Introduction to GIS Methods in Economics

Giorgio Chiovelli Sebastian Hohmann

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Overview

The plan for today

Network in Applied Economics

- Storeygard, 2016
- Dell 2016

Network Analysis

- Introduction to Network Analyst
- Setting the Network structure
- Create a Netwok Database
- Solving Best Route problem
- Djkastra Algorithm

Market Access

- Replication of Donaldson and Hornbeck, 2015

Paper examples: network

Trasport Costs and Economic Development: Storeygard (2016)

Storeygard, Adam (2016). "Farther on down the road: transport costs, trade and urban growth in sub-Saharan Africa" RES 123(1): 139-176.

Motivation

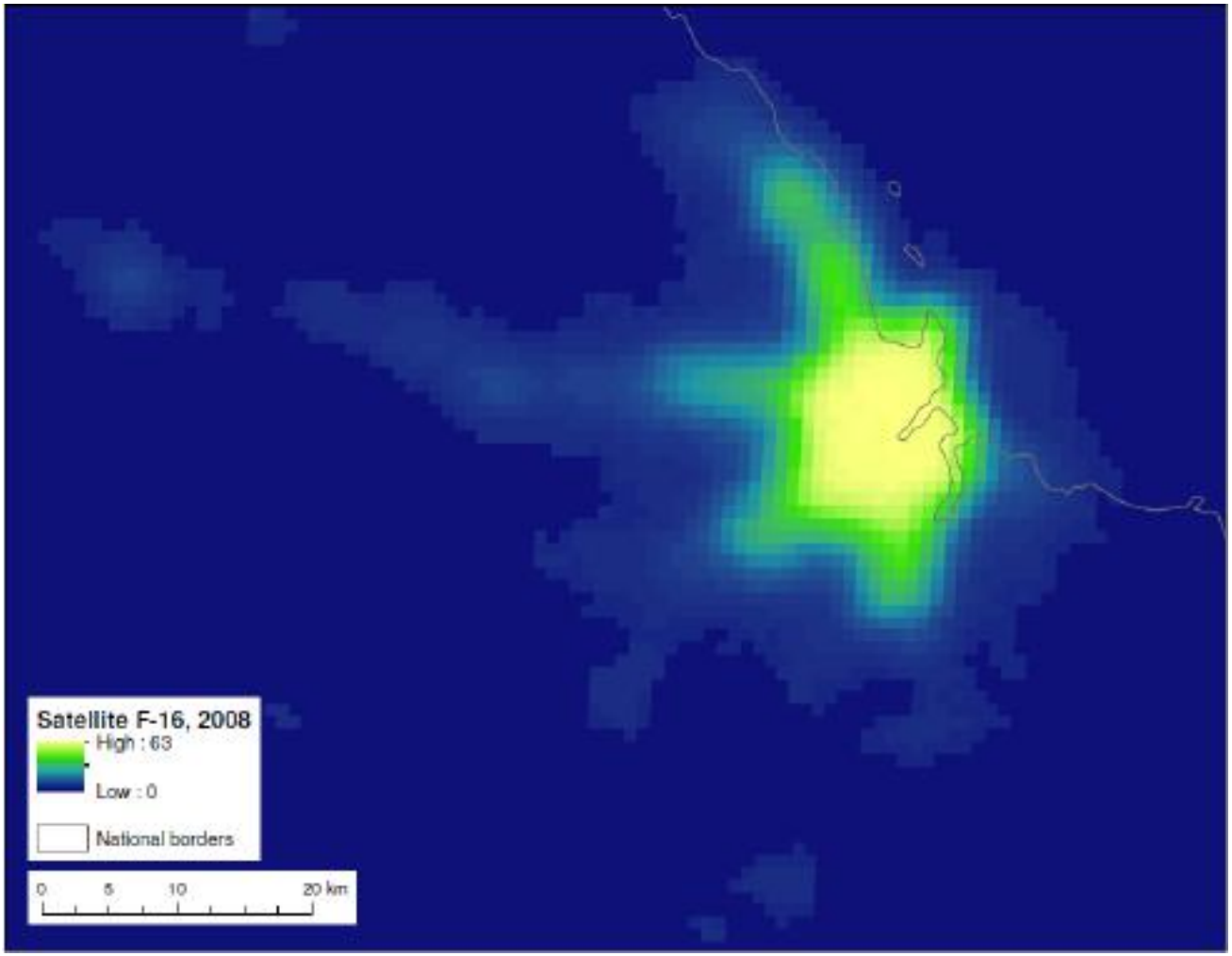
How inter-city connectivity determines the income of sub-Saharan African cities.

Contribution

Using road quality/type, lights, and oil price shock, estimates how growth is propagated far away from the city port. Negative elasticity of city economic activities wrt transport costs. Effect is heterogeneous in road quality (paved/unpaved).

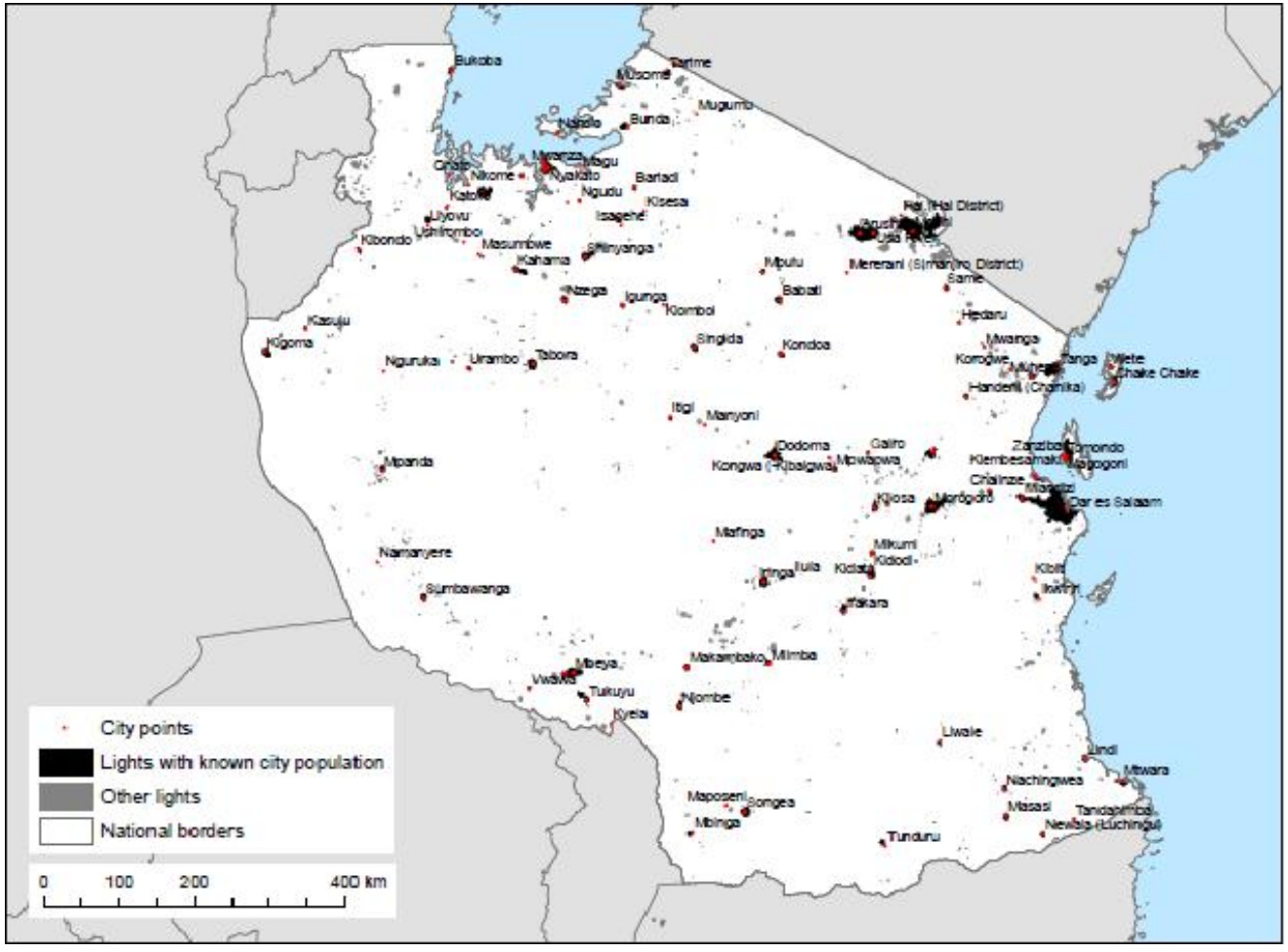
Paper examples: network

Luminosity (2008) in Dar el Salaam



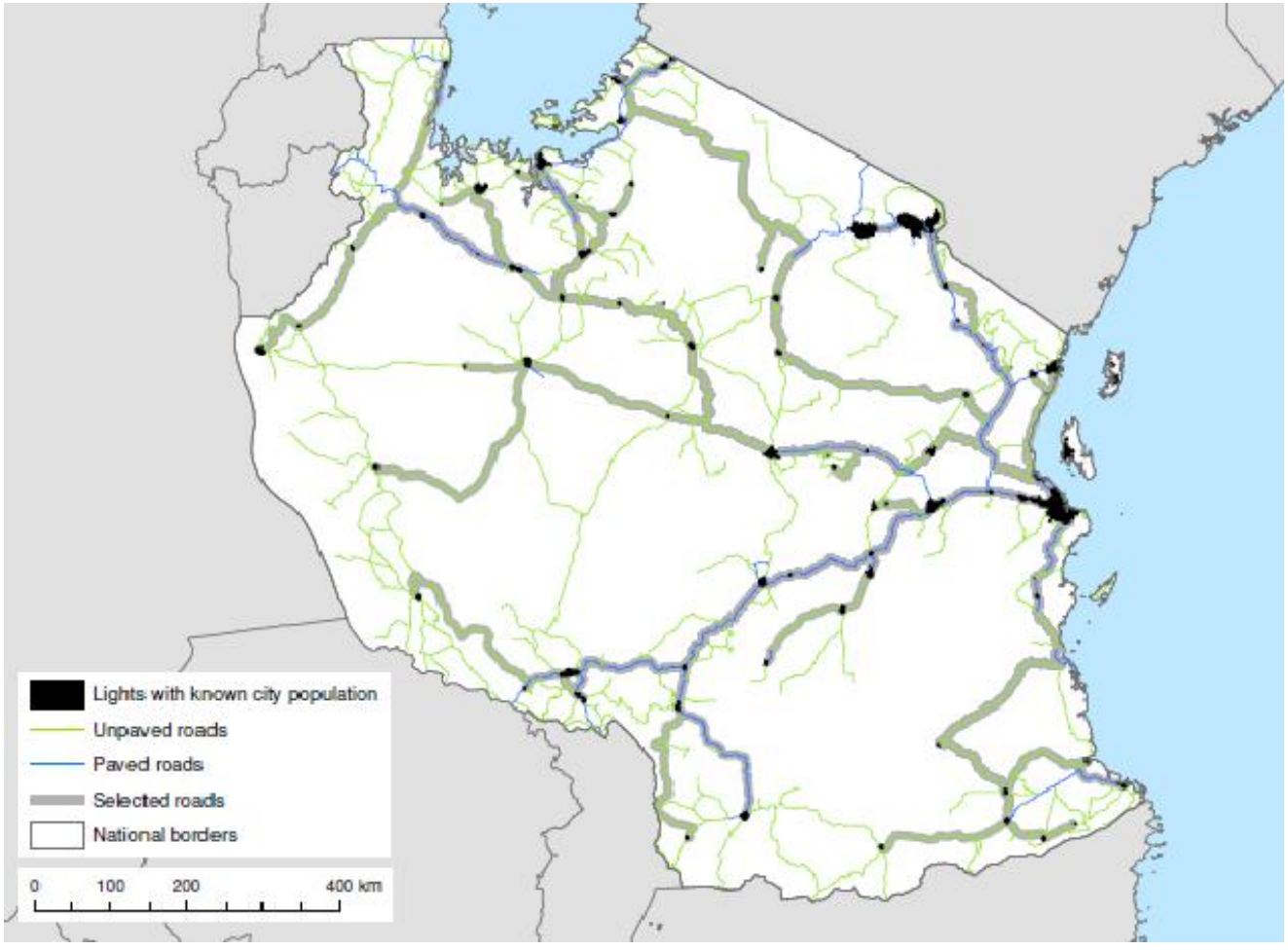
Paper examples: network

City Distribution in Tanzania



Paper examples: network

Roads connection to Dar el Salaam (Tanzania)



Paper examples: network

Trafficking Networks and the Mexican Drug War: Dell (2016)

Dell, Melissa (2016). "Trafficking Networks and the Mexican Drug War" AER

Motivation

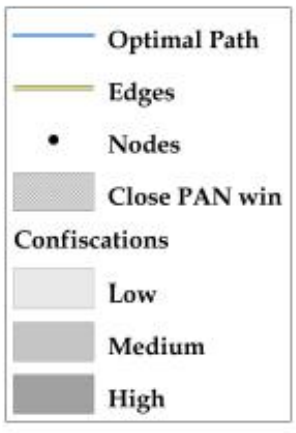
How crime repression policy affects spatial pattern of violence and crime.

Contribution

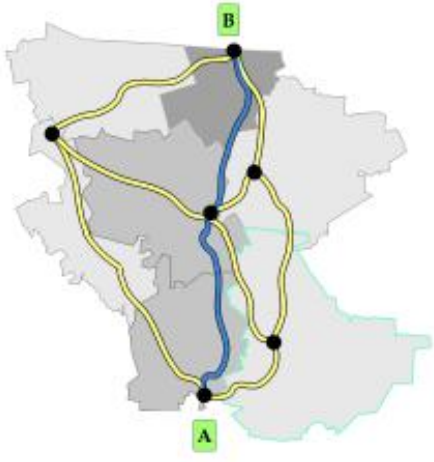
Using close elections, disaggregated crime data, and road network, to identify how crime reacts to crackdown policy. Quantification of externalities and unintended consequences of crime repression.

Paper examples: network

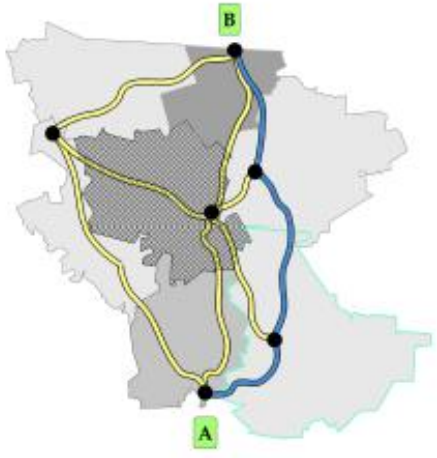
Spillover Methodology



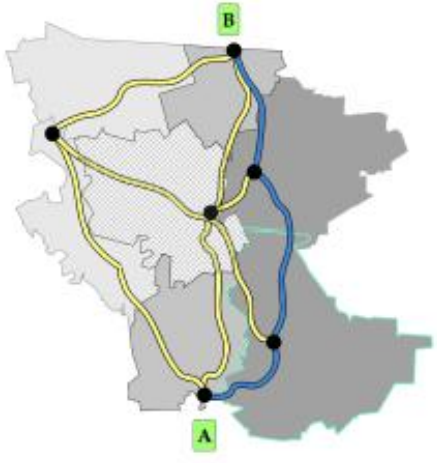
(a) Legend



(b) Basic environment



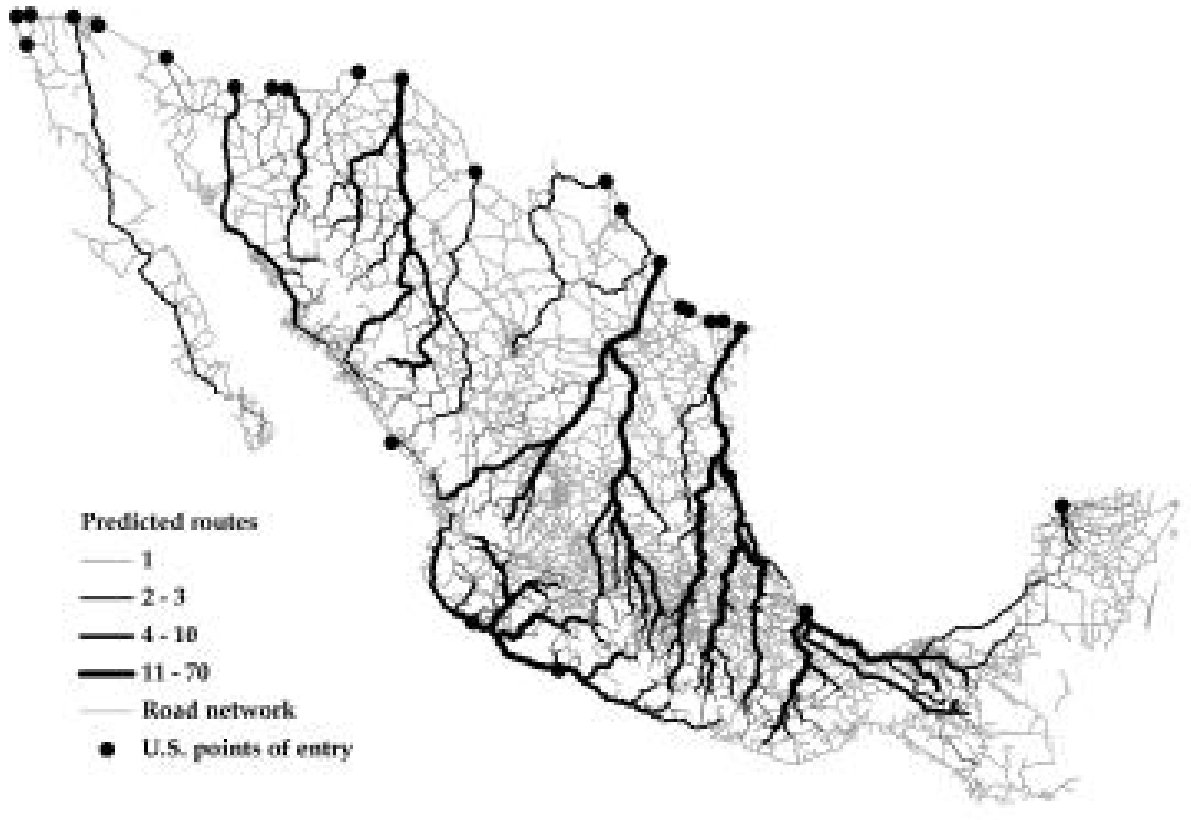
(c) Close PAN victory increases costs; routes change



(d) Do confiscation patterns also change?

Paper examples: network

Roads Network and Predicted Trafficking Routes



Working with Network Database in ArcGIS

This Section

1. Organize shapefiles needed to build the network and store them in a feature dataset
2. Create the network dataset and set the parameters and the characteristics of the network
3. Solve for the best route problem

Working with Network Database in ArcGIS

Step 1 [doable in Python]

Prepare your ground

1. Organize shapefiles needed to build the network and store them in a feature dataset

- Polylines are usually used in network
- Check projection of all elements
- Check if each element is able to be connected to any other element of the network
    - [snapping can be a useful edit tool in this case]
- Save everything in a **Feature Dataset**.
  This is the environment ArcGIS' Network extension recognizes
- Feature Datasets have to be saved inside **Geodatabases**

Working with Network Database in ArcGIS

Step 2: Part I [ArcMap only]

Setting up the network

2. Create the network dataset and set the parameters and the characteristics of the network

- Open ArcCatalog in ArcMap
- Go to your feature dataset and right click
- Select new and click on "Network Database"
- Name your network database
- Select the feature classes you want to participate to the network.
  - Note that all the feature class stored in the feature dataset will appear
  - Select only the network element (polylines). Points, polygons etc. will be added at a later stage

Working with Network Database in ArcGIS

Step 2: Part II [ArcMap only]

Setting up the network

2. Create the network dataset and set the parameters and the characteristics of the network

- Choose whether you want to model turns in the network (usually yes)
- Connectivity. Connectivity is usually established only at coincident endpoints of line features during the building process. Here you can specify different connectivity.
  - Note that if you build you network element in the correct way, all endpoints will be coincident
- Elevation Field. It allows to take into account elevation (Z coordinates). Rarely used in economics.

Working with Network Database in ArcGIS

Step 2: Part III [ArcMap only]

Setting up the network

2. Create the network dataset and set the parameters and the characteristics of the network

- Attribute for the network. Here you can set up the parameters defining the network.
  - Notice that ArcGis recognized automatically the fields named "Lengths" and "Cost" as the proper length and cost parameter of the network.
  - Then other parameter can be specified like Hierachy (which element of the network has to be preferred); Oneway (direction); RoadClass; Traveltime.
  - All parameters can be inspected by clicking on Evaluators.

Working with Network Database in ArcGIS

Step 2: Part IV [ArcMap only]

Setting up the network

2. Create the network dataset and set the parameters and the characteristics of the network

- Summary. It will summarize all your choices
- Then the network will be created.
- Click yes when asked to build the network
  - If some errors in connectivity are present at the end of the building process.
  - Notice that the network can still be used in the analysis but invalid features will be excluded from the network
  - **Show Build Errors** will allow you to check which object of the network elements are invalid. You can correct the errors and build the network again.
  - Typical error: geometry absent or too small to participate to the network.
- The network is now ready to be used.

Working with Network Database in ArcGIS

Step 3: Part I [doable in Python]

Network Solution

3. Solve for the best route problem

- Choose the environment in which you want to compute the Dijkstra's Algorithm solution for the best route.
  - **O(rigin)D(estination) Matrix**.
    OD Matrix is ideal for calculation of big $N \times N$ matrixes as it does not draw the problem solution graphically. It visualizes the results of the Dijkstra's algorithm as straight lines.
    Typical application: Compute shortest route for each dyad of US counties.
  - **Closest Facility.**
    To be chosen when there is the need to produce maps showing the solution to a particular "shortest path problem".
    Typical application: Show the shortest route linking Providence to Boston.

Working with Network Database in ArcGIS

Step 3: Part II [doable in Python]

Network Solution

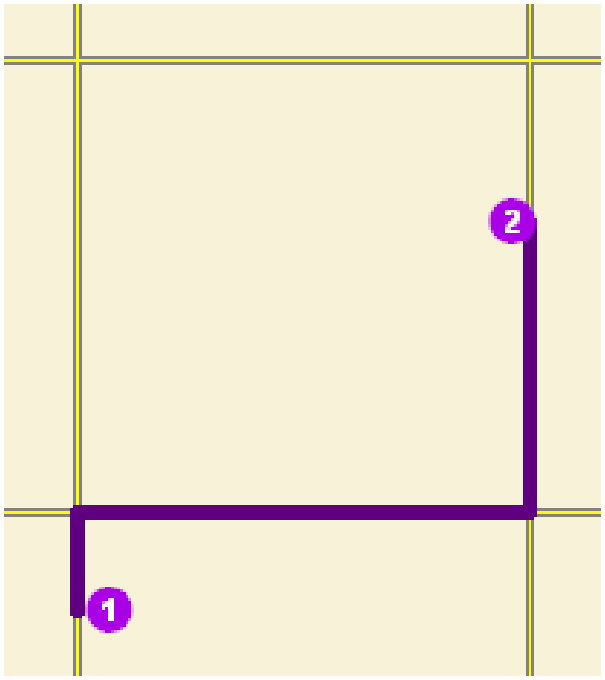
3. Solve for the best route problem

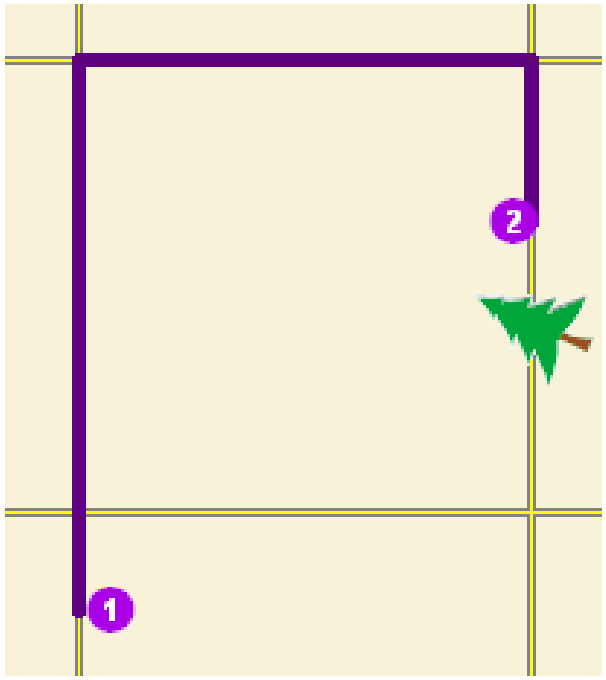
- For both options, you need to use `Add Location` to associate to the OD Matrix (Closest Facility) layer:
  - **Origins (incidents)**. Usually the point feature you want to connect to the network
  - **Destinations (facilities)**. The point feature you want the origins (incidents) to be connected to.
  - **Point/Line/Polygon Barriers**. Obstacles to be taken into account while solving the network problem.
    You can model the value of the obstacle as "Restriction" (Impassable) or "Scaled Cost" (you can pass but at a given cost).

Working with Network Database in ArcGIS

Step 3: Part II [doable in Python]

Point Barrier - Restricted

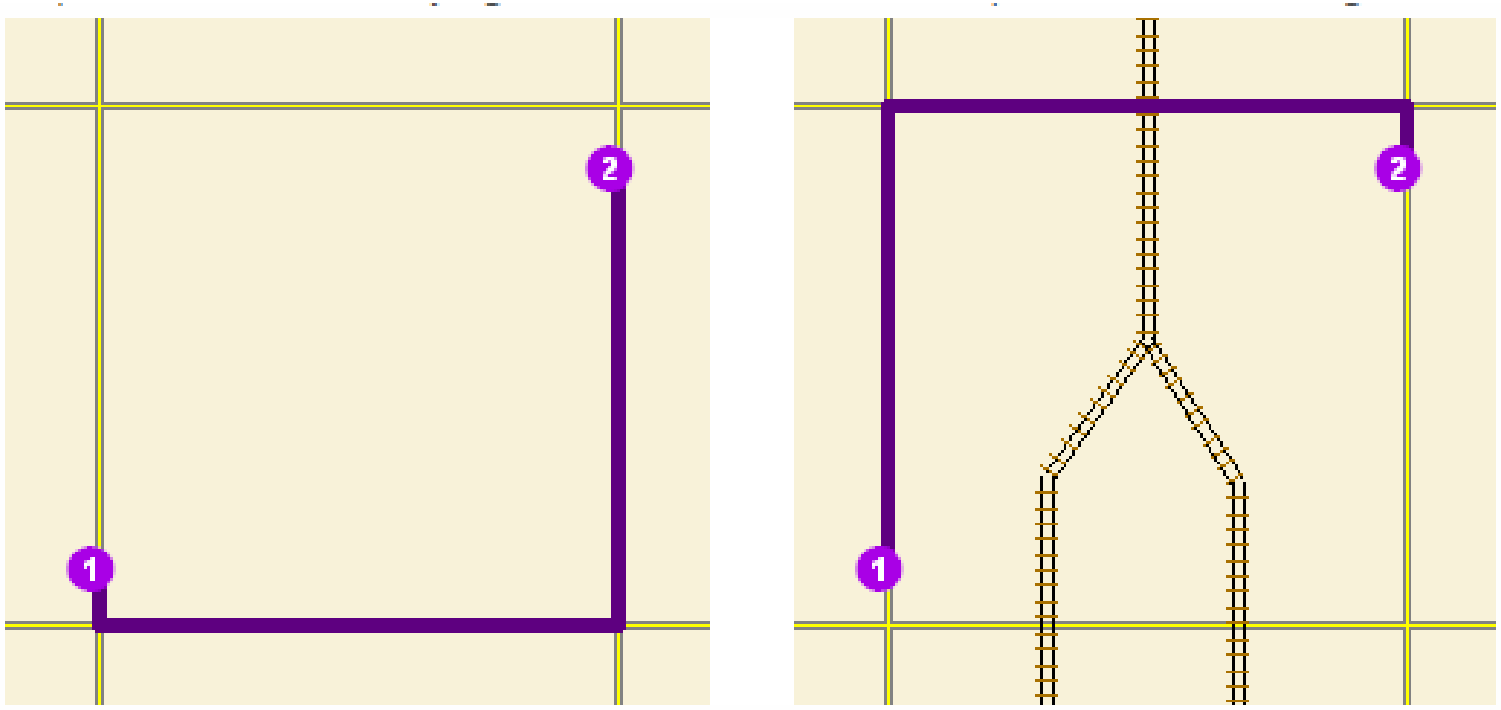




Working with Network Database in ArcGIS

Step 3: Part II [doable in Python]

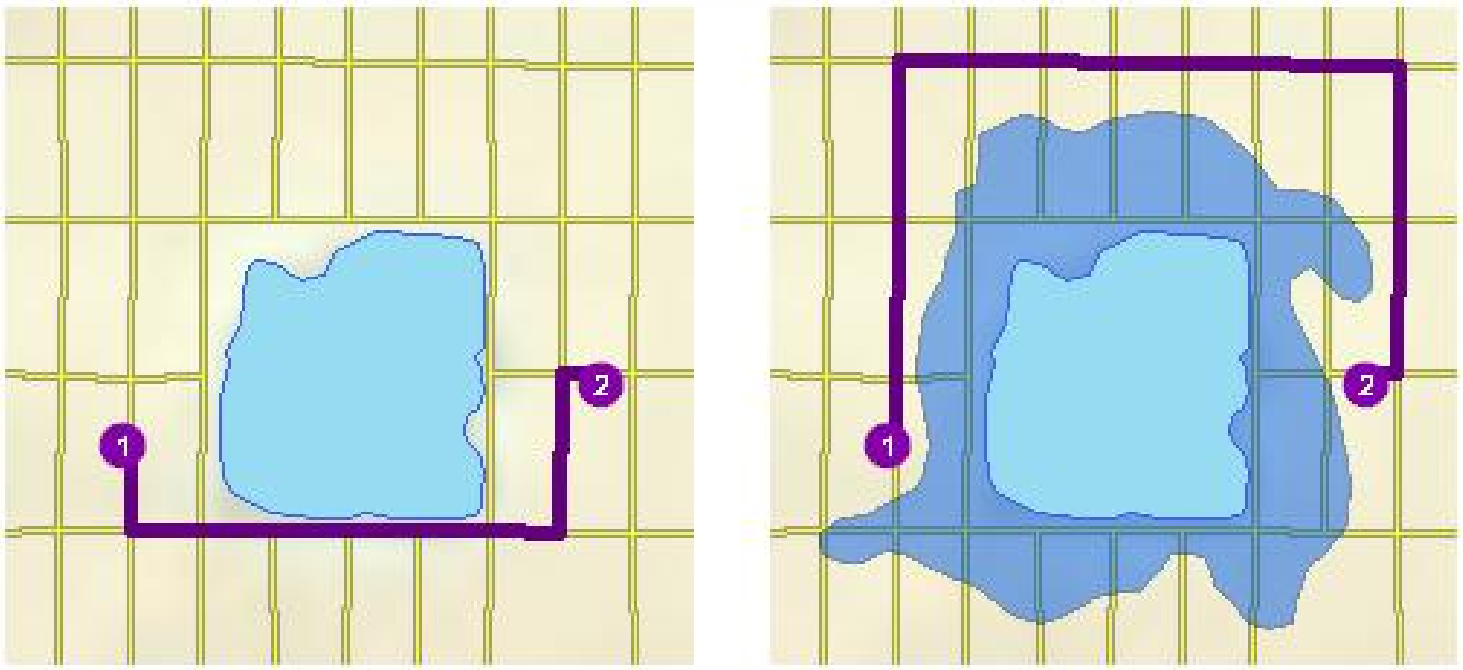
Point Barrier - Scaled



Working with Network Database in ArcGIS

Step 3: Part II [doable in Python]

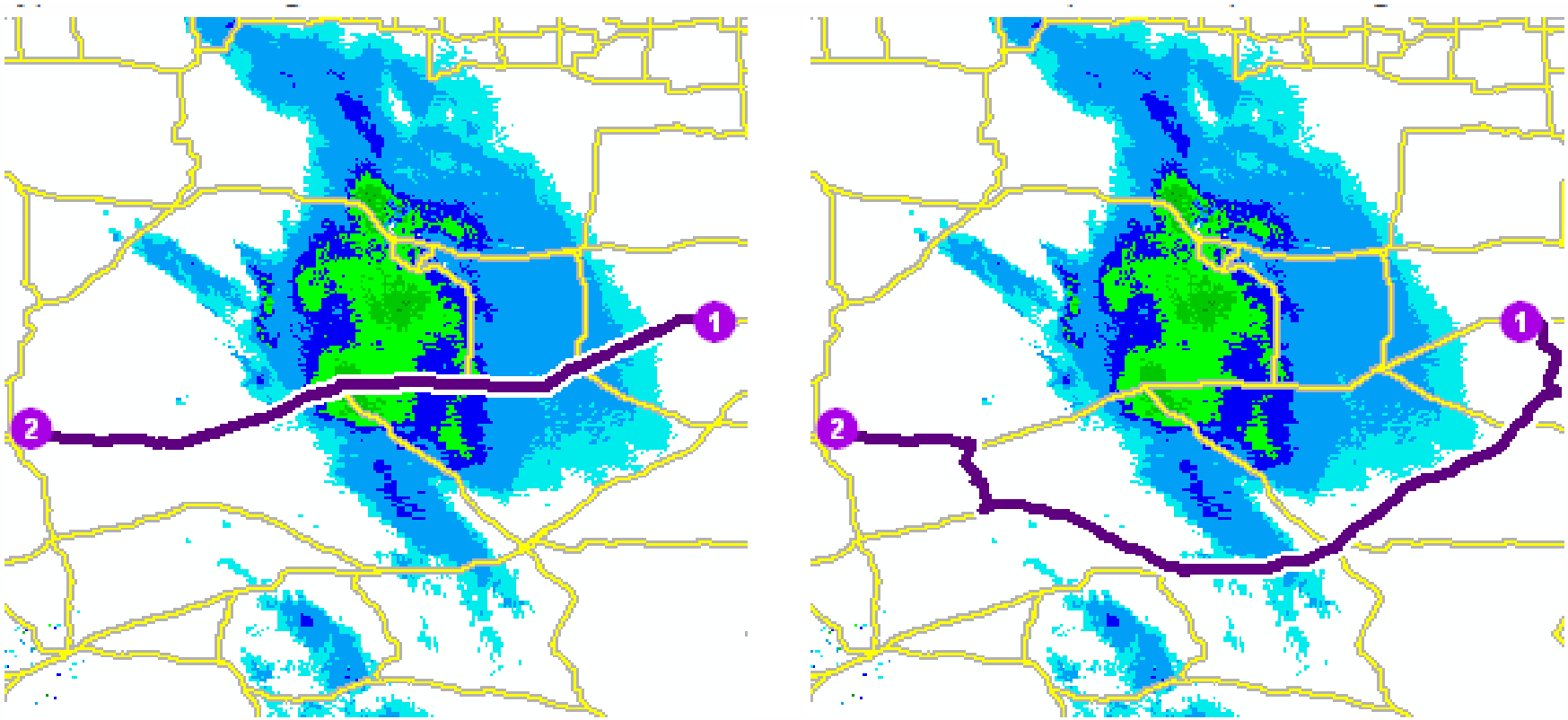
Polygon Barrier - Restricted



Working with Network Database in ArcGIS

Step 3: Part II [doable in Python]

Polygon Barrier - Scaled



Working with Network Database in ArcGIS

Step 3: Part II [doable in Python]

Network Solution

3. Solve for the best route problem

- Once you set up all additional component of your network, you can Solve the network problem
  - If you chose Closest Facility, now the layer "lines" will show the shortest path and the results are stored in its attribute table.
  - If you chose OD Matrix, the layer stored results in its attribute table
- Export the results of the Solve to csv or txt

Market Access

Railroads and American Economic Growth: Donaldson and Hornbeck (2015)

Donaldson, Dave and Hornbeck, Richard (2015). "Railroads and American Economic Growth: A "Market Access" Approach" QJE

Motivation
Evaluate the role of railway construction for US economic growth.

Contribution
Combine transportation network over time and census data to show that expansion of the railway network fostered both local and aggregated economic growth. Theory-based application of intra-country trade model (Eaton and Kortum, 2002) in a reduce form framework to quantify the spillover effect of infrastructure project.
Railways expansion fostered US economic growth. Aggregate effects are considerably larger than local effects (due to higher "market access").

Market Access

Railroads and American Economic Growth: Donaldson and Hornbeck (2015)

Key expression that provides a first-order approximation to counties' market access:

$$MA_o \approx \sum_d \tau_{od}^{-\theta} N_d \tag{1}$$

where:

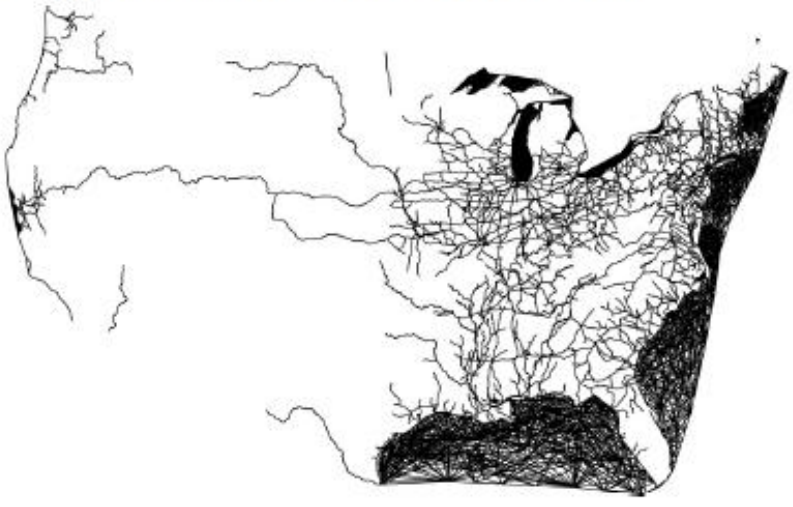
- MA_o: Market Access at origin (o)
- τ_{od}: bilateral transportation cost between origin (o) and destination (d)
- N_d: Population count at destination (d)

In our application, we are interested in deriving τ_{od}.

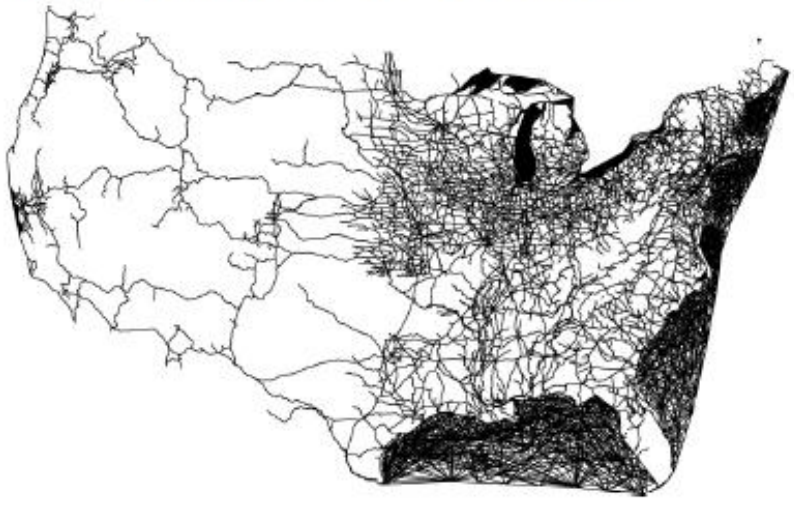
Market Access

Railway expansion 1870-1890

C. Natural Waterways, Canals, and 1870 Railroads

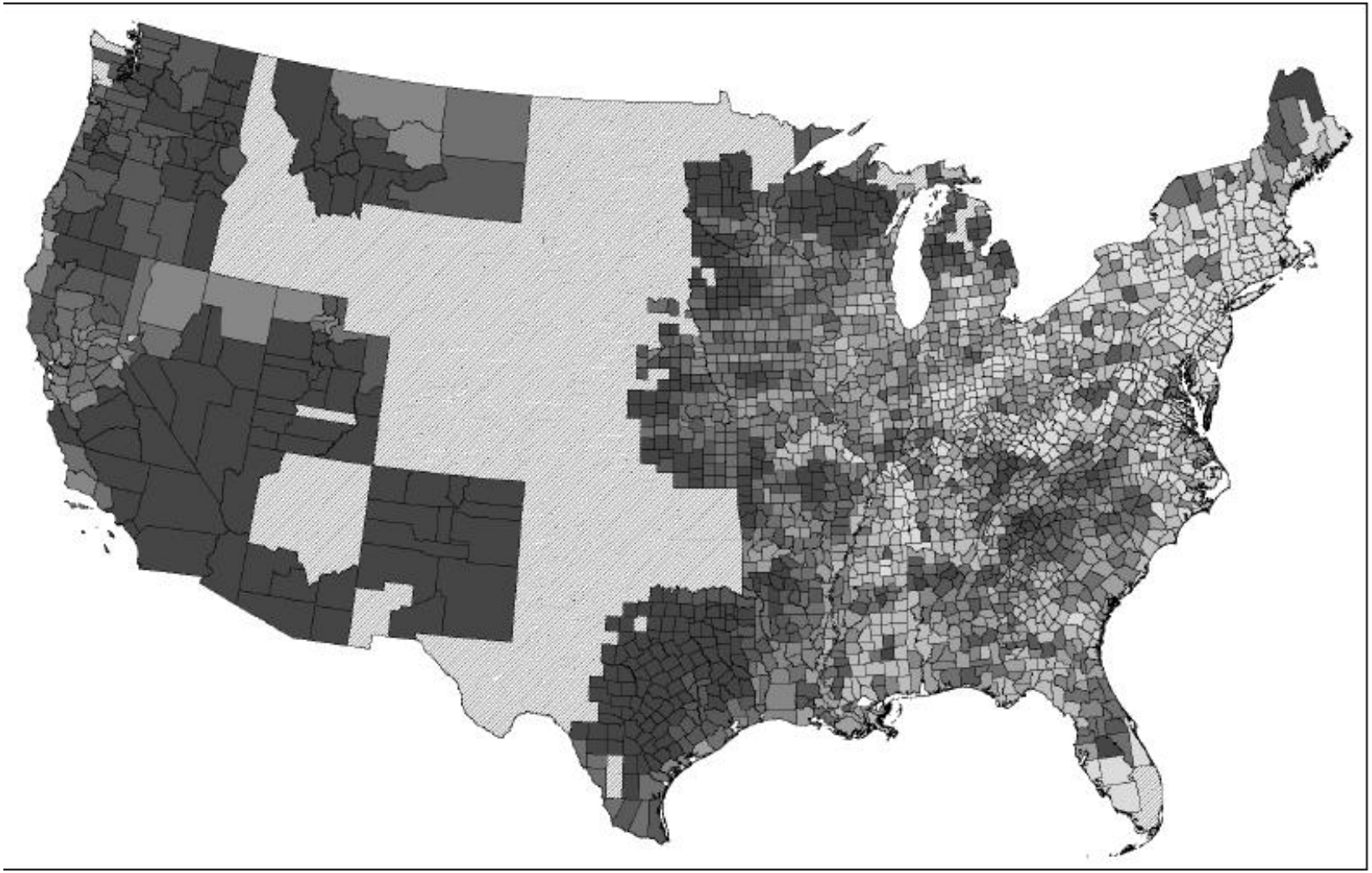


D. Natural Waterways, Canals, and 1890 Railroads



Market Access

Change in Market Access 1870-1890



Market Access

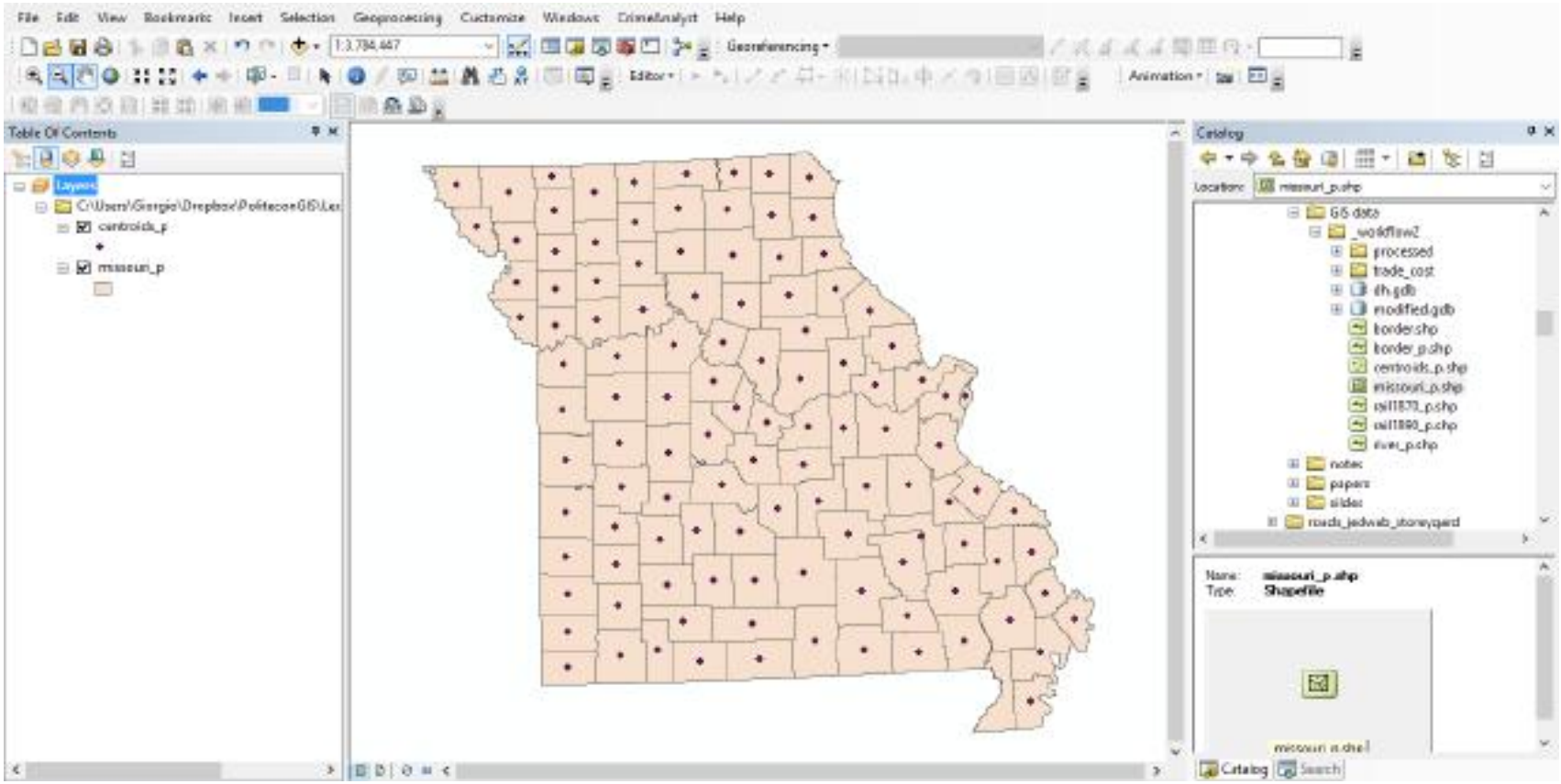
Replication DH network construction - Missouri

- We are going to construct the bilateral transportation costs in 1870 and 1890 for Missouri
- Prepare the network elements: net_prep.py
- Solve the best routes problem in both periods: trade_cost_od.py

Market Access

Replication DH network construction - Missouri

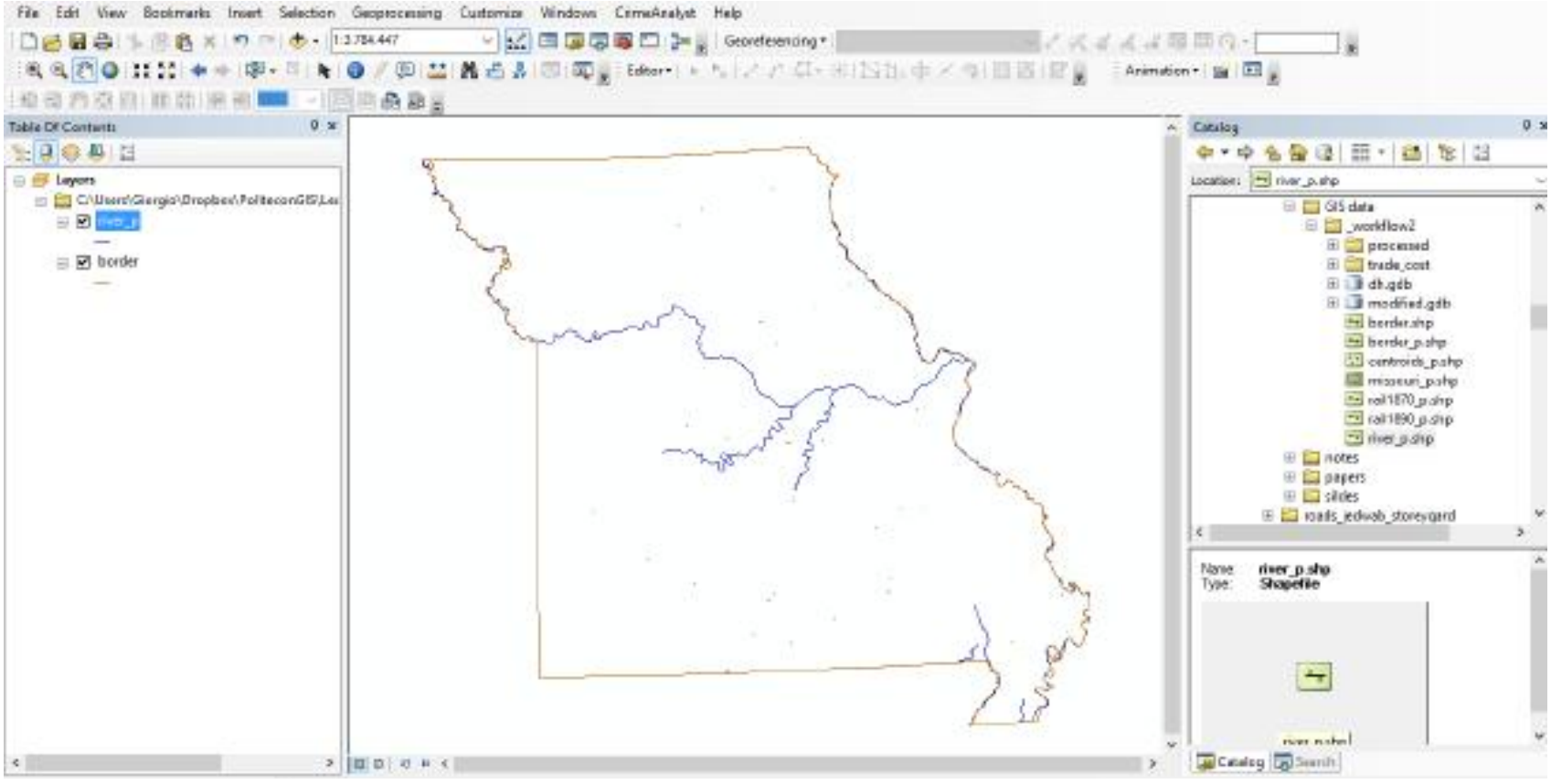
Centroids and Counties 1890



Market Access

Replication DH network construction - Missouri

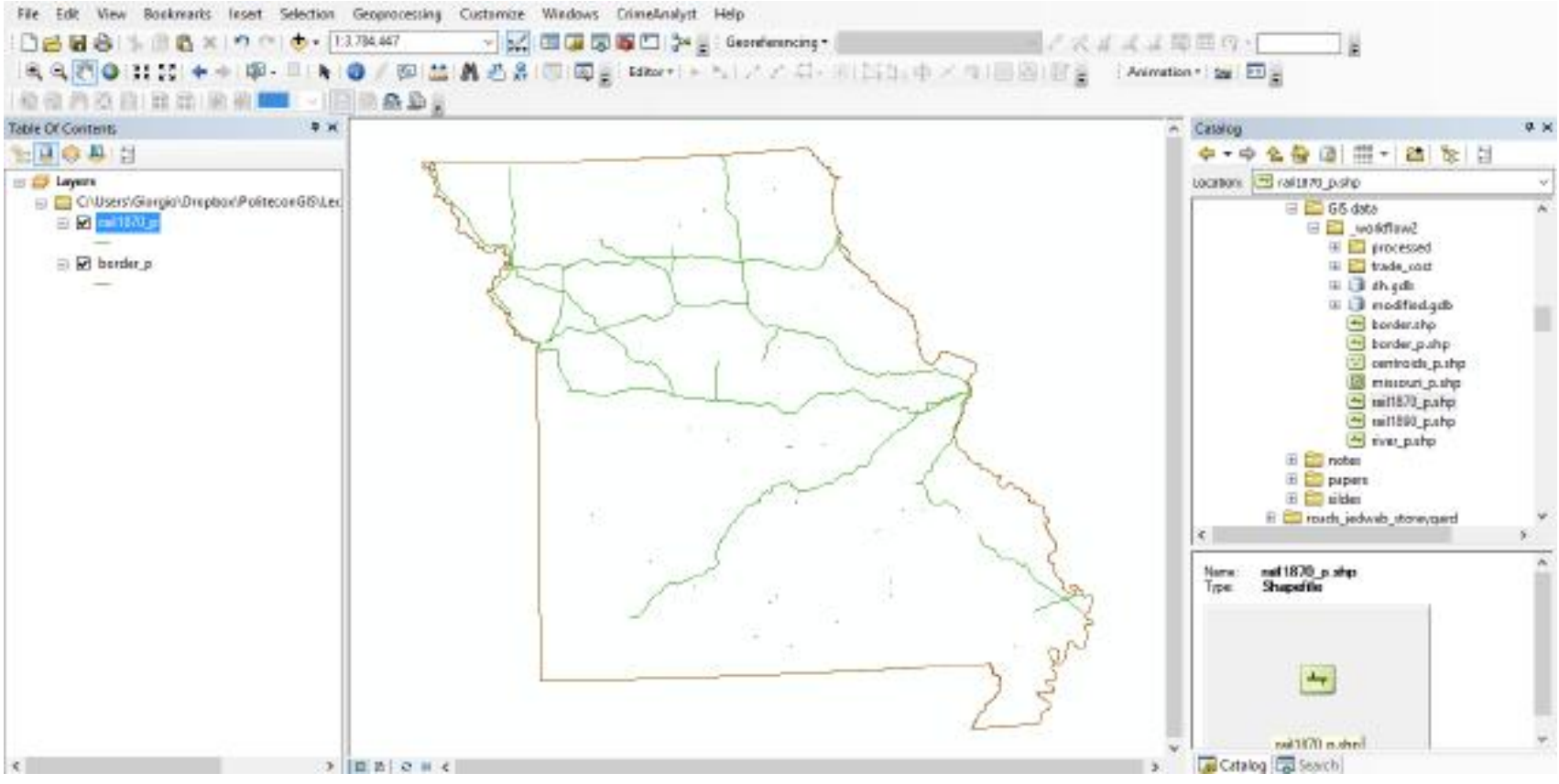
River Distribution



Market Access

Replication DH network construction - Missouri

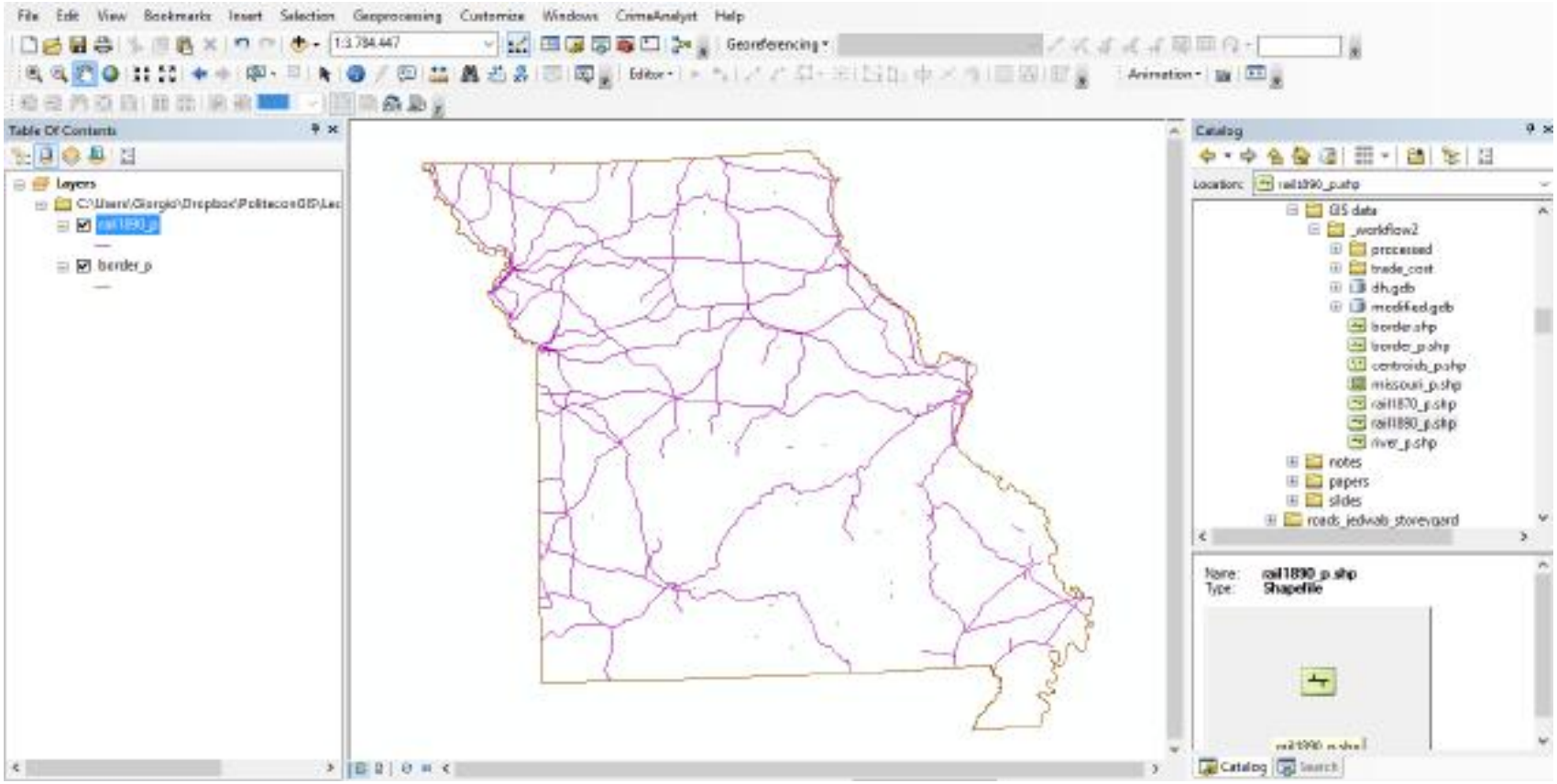
Railway expansion 1870



Market Access

Replication DH network construction - Missouri

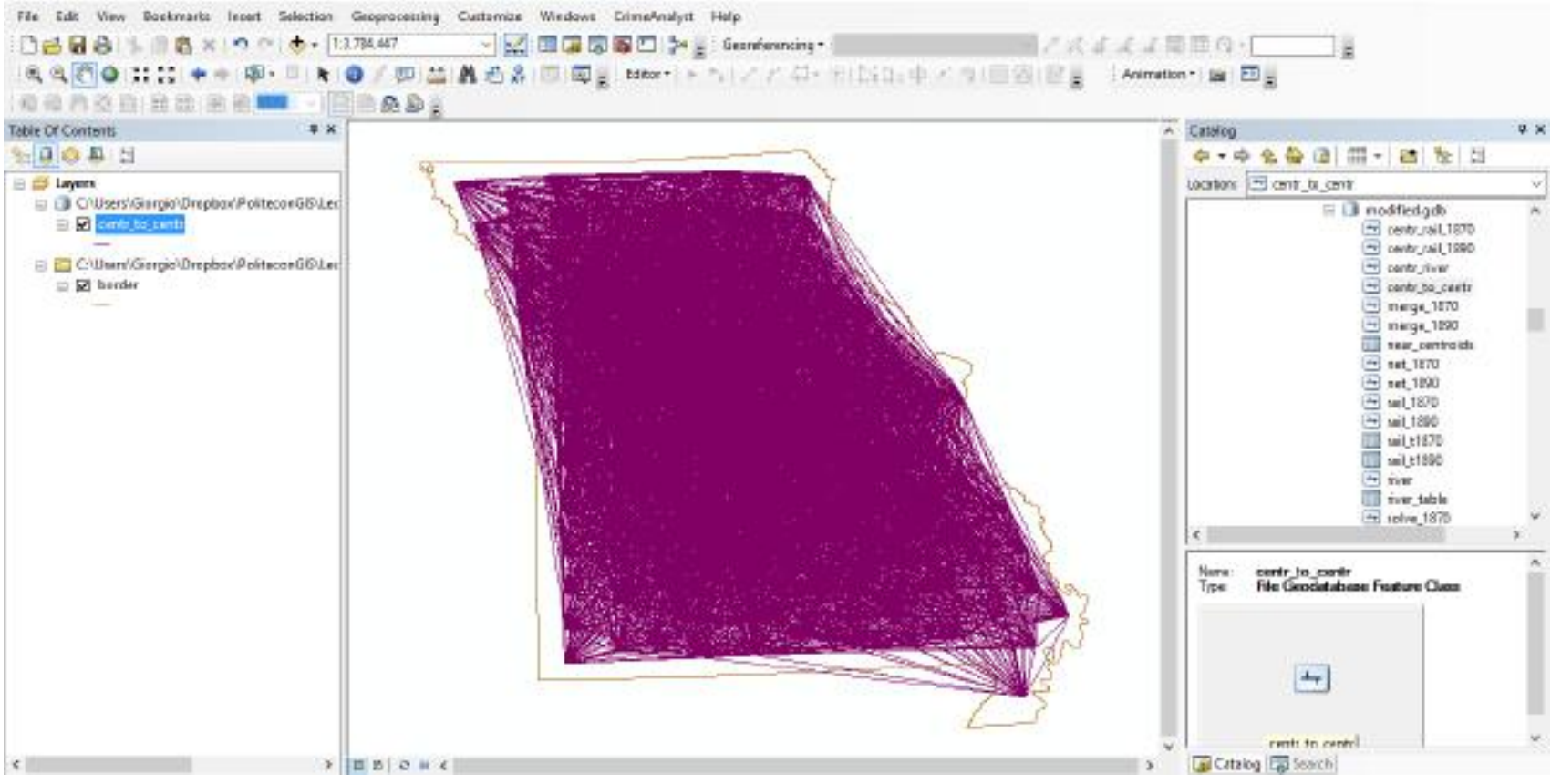
Railway expansion 1890



Market Access

Replication DH network construction - Missouri

Pairwise Centroid Connection



Market Access

Replication DH network construction - Missouri

Cost Parameters (Fogel, 1962)

- River = 0.0049 USD (tons/mile)
- Rail = 0.0063 USD (tons/mile)
- Wagon Routes = 0.231 USD (tons/mile)

We are going to ignore Transshipment Cost (0.50 USD) in this replication.

What we are going to do is to prevent switching transportation modes.

Total Cost = Parameter x Length (in miles)

Market Access

Replication DH network construction - Missouri

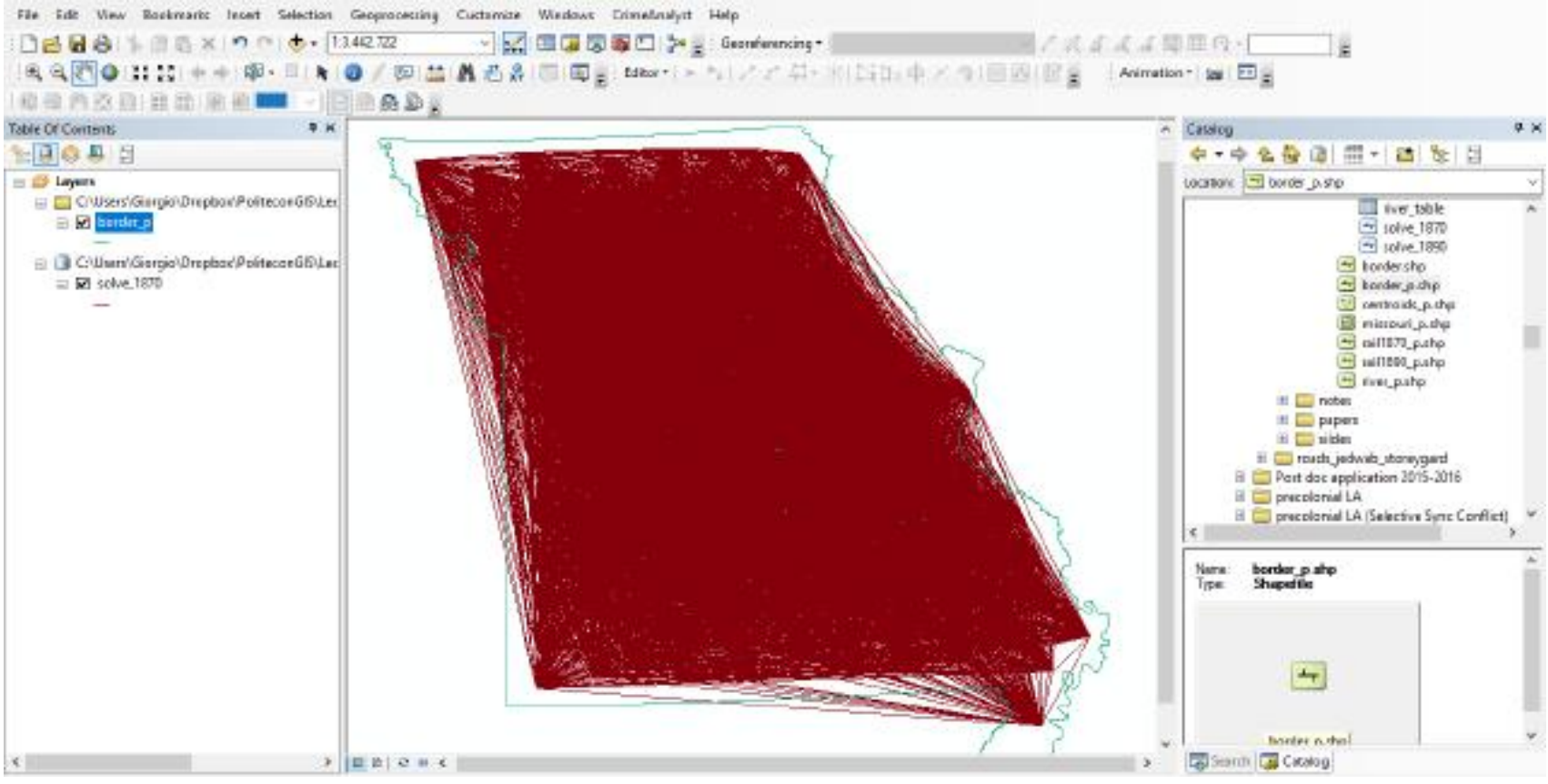
Solving the Best Routes Problem

- We are going to solve the network in 1870 and 1890
- We obtain a matrix of 114x114 of bilateral transportation costs
- This is the τ in the Market Access expression

Market Access

Replication DH network construction - Missouri

Solution Output in OD matrix



Use Closest Facility to visualize actual best routes solution.

Market Access

Replication DH network construction - Missouri

Solution Output Table in OD matrix