Econometric Modelling for Characterizing Spatial Distribution of Urban Economic Activities

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❖ Effective Decision-Making Methods for Freight-Efficient Land Use

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Background

Freight and the metropolitan economies…

❖ 60% of Global GDP → Produced in top 600 cities

❖ In the US, metro/micropolitan areas represent:

  ❖ 83% of establishments, 78% of employment, and 76% of the value of manufactures

  ❖ 80% of US cargo transported (top 100 metro areas)

❖ Statistics about freight transported:

  ❖ USA (entire country) → USA: 114 kg/person-day

  ❖ New York City, USA → 45 kg/person-day

  ❖ Beijing, China → 35 kg/person-day

  ❖ Medellin, Colombia → 25 kg/person-day

NAICS	Freight-Intensive Sector (FIS)	NAICS	Service-Intensive Sector (SIS)
11	Agriculture, Forestry, Fishing, Hunting	51	Information
21	Mining, Quarrying, Oil/Gas …	52	Finance and Insurance
22	Utilities	53	Real Estate and Rental and Leasing
23	Construction	54	Professional, Scientific, Tech. Services
31-33	Manufacturing	55	Management of Companies
42	Wholesale Trade	56	Administrative Support, Waste Manag.
44-45	Retail Trade	61	Educational Services
48-49	Transportation and Warehousing	62	Health Care and Social Assistance
72	Accomodation and Food Services	71	Arts, Entertainment, and Recreation
		81	Other Services
		92	Public Administration

Source: Holguin-Veras et al. (2018)

❖ The index considers intra-industry connections as the key determinant of centrality

❖ The economic center is influenced by the efficiency of the transportation systems that connects the areas to other parts of the metropolitan area
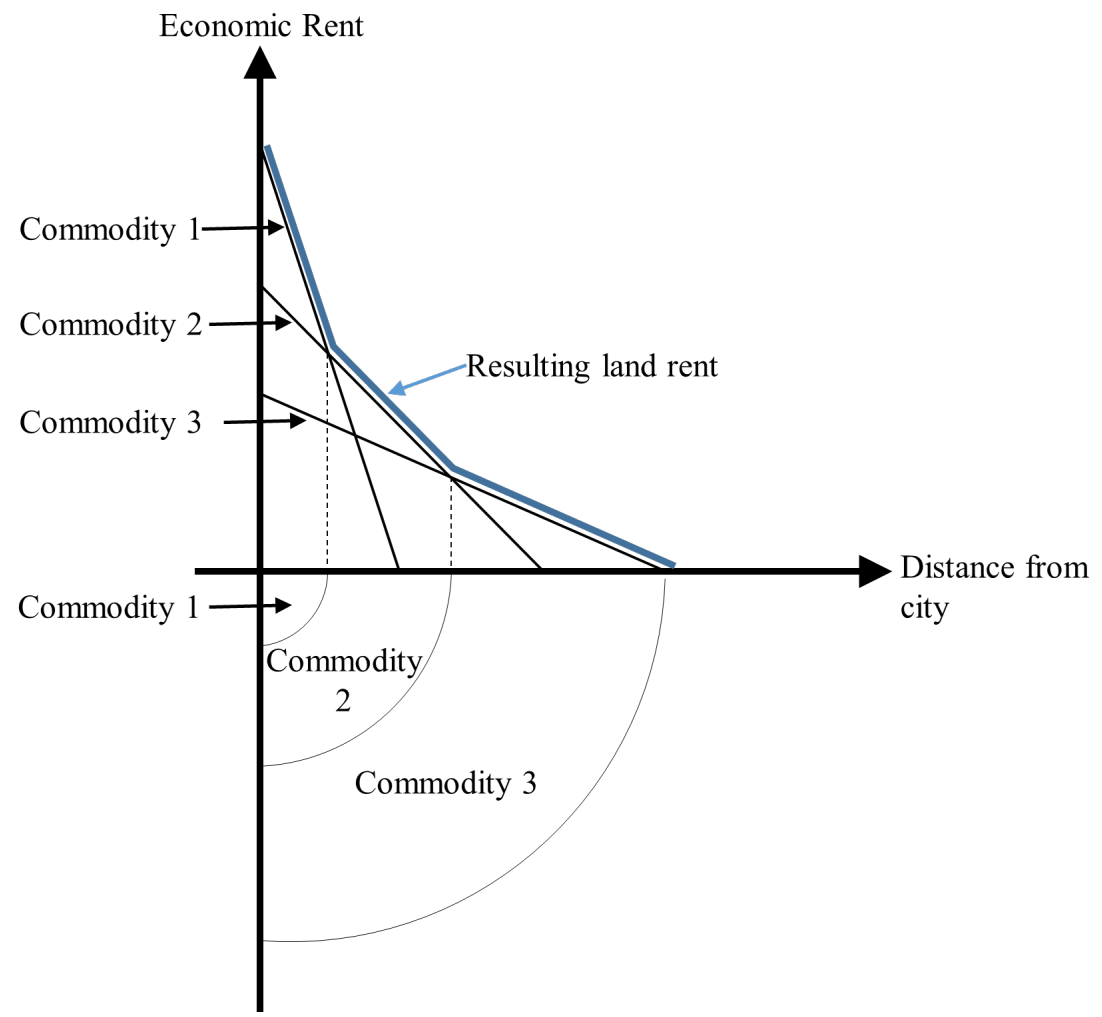
$$Interaction\ Index\ at\ Location\ \text{i} = \sum_j \frac{E_i^k \cdot E_j^k}{C_{ij}}$$
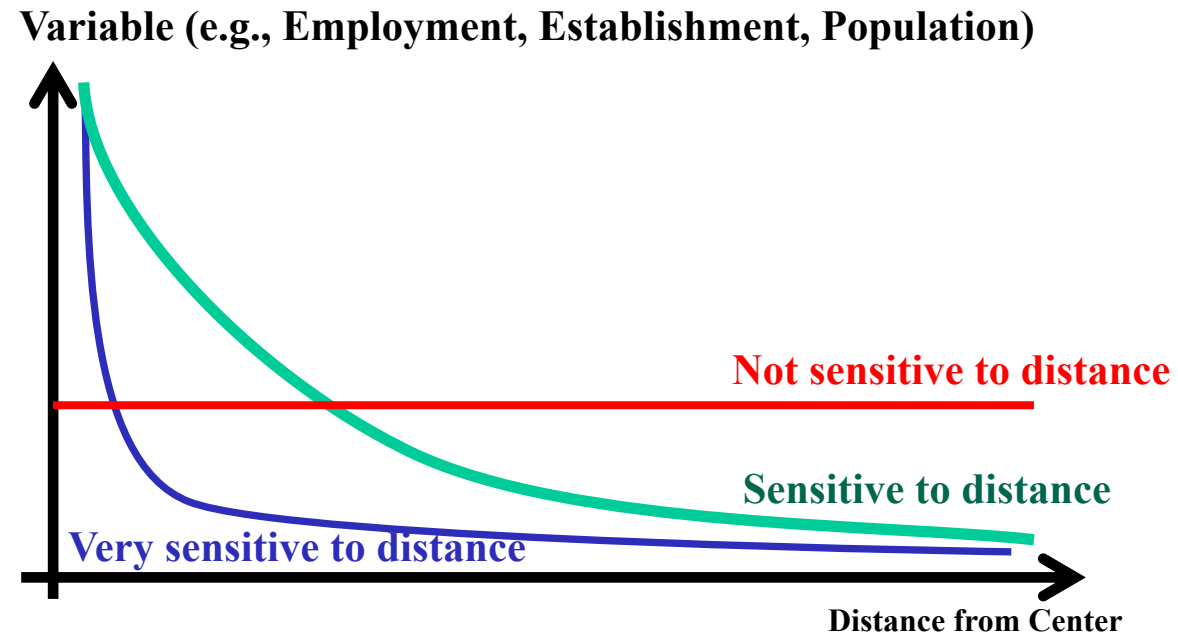
Where:
E_i^k and E_j^k are the employment of origin i and destination j in industry k
C_{ij} is the impedance between i and j
k is the industry sector

**The larger the employment at i and j, the larger the index
The larger the separation C_{ij}, the smaller the index**

Demand for Space: Land Use Activity Models

Von Thunen's model

Demand Functions

Methodology

Methodology

❖ Demand functions based on nonlinear models in which the density decays with respect to the distance to the economic pole of the region

    ❖ Establishment density models

    ❖ Models for Freight Trip Attraction (FTA) and Freight Trip Production (FTP) density

        ❖ Estimates come from "Using Commodity Flow Survey Microdata to Estimate the Generation of Freight, Freight Trip Generation, and Service Trips"

        ❖ Limitation: Only available to FIS

❖ The functional form of the regression model used is an exponential function.

$$\text{Establishment Density} = \alpha * \mathrm{e}^{\beta * Dis \tan ce} + \mu$$

❖ Two methodologies were used for this research: Ordinate Least Squares (OLS) and Quantile Regressions

Why Quantile Regression?

❖ Study the impact of independent variables on different quantiles of dependent variables distribution. **Provides a complete picture**

❖ **Robust to outliers**

❖ Estimation and inferences are **distribution-free**.
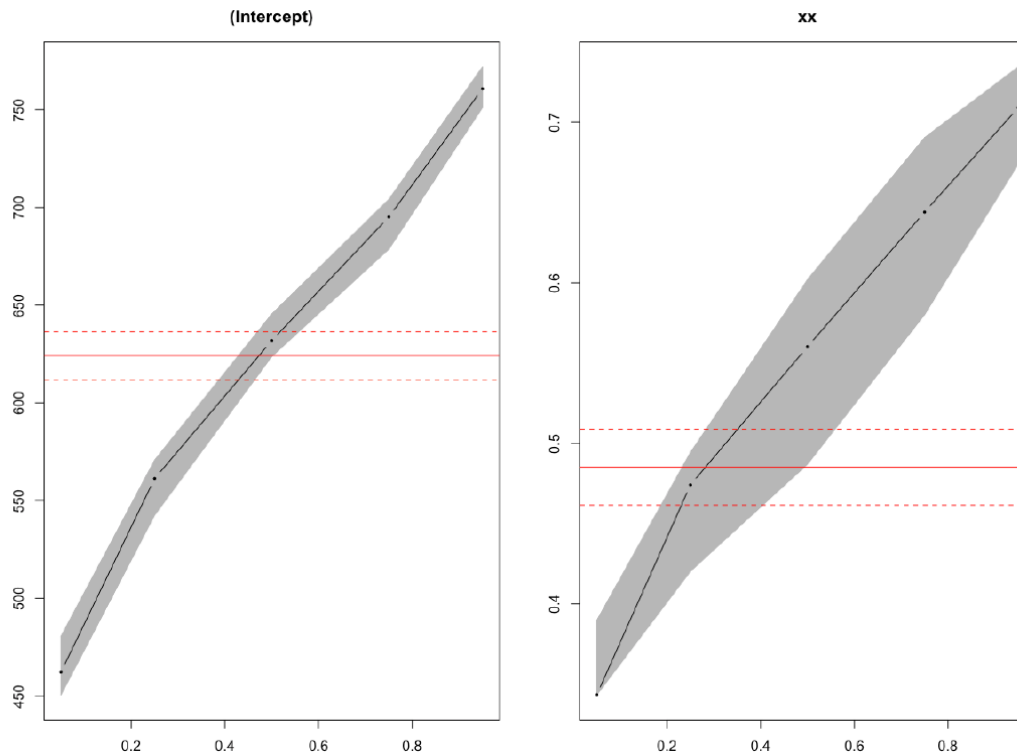
Provides an estimator by quantile

OLS estimator is similar to the median quantile 50

**Six metropolitan areas as case studies: NYC, Los Angeles, Houston, Washington, New Orleans and Albany**

Results

Economic Pole by Metro Area

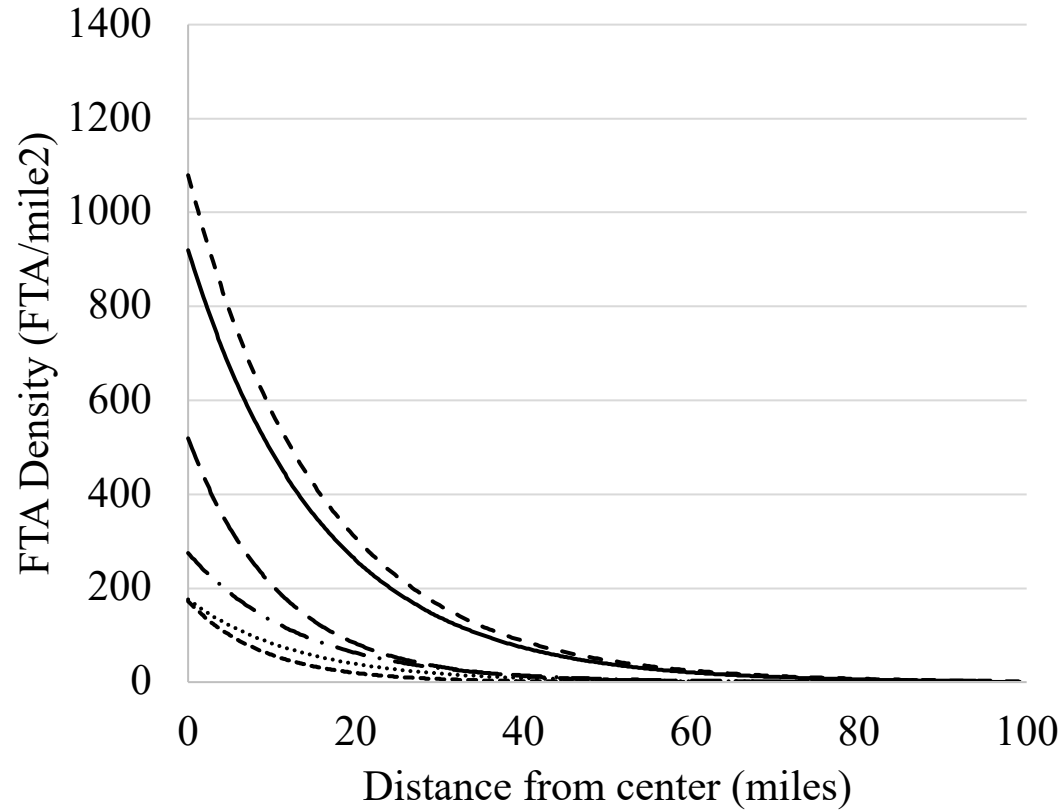| MSA	ZIP Code	Size	Description
New Orleans	70130	Small	Located in the Lower Garden District (near downtown) contains a large population density
Albany	12205	Small	Situated near downtown; with the two largest malls in the Capital Region
Houston	77002	Medium	Placed in downtown; it incorporates the CBD of the Metro area
Washington, D.C.	20005	Medium	Located in downtown; it allocates several hotels and restaurants
Los Angeles	90017	Large	Placed west of downtown LA and south of Chinatown; it is close to two major highways (I-110 and I-10)
New York City	10017	Large	Located in east midtown Manhattan with large amount of commerce activities

FIS and SIS Establishment Density
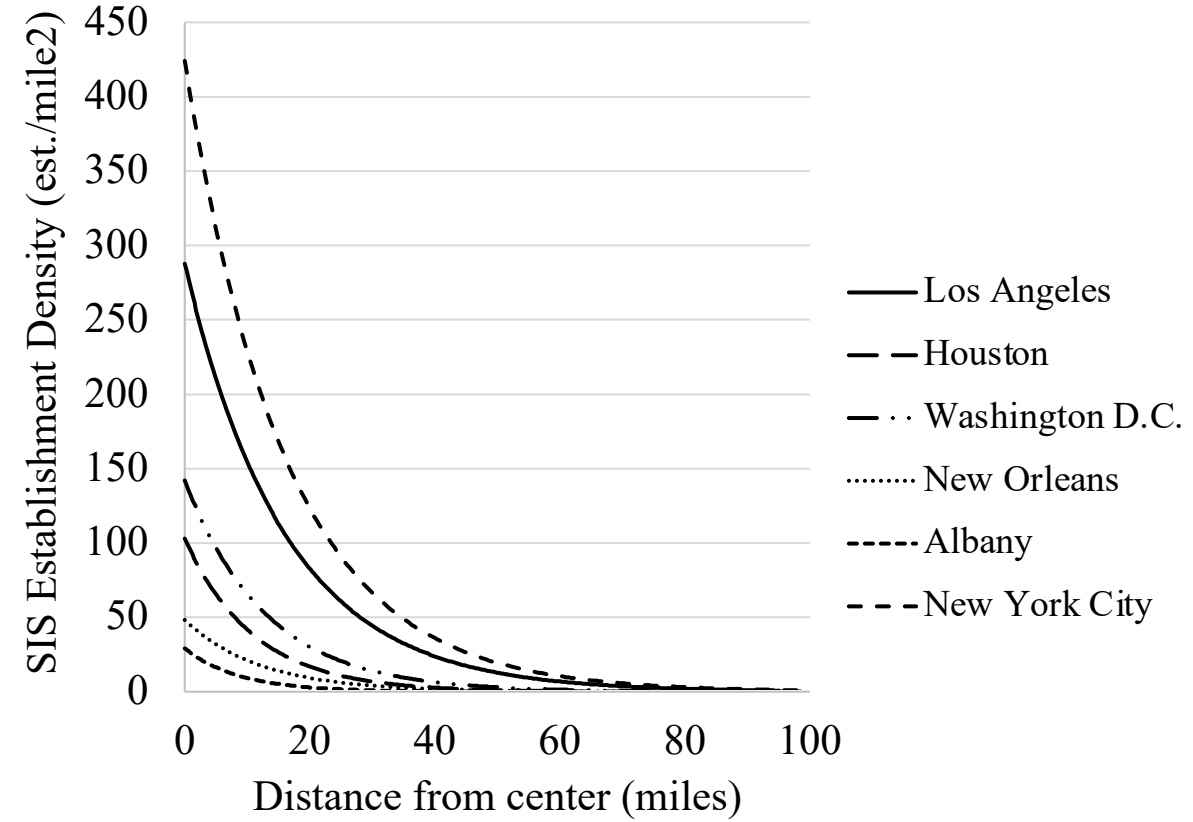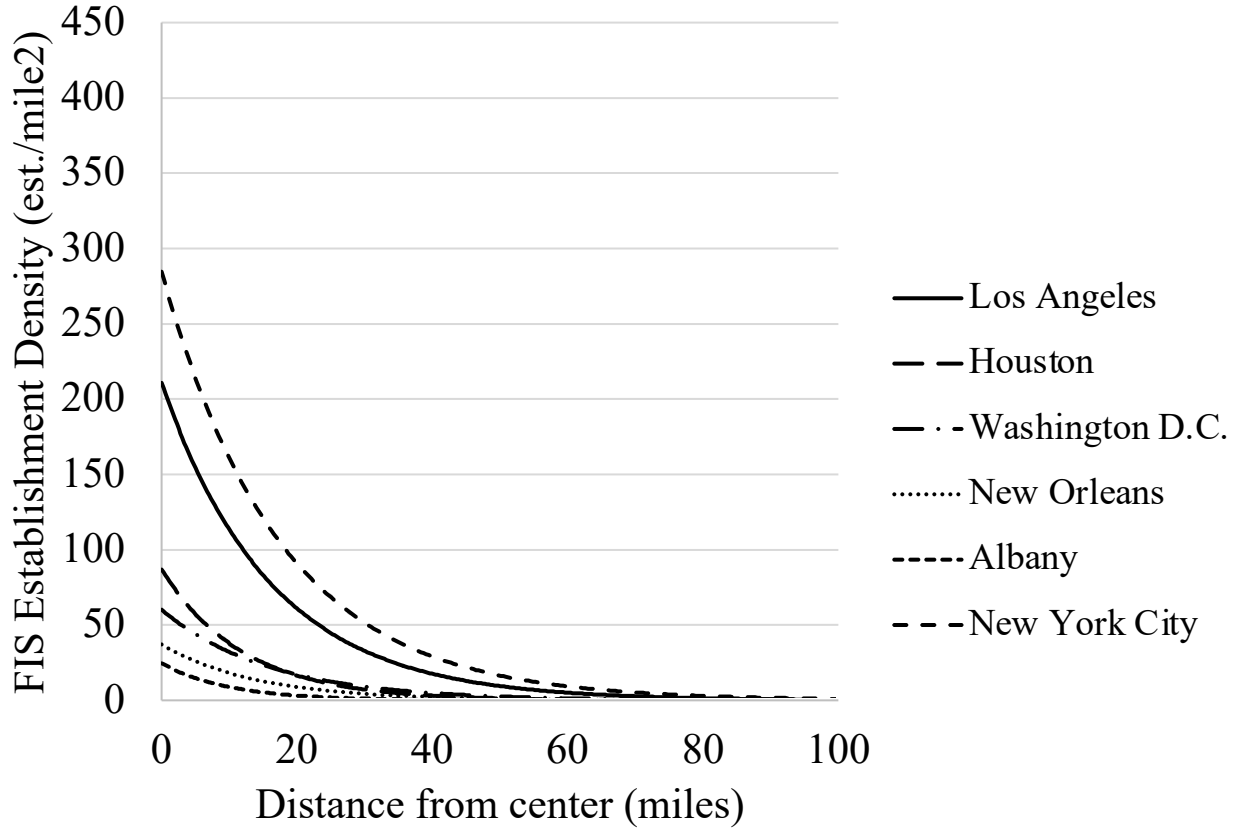
SIS establishments have a greater preference to be close to the economic center

Industry Sectors Elasticities

NAICS	Description	New York City MSA	Los Angeles MSA	Houston MSA	Washington, D.C. MSA	New Orleans MSA	Albany MSA
21	Mining, Quarrying, Oil / Gas…	-0.049	-0.049	-0.070	-0.049	-0.048	-0.043*
23	Construction	-0.042	-0.040	-0.068	-0.048	-0.071	-0.091
31	Food, Beverage, Tobacco, Textile, Apparel	-0.054	-0.068	-0.081	-0.050	-0.068	-0.079
32	Manufacturing (Wood, paper, chemical,…)	-0.054	-0.051	-0.079	-0.049	-0.069	-0.071
33	Manufacturing (Metal, machinery, …)	-0.051	-0.047	-0.072	-0.042	-0.061	-0.071
42	Wholesale Trade	-0.065	-0.060	-0.093	-0.067	-0.065	-0.104
44	Retail Trade (Motor vehicle, furniture, ….)	-0.060	-0.061	-0.084	-0.071	-0.075	-0.103
45	Retail Trade (Sporting goods, hobby, …)	-0.056	-0.052	-0.076	-0.061	-0.081	-0.087
48	Modal Transportation & Support Activities	-0.059	-0.061	-0.077	-0.053	-0.057	-0.095
49	Warehousing	-0.059	-0.056	-0.080	-0.057	-0.056	-0.107
51	Information	-0.062	-0.067	-0.077	-0.079	-0.094	-0.105
52	Finance and Insurance	-0.061	-0.049	-0.089	-0.077	-0.104	-0.105
53	Real Estate	-0.069	-0.054	-0.085	-0.076	-0.088	-0.115
54	Professional and Technical Services	-0.059	-0.053	-0.088	-0.083	-0.093	-0.114
55	Management of Companies	-0.067	-0.047	-0.085	-0.070	-0.104	-0.082
56	Administrative and Support, Waste …	-0.050	-0.051	-0.085	-0.071	-0.076	-0.100
61	Education Services	-0.058	-0.053	-0.073	-0.079	-0.108	-0.089
62	Health Care and Social Assistance	-0.063	-0.062	-0.094	-0.080	-0.093	-0.107
71	Entertainment	-0.049	-0.062	-0.070	-0.062	-0.066	-0.079
72	Accommodation and Food Services	-0.059	-0.058	-0.085	-0.073	-0.084	-0.106
81	Other Services (except Public Admin)	-0.061	-0.063	-0.080	-0.072	-0.084	-0.111

Freight Trip Attraction

NAICS	Description	New York City MSA	Los Angeles MSA	Houston MSA	Washington, D.C. MSA	New Orleans MSA	Albany MSA
23	Construction	-0.046	-0.033	-0.087	-0.064	-0.080	-0.094
31	Food, Beverage, Tobacco, Textile, Apparel	-0.116	-0.077	-0.104	-0.045	-0.067	-0.096
32	Manufacturing (Wood, paper, chemical,…)	-0.080	-0.049	-0.079	-0.040	-0.062	-0.071
33	Manufacturing (Metal, machinery, …)	-0.069	-0.043	-0.073	-0.041	-0.063	-0.082
42	Wholesale Trade	-0.100	-0.054	-0.092	-0.073	-0.064	-0.102
44	Retail Trade (Motor vehicle, furniture, ….)	-0.072	-0.056	-0.091	-0.082	-0.082	-0.121
45	Retail Trade (Sporting goods, hobby, …)	-0.059	-0.047	-0.080	-0.065	-0.090	-0.112
48	Modal Transportation & Support Activities	-0.126	-0.057	-0.078	-0.057	-0.055	-0.092
49	Warehousing	-0.085	-0.051	-0.082	-0.050	-0.054	-0.104
72	Accommodation and Food Services	-0.082	-0.059	-0.096	-0.085	-0.103	-0.109

—— Los Angeles   – – Houston

– · · Washington D.C.   ······· New Orleans

- - - - Albany   – – – New York City

Quantile Regression FIS Establishment Density

		Quantile								
		10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
New York City	Intercept	4.762	5.182	5.256	5.478	5.615	5.792	6.052	6.370	6.946
		(46.46)	(71.95)	(90.74)	(84.98)	(87.54)	(77.14)	(71.12)	(66.72)	(39.30)
	Distance	-0.073	-0.072	-0.064	-0.061	-0.058	-0.055	-0.053	-0.052	-0.052
		-(23.98)	-(25.57)	-(24.83)	-(28.00)	-(25.06)	-(22.54)	-(22.32)	-(21.66)	-(12.40)
Los Angeles MSA	Intercept	4.220	4.744	5.039	5.071	5.262	5.234	5.464	5.665	6.117
		(15.45)	(21.81)	(38.20)	(57.59)	(66.07)	(54.55)	(53.75)	(53.70)	(31.70)
	Distance	-0.086	-0.070	-0.065	-0.055	-0.053	-0.041	-0.037	-0.037	-0.039
		-(6.25)	-(6.18)	-(9.35)	-(9.60)	-(9.63)	-(7.19)	-(9.03)	-(10.37)	-(10.28)
Houston MSA	Intercept	3.410	3.923	4.195	4.473	4.521	4.717	4.940	5.298	5.498
		(13.99)	(20.56)	(26.89)	(31.25)	(34.63)	(34.76)	(36.03)	(30.43)	(30.10)
	Distance	-0.093	-0.097	-0.090	-0.090	-0.082	-0.081	-0.081	-0.081	-0.071
		-(11.50)	-(16.25)	-(16.03)	-(16.09)	-(17.50)	-(17.87)	-(21.03)	-(12.42)	-(9.60)
Washington MSA	Intercept	3.088	3.493	3.899	4.027	4.223	4.457	4.651	4.901	5.368
		(16.81)	(18.93)	(31.59)	(37.44)	(43.71)	(33.99)	(38.86)	(42.64)	(24.38)
	Distance	-0.083	-0.076	-0.075	-0.071	-0.070	-0.068	-0.062	-0.058	-0.058
		-(20.00)	-(11.61)	-(16.20)	-(21.31)	-(18.58)	-(15.19)	-(13.22)	-(15.51)	-(7.42)
New Orleans MSA	Intercept	2.875	3.315	3.317	3.674	3.905	4.413	4.518	4.603	5.529
		(5.19)	(10.52)	(9.58)	(11.64)	(11.63)	(15.26)	(15.31)	(11.58)	(6.87)
	Distance	-0.136	-0.115	-0.087	-0.092	-0.089	-0.091	-0.070	-0.052	-0.049
		-(6.04)	-(5.50)	-(5.01)	-(6.25)	-(6.11)	-(5.93)	-(4.28)	-(2.44)	-(2.01)
Albany MSA	Intercept	1.544	2.147	3.069	3.341	3.315	3.355	3.815	3.977	4.846
		(4.76)	(5.41)	(9.62)	(11.56)	(16.22)	(15.23)	(14.56)	(8.86)	(7.73)
	Distance	-0.096	-0.102	-0.123	-0.123	-0.110	-0.099	-0.105	-0.101	-0.099
		-(12.08)	-(10.23)	-(15.54)	-(10.93)	-(11.67)	-(9.53)	-(9.08)	-(5.65)	-(4.06)

OLS vs Quantile Regressions
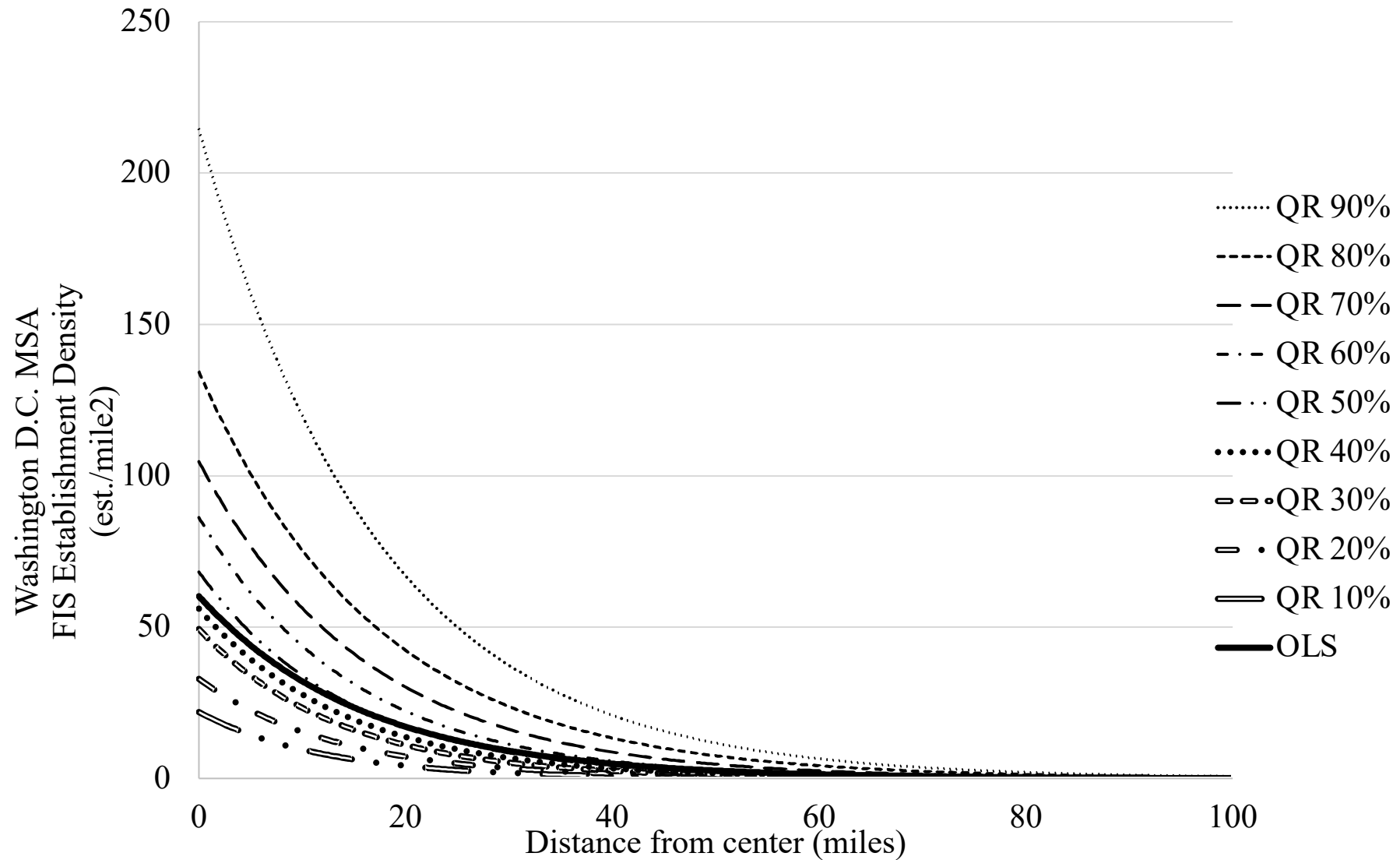
Final Remarks

❖ For all MSAs tested, there is a higher SIS establishment density than FIS establishment density at the economic pole

❖ The results from the models pointed out how:

  ❖ Establishments that belong to the industry sectors of: (1) information, (2) finance and insurance, (3) professional and technical services, (4) management of companies and, (5) health care and social assistance have higher preference to be located nearby the economic pole

  ❖ FTA and FTP density demand functions showed how the FIS of: (1) food, beverage, tobacco, textile, apparel, (2) wholesale, (3) retail and (4) accommodation and food services have a larger preference to be located close to the economic pole

Final Remarks (II)

❖ Two different econometric techniques were used to model how demand functions change over space

  ❖ The advantage of using quantile regression is that the chosen dependent variable is estimated to have a different relationship with distance for each quantile level

❖ Understanding the willingness of establishments to locate close to the economic pole of an MSA helps planners predict future dense areas and their impacts

  ❖ Demand functions can work as an input to help designing policies that target specific industry sectors

Thanks