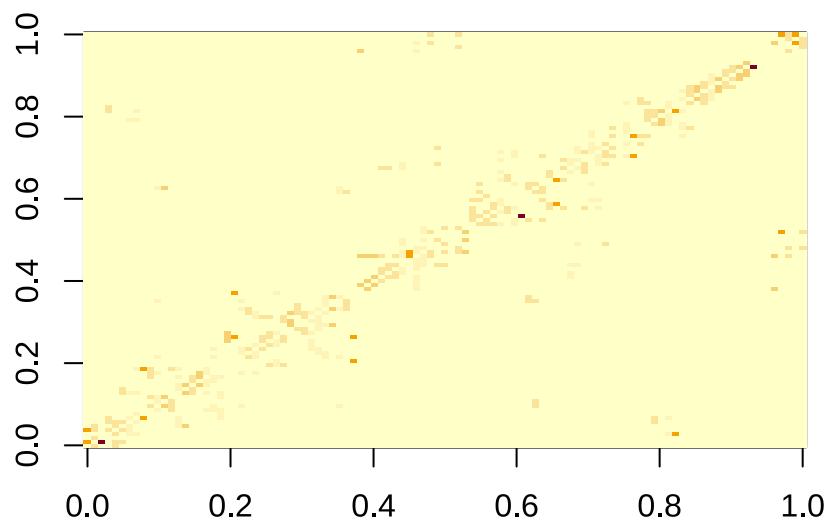
**Distance Threshold Spatial Weights Matrix**



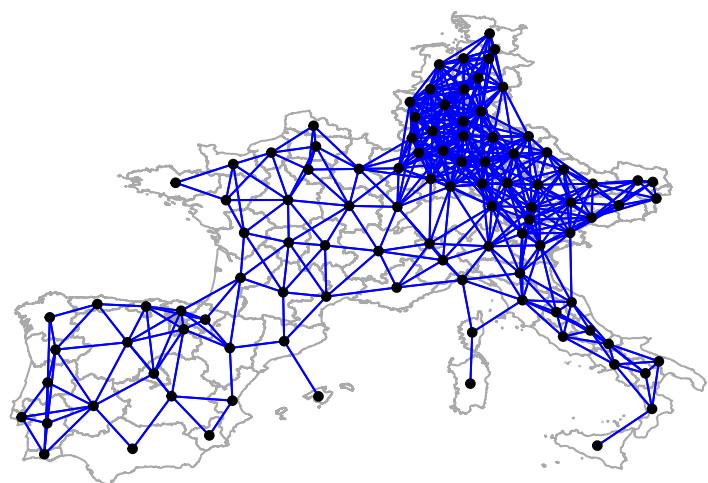
**Smooth Distance-Decay Spatial Weights Matrix**



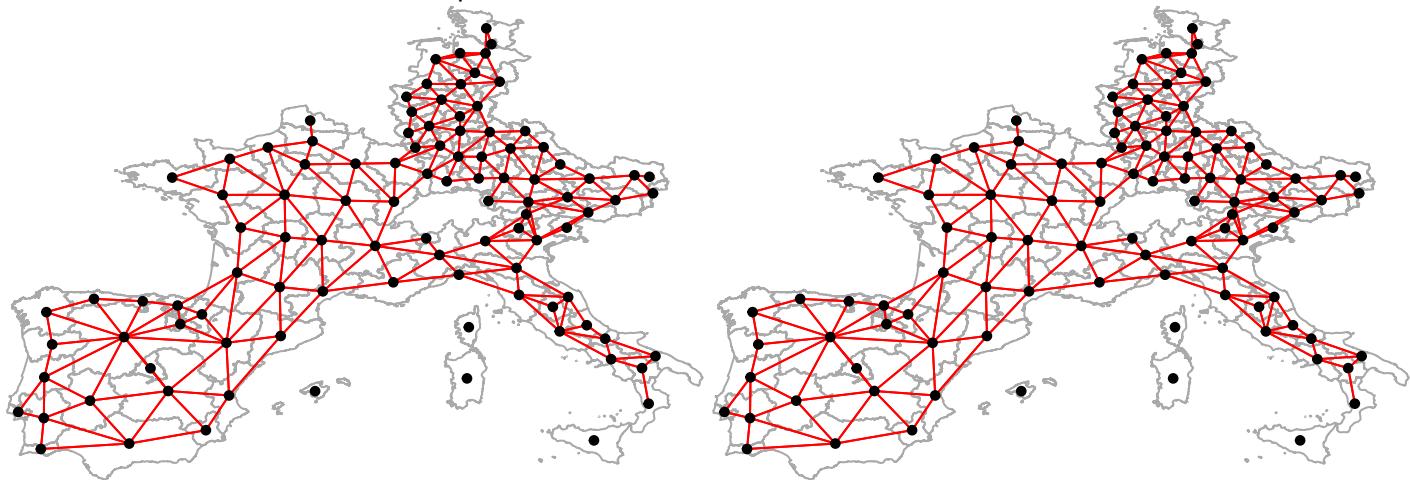
**Contiguity-Based Spatial Weights Matrix**



Try to visualize the network they represent



Let us first visualize the distance based spatial matrix.



Compute a suitable measure of spatial autocorrelation for productivity growth using these matrices. Point out differences, if there are any.

```
##          Length Class  Mode
## statistic    1   -none- numeric
## p.value      1   -none- numeric
## estimate     3   -none- numeric
## alternative 1   -none- character
## method       1   -none- character
## data.name    1   -none- character
```

Table 1:

<i>Dependent variable:</i>	
	<i>prod_growth</i>
pr80b	-0.253*** (0.025)
Ininv1b	0.032*** (0.008)
Indens.empb	0.007 (0.009)
Constant	0.314*** (0.061)
Observations	103
R <sup>2</sup>	0.528
Adjusted R <sup>2</sup>	0.514
Residual Std. Error	0.080 (df = 99)
F Statistic	36.983*** (df = 3; 99)

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Estimate a linear regression model using OLS.

