The Geography of Trade in Services: New Evidence from Credit Card Transactions

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[1]Federal Reserve Board

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Thanks to Gal Wachtel, Dan Williams, and other staff at Palantir and Fiserv for their many contributions to this project. All results have been reviewed to ensure that no confidential information is disclosed. The views expressed are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System.

New Measurement of Services Trade Flows

- Exports of services account for one-third of U.S. exports
- Yet, measurement of services trade poses considerable challenges
- Better data could have many policy and research applications
  - improve research that studies transmission of shocks across (and within) countries

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Summarize work that captures international and intra-national trade in services via credit card transactions

- Novel data resulting from a collaboration between The Federal Reserve Board and Palantir Technologies, and enabled in part by transaction data from Fiserv Merchant Services

Outline

Data

- Demonstrate how credit card transactions can yield credible signal on intranational and international trade in services

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New Facts

- While export shares in services are lower than in manufacturing, there is lots of industry/geographic heterogeneity
- Geography and distance play an important role

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New Finding

- The spatial decay of the exchange rate elasticity: The sensitivity of Canadian sales to exchange rate changes declines with distance from the border

Related Literature

Micro-Data from Credit Card Transactions

- Agarwal, Jensen, and Monte (2018), Einav et al (2017), Hortasçsu et al (2009), Dunn and Gholizadeh (2020)

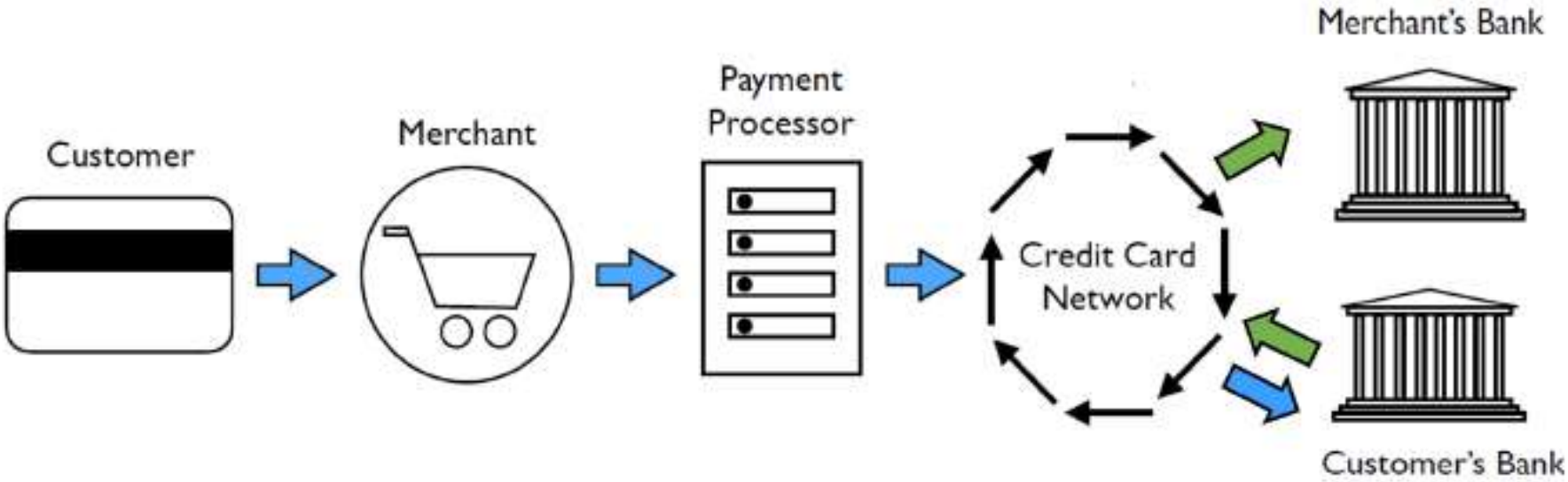
Services Trade

- Anderson et al (2018), Faber and Gaubert (2018), Gervais and Jensen (2015), Kimura and Lee (2006)

Cross-Border Exports and Shopping

- Chandra, Head, and Tappata (2014), Chen et al (2017), Campbell and Lapham (2004), Baggs et al (2015)
- Engel and Rogers (1996), Gorodnichenko and Tesar (2009), Holmes and Stevens (2012),

Data Source: Payments Processing



- Fiserv: A large processor of credit, debit, and electronic payment transactions
- More than \$2 trillion in card transactions per year across 6 million merchant locations

Fiserv: Features of Raw Data

The raw confidential data include:

- Transaction data anonymized and aggregated at merchant category code (MCC) and zipcode.
- Date and dollar value of individual transactions
- Includes both in-store and electronic transactions across Fiserv payment processing networks
- No cardholder PII (personally identifiable information) is available

Fiserv and their contractors only disclose *aggregates* to us, no individual data

Two Additions to Raw Data

1. Algorithm to identify home location (metro area) of cards based on spending patterns

2. Use card attributes to identify foreign-based cards

1. City Home Location of Cards

A small fraction of cards contain home zipcode (from AVS)

For remaining, need to impute card home locations:

- Unit of geography is a CBSA ($\approx$ 930 in U.S.) ▸ CBSA example
- Use location of card transaction and merchant industry.
- Exploit industry variation in signal of home location
- Train logit model on zipcode subset of data with known home location.
- Use estimated coefficients to impute home location for all cards.

1. City Home Location of Cards: Details

In the sample with addresses: Estimate a logit model with regularization (ridge):

- Data has a row for every card-city pair ▸ Example
- Dep. variable: 0/1 indicator for whether the city is the card's home location.
- Regressors: transaction counts for the card in the city at different merchant types.
- About 50 regressors (columns), a row for each card-city pair.
- Estimate model coefficients, choosing regularization by C.V.

Assign card to the city with the highest likelihood of being home location.

1. City Home Location of Cards: Details

Examples of Industry Estimates:

- Positive coefficients: Grocery stores, car dealers/repair.
- Near-zero coefficients: Transit, nonstore retailers.
- Negative coefficients: Accommodation.

▸ Details

Out of Sample Performance: Allocate 90 percent of cards to correct city

- Similar when spending-weighted.

2: Identifying Foreign Cards

Upstream Steps (before we touch the data):

- First 4-6 digits of card (BIN / IIN) identify attributes of issuing institution
- Merge to third-party concordance including variables indicating country of issuance
- Series of manual checks to ensure consistency over time

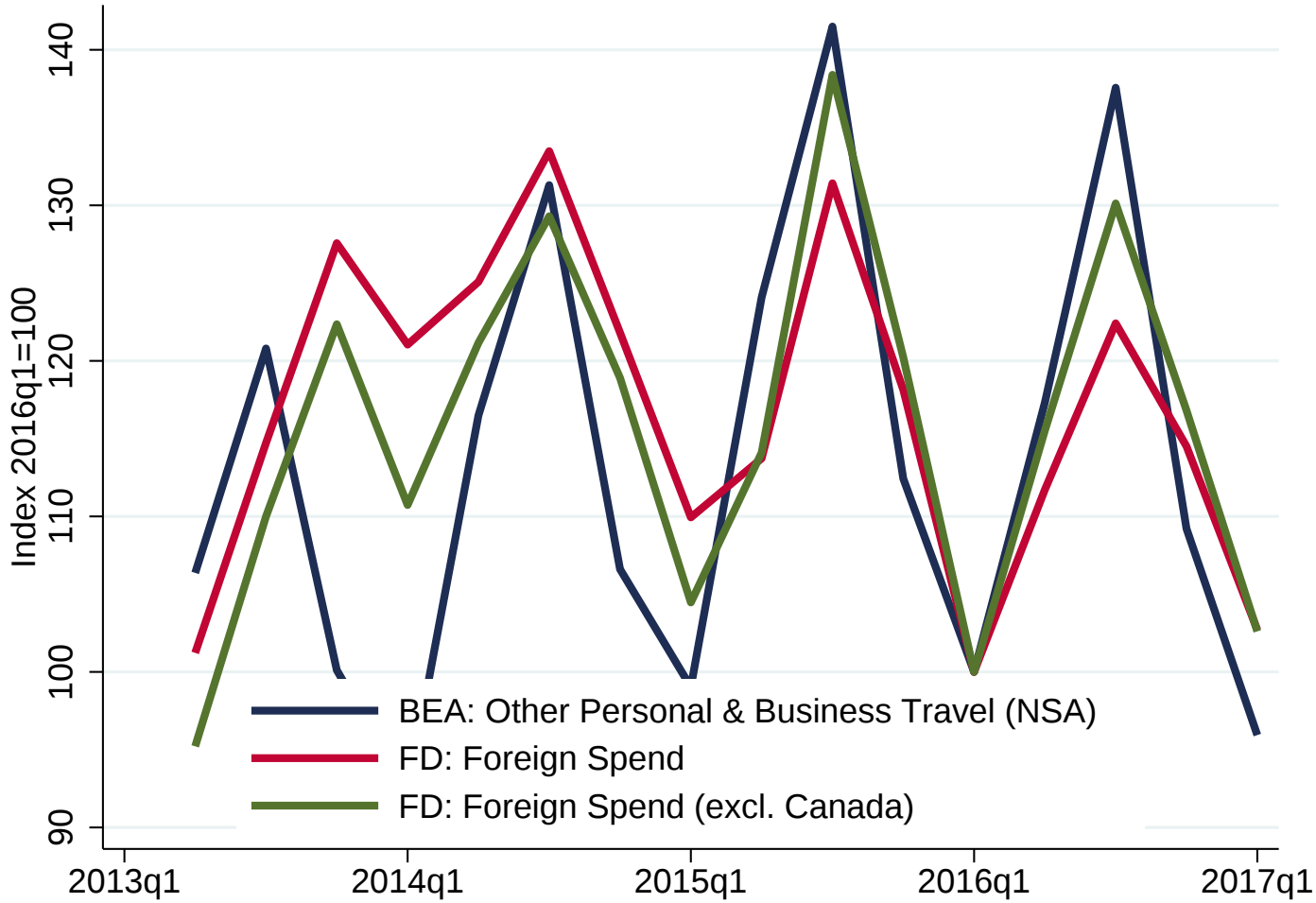
Following aggregation and application of suppression rules:

- Conduct validation exercises, comparing to official data published by the BEA ▸ BEA Measurement of Travel Services

2: Checks on Foreign Country Variables

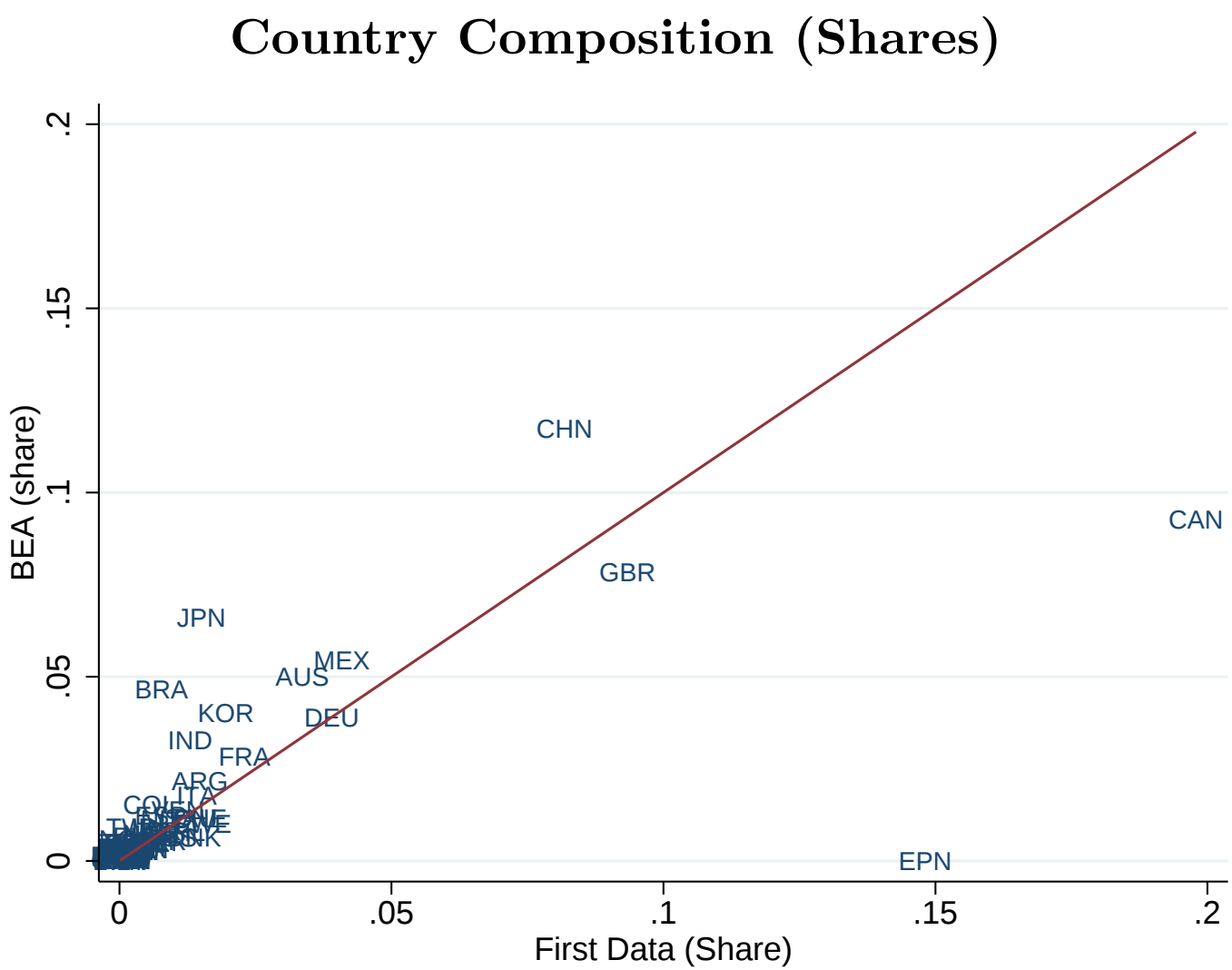
- Restrict to industries that likely match BEAs "Other Personal and Business Travel" category
- Compare to official data along two dimensions:
  1. Time Series: Aggregate quarterly foreign card spending (and, excluding Canada) and index to 2016Q1
  2. Country composition: aggregate to annual totals by country, compare to BEA country shares

Benchmarking Foreign Travel Exports: 1



▸ Details: U.S. Exports to Canada

Benchmarking Foreign Travel Exports 2



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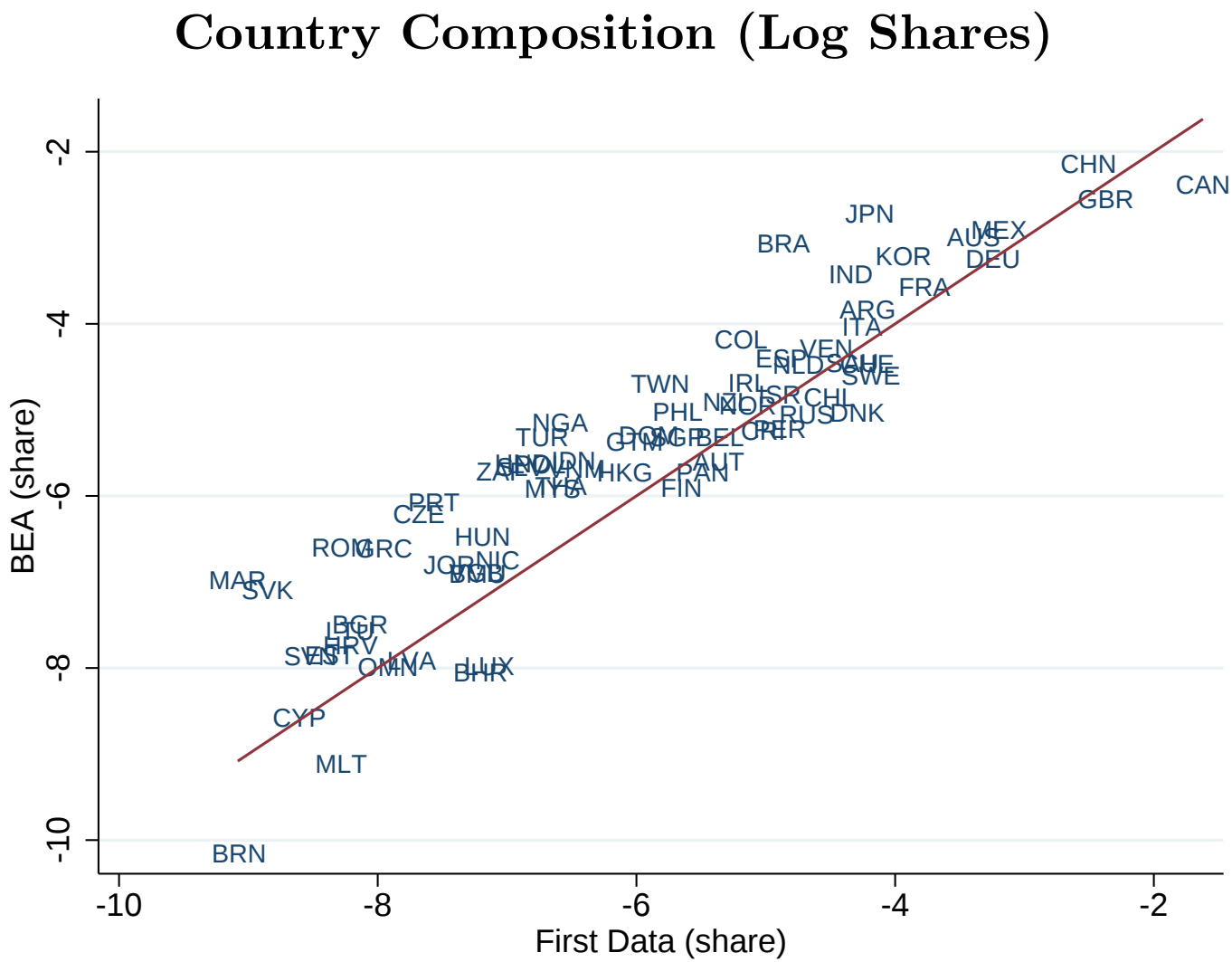


Data Processing

- Apply Foreign Country and Home Location to Cards
- Convert MCC industry codes to NAICS
- Aggregate and apply suppression rules
- Re-weight to match economic census

Resulting dataset:

- For each CBSA and industry of merchant: share of spending from all other CBSAs as well as foreign countries
- Add: bilateral distances (CEPII), population (Census), etc

▸ Example: Burlington, NC

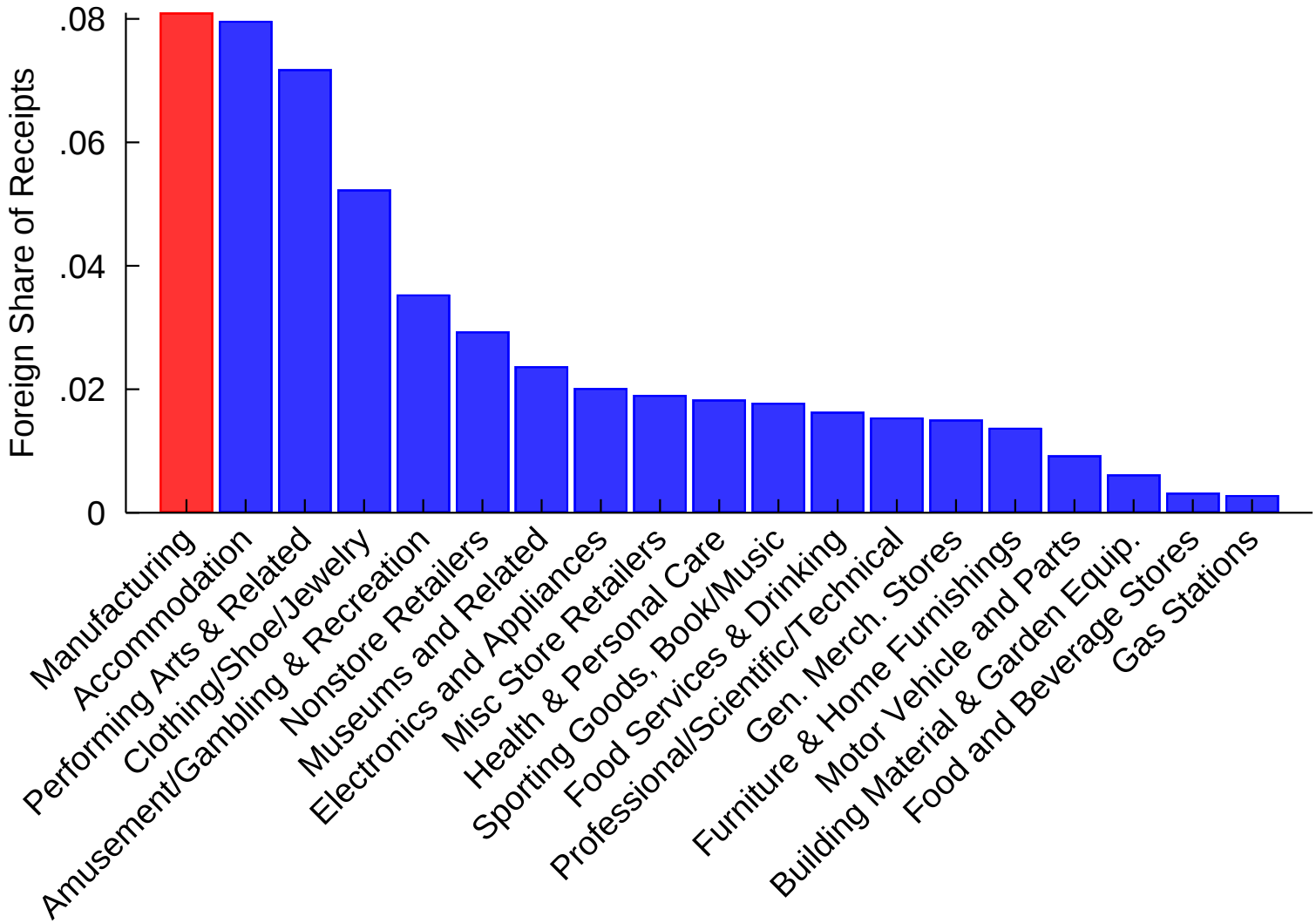
Outline

- **Data:** Measuring services trade flows
- **New Facts:** Geographic Patterns of Trade in Services
- **New Finding:** Spatial Decay of the Exchange Rate Elasticity

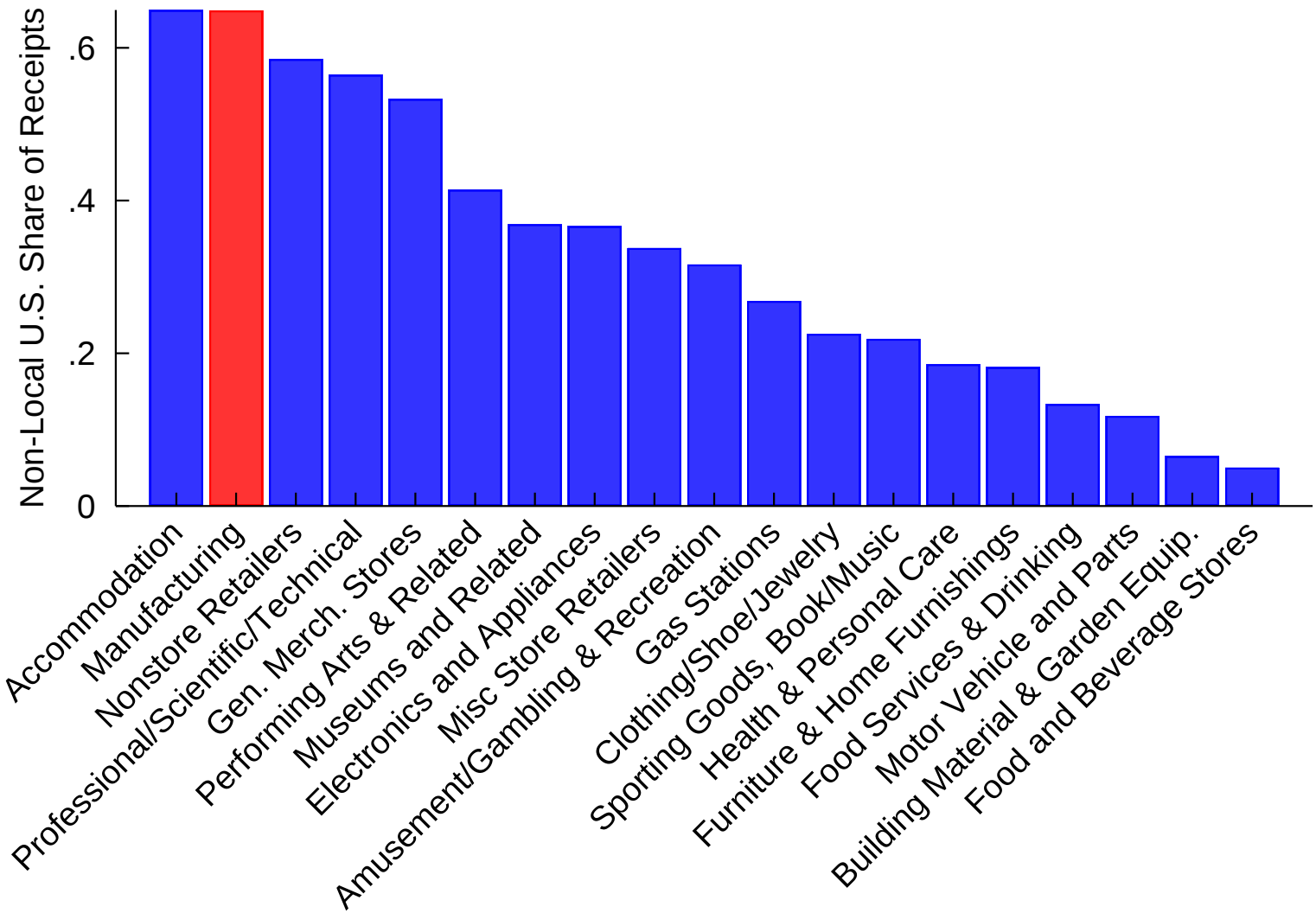
International and Intra-national Trade

- Compare international/intra-national trade shares for manufacturing vs services
- Use 2012 PUMS version of Commodity Flow Survey for manufacturing trade flows
  - Aggregate data to 130 CFS areas to match CFS
- Calculate:
  1. Foreign share,
  2. Non-Local share of receipts

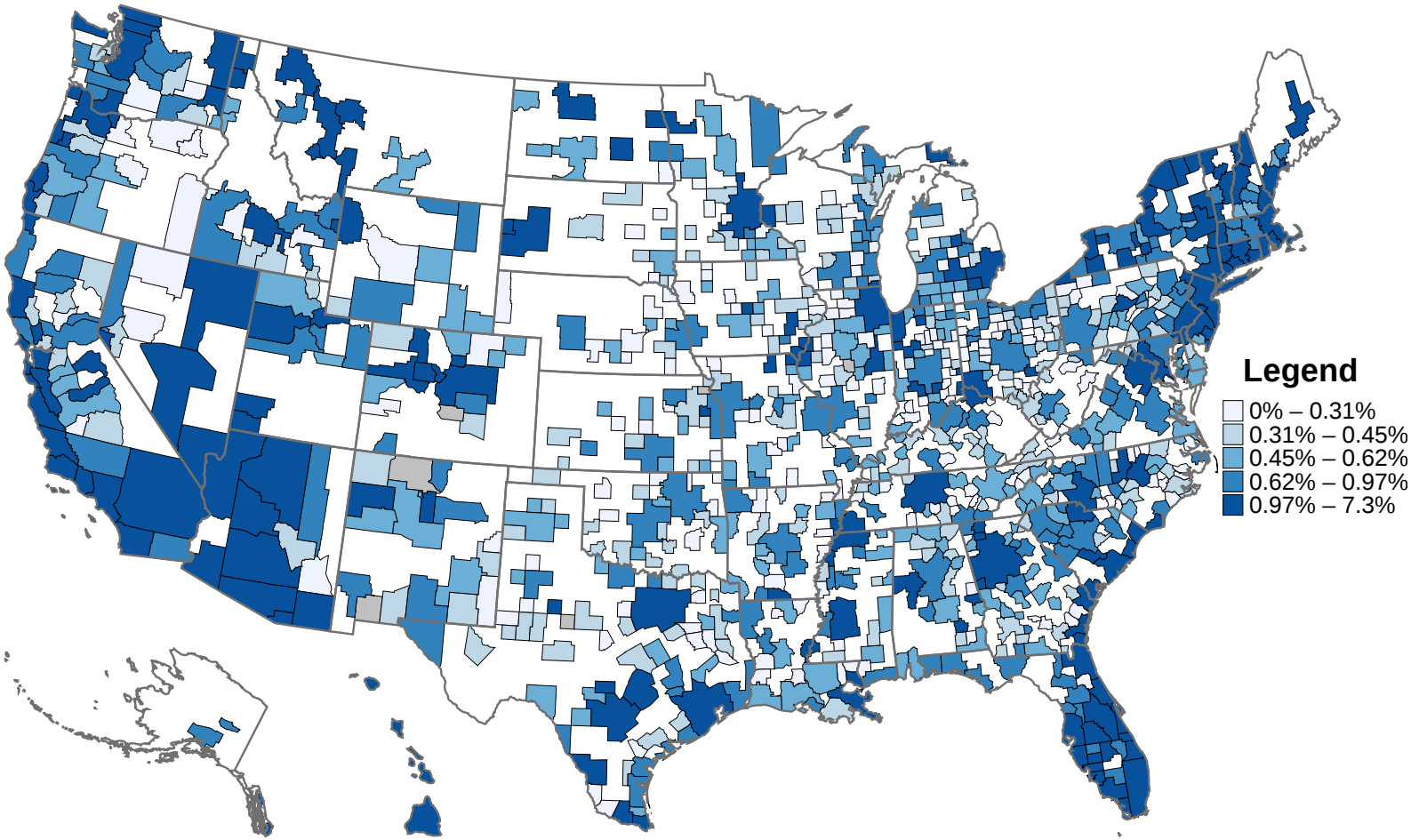
Foreign Share of Receipts



Non-Local Share of Receipts



Foreign Share of Receipts by CBSA, Restaurants (NAICS 7221)



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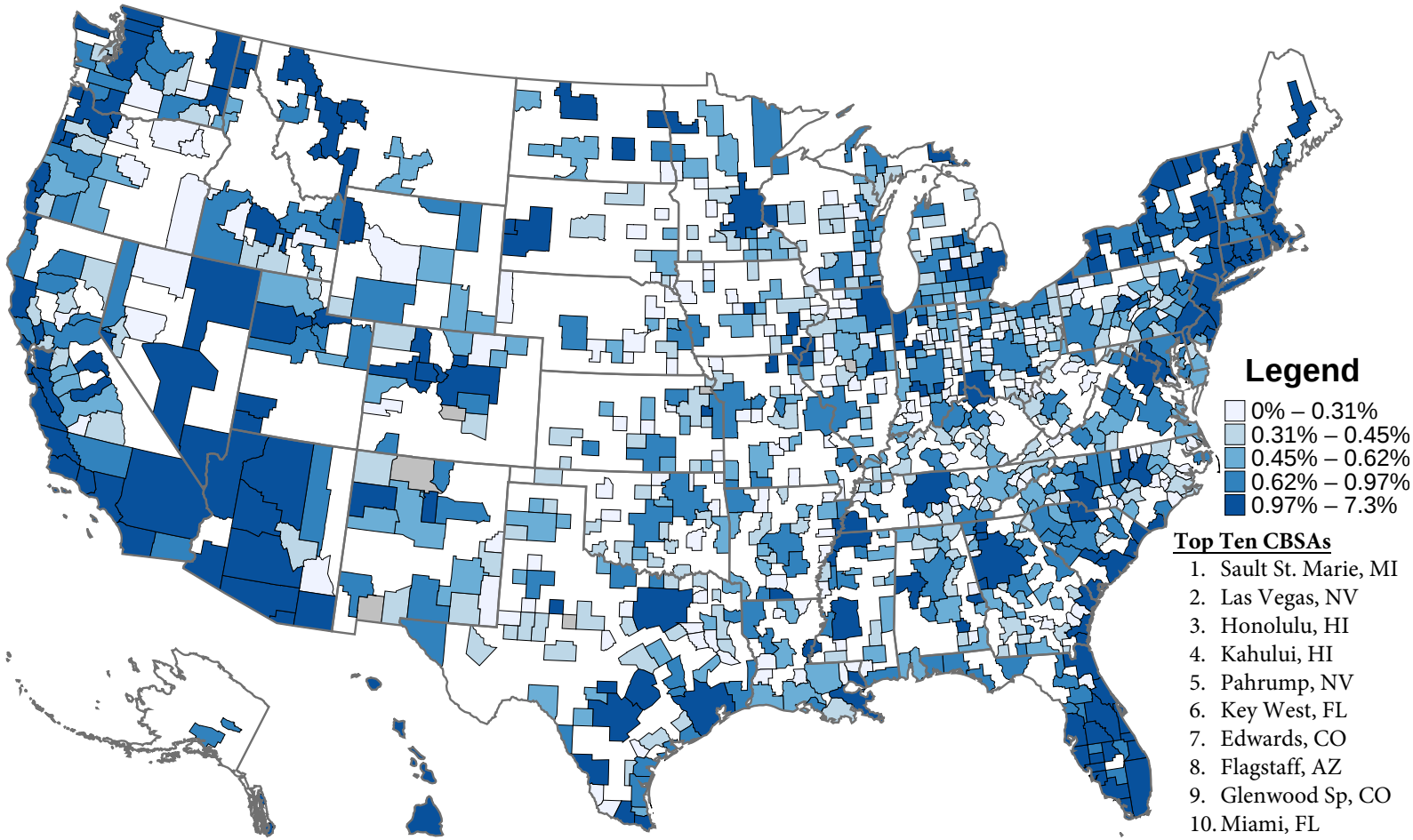

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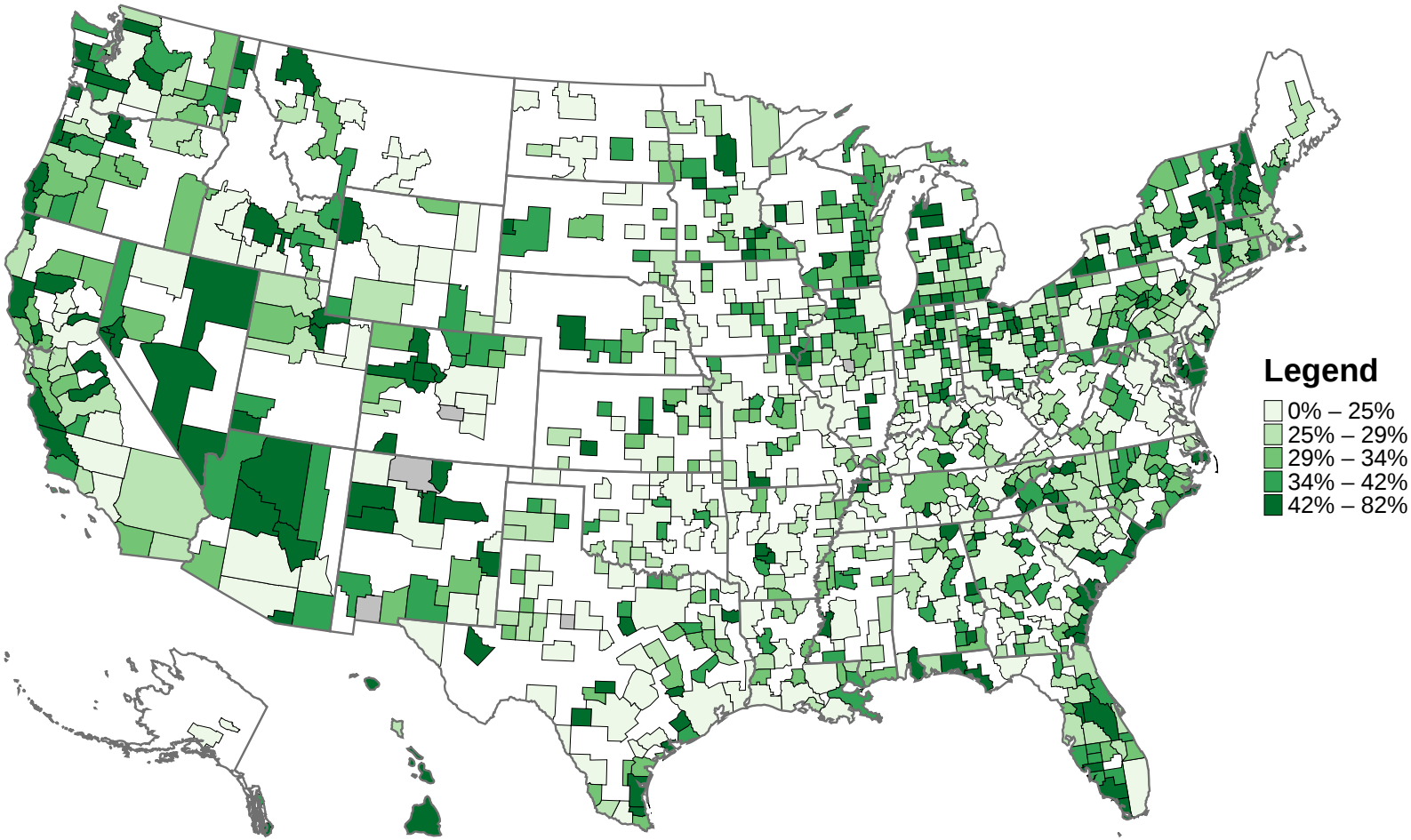

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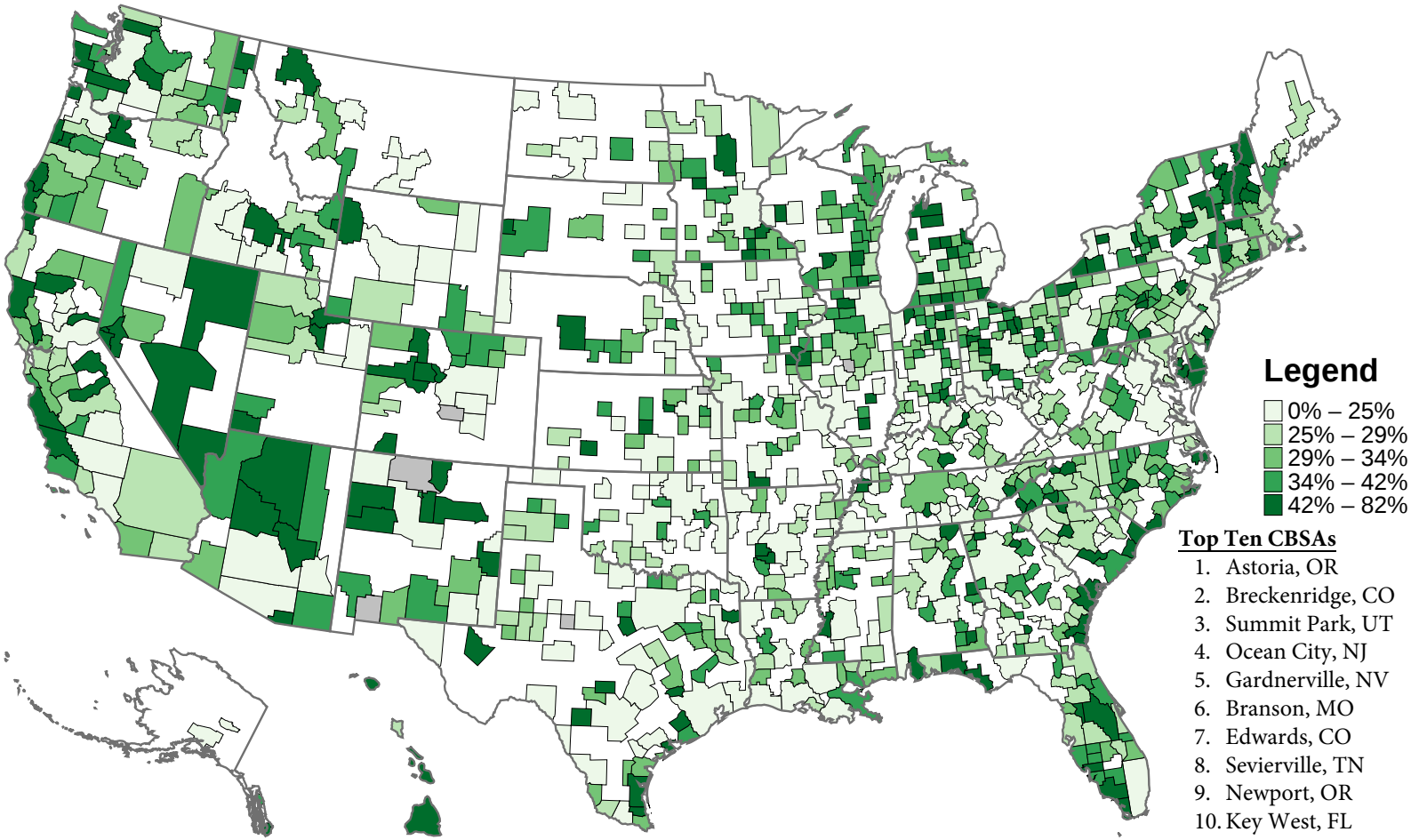

Digging Deeper: Role of Trade Frictions

A wide class of trade models produce gravity-type relationships

- bilateral trade flows X_{ij}^k from region j to region i in sector k a function of:
- Y_i^k total sectoral sales in origin area,
- Y_j^k: total sectoral expenditure in destination area,
- τ_{ij}^k, bilateral trade costs
- Π_i^k and P_j^k : multilateral resistance

$$X_{ij}^k = Y_i^k Y_j^k \left(\frac{\tau_{ij}^k}{\Pi_i^k P_j^k} \right)^{1-\sigma_k} . \tag{1}$$

where σ_k is the trade elasticity of substitution across origins in services k.

Digging Deeper: Role of Trade Frictions

Denoting x_{ij}^k as the share of location i receipts in industry k coming from location j, we estimate the following:

$$\log x_{ij}^k = \alpha^k + \gamma_i^k + \theta_j^k + \beta^k \log d_{ij} \tag{2}$$

where γ_i^k and θ_j^k are merchant/card CFS fixed effects

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Run for 17 service industries as well as overall goods trade

Gravity Model: CFS Geographies

Distance Coefficients

Sector	Sector Description	Distance Coefficient	Obsv	Adj. R^2
454	Nonstore Retailers	-0.81***	17,677	0.8
541	Professional/Scientific/Technical	-1.12***	18,957	0.82
453	Misc. Store Retailers	-1.20***	19,775	0.87
443	Electronics and Appliances	-1.29***	18,392	0.86
451	Sporting Goods, Book/Music	-1.34***	19,110	0.84
448	Clothing/Shoe/Jewelry	-1.40***	19,276	0.86
311-339	**All Goods**	**-1.40*** **	**18,533**	**0.59**
711	Performing Arts/Related	-1.41***	10,952	0.7
721	Accommodation	-1.42***	19,953	0.88
442	Furniture and Home Furnishings	-1.45***	17,540	0.78
722	Restaurants & Bars	-1.45***	20,275	0.93
446	Health and Personal Care	-1.47***	16,908	0.77
441	Motor Vehicle and Parts	-1.49***	19,757	0.84
445	Grocery Stores	-1.49***	19,921	0.89
444	Building Material & Garden Equip.	-1.53***	19,452	0.86
713	Amusement/Gambling/Recreation	-1.58***	18,646	0.82
452	Gen. Merchandise Stores	-1.59***	19,279	0.86
447	Gas Stations	-1.61***	20,243	0.91

▸ CBSA Results for Services

Connecting Gravity with Firm Size

Magnitude of distance effects has puzzled trade economists

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Chaney (2018): Gravity equation will hold if 3 conditions are met:

1. firm sizes follow a Pareto distribution with shape parameter $\lambda \geq 1$,
2. the average squared distance of exports is an increasing power function (parameter μ) of firm size,
3. and the parameter restriction $\lambda < 1 + \mu$,

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3. and the parameter restriction $\lambda < 1 + \mu$,

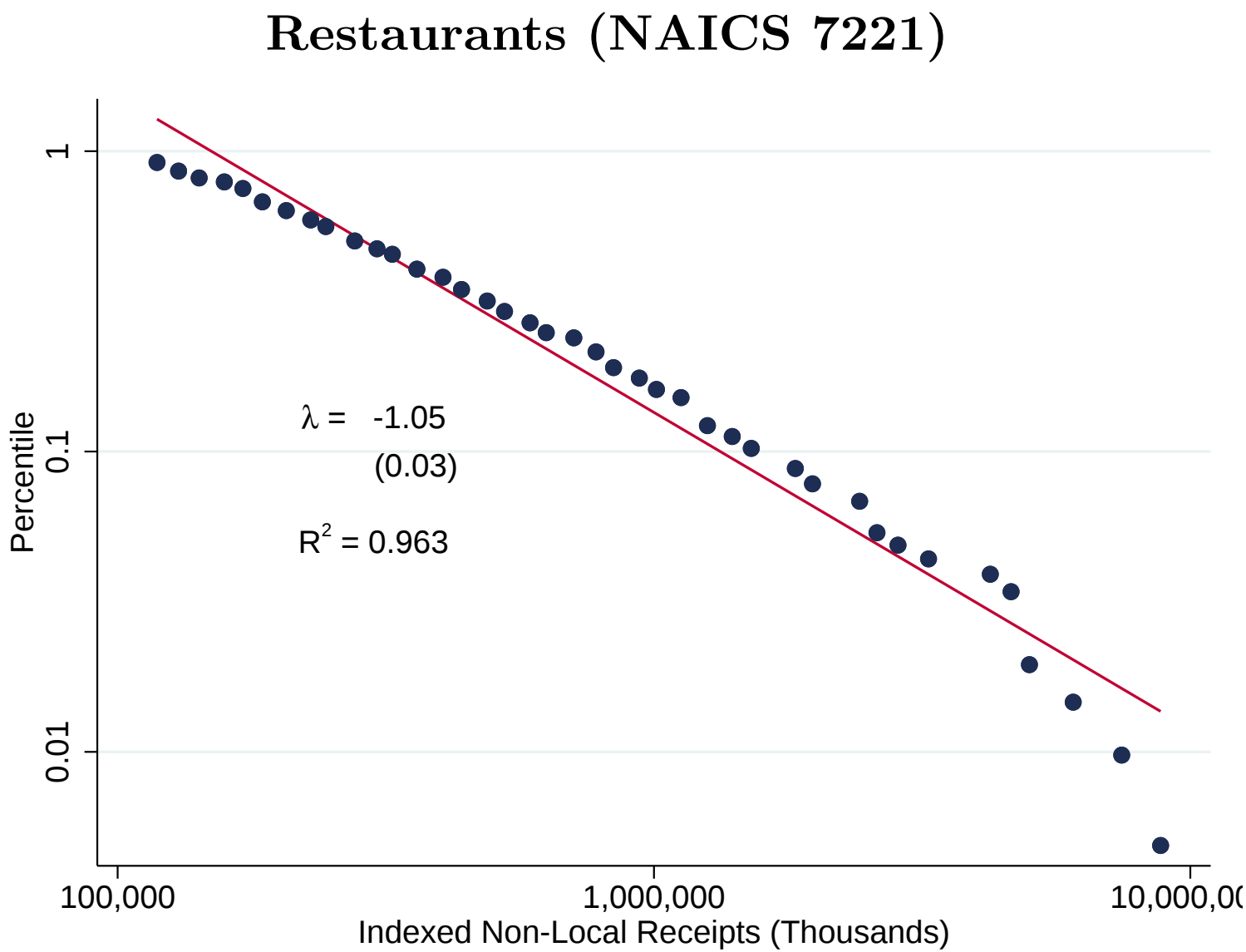
Implied distance elasticity of trade $\approx 1 + \frac{2(\lambda-1)}{\mu}$

Connecting Gravity with (CBSA) Size

Application of Chaney (2018) to CBSA size

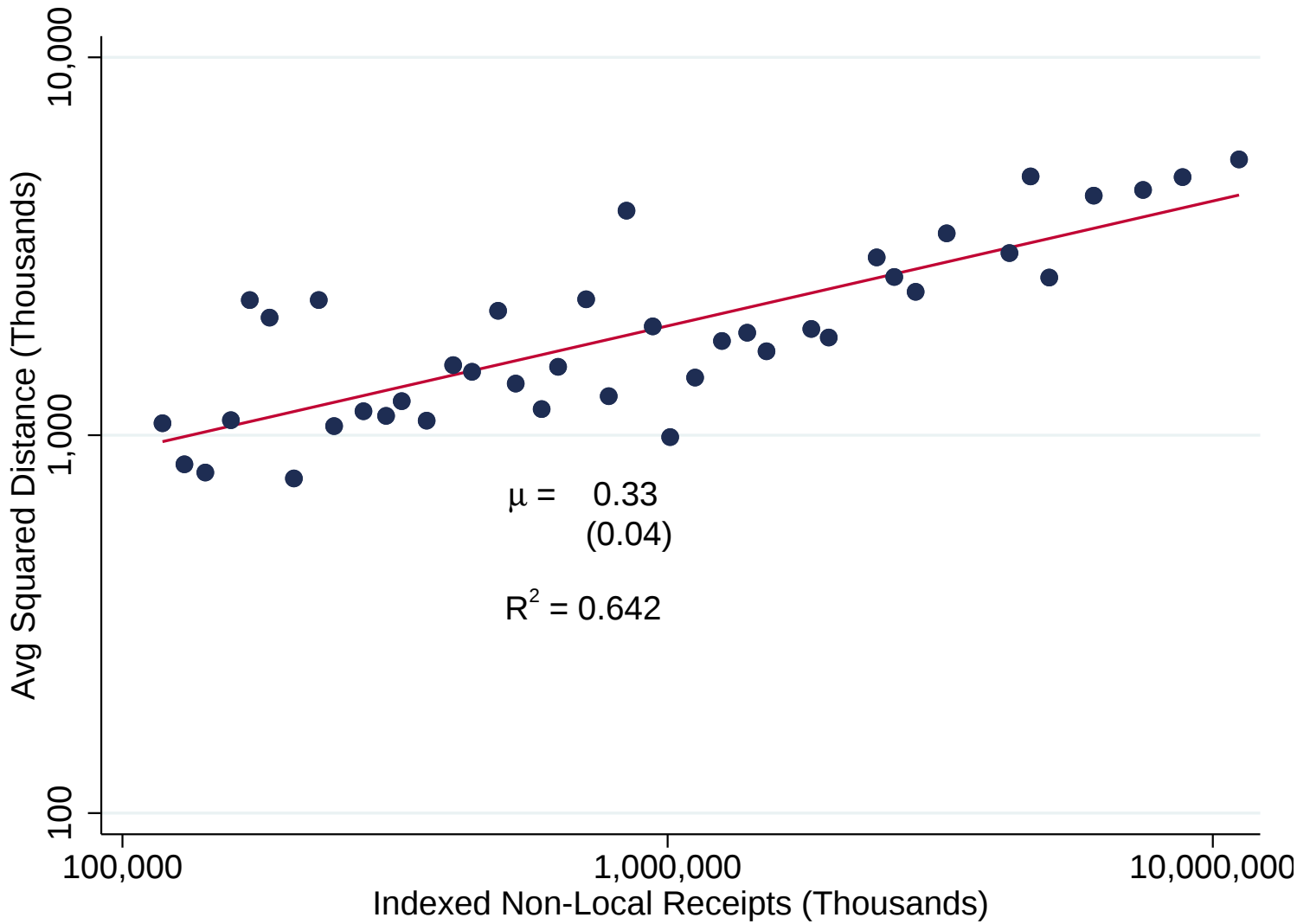
- Widely-known empirical regularity of Zipf's Law in city size
- Follow Axtell (2001), order CBSAs and create 50 bins of equal log width (above 500,000 population)
- Calculate distribution, value of CBSA exports, average squared distance of exports

CBSA Distribution of Size (Export Receipts)



Size vs Average Distance of Exports

Avg Squared Distance of Exports & Size (Export Receipts)
Restaurants (NAICS 7221)



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- **New Finding:** Spatial Decay of the Exchange Rate Elasticity

Focus Attention on Canadian Spending

- Significant cross-border spending
  - countries share a border spanning 4000 miles, 110 land border crossings
  - 90 percent of Canadian population lives within 100 miles of border
- Exchange rate changes: act as shocks to relative prices
  - plausibly exogenous with respect to both consumers and merchants

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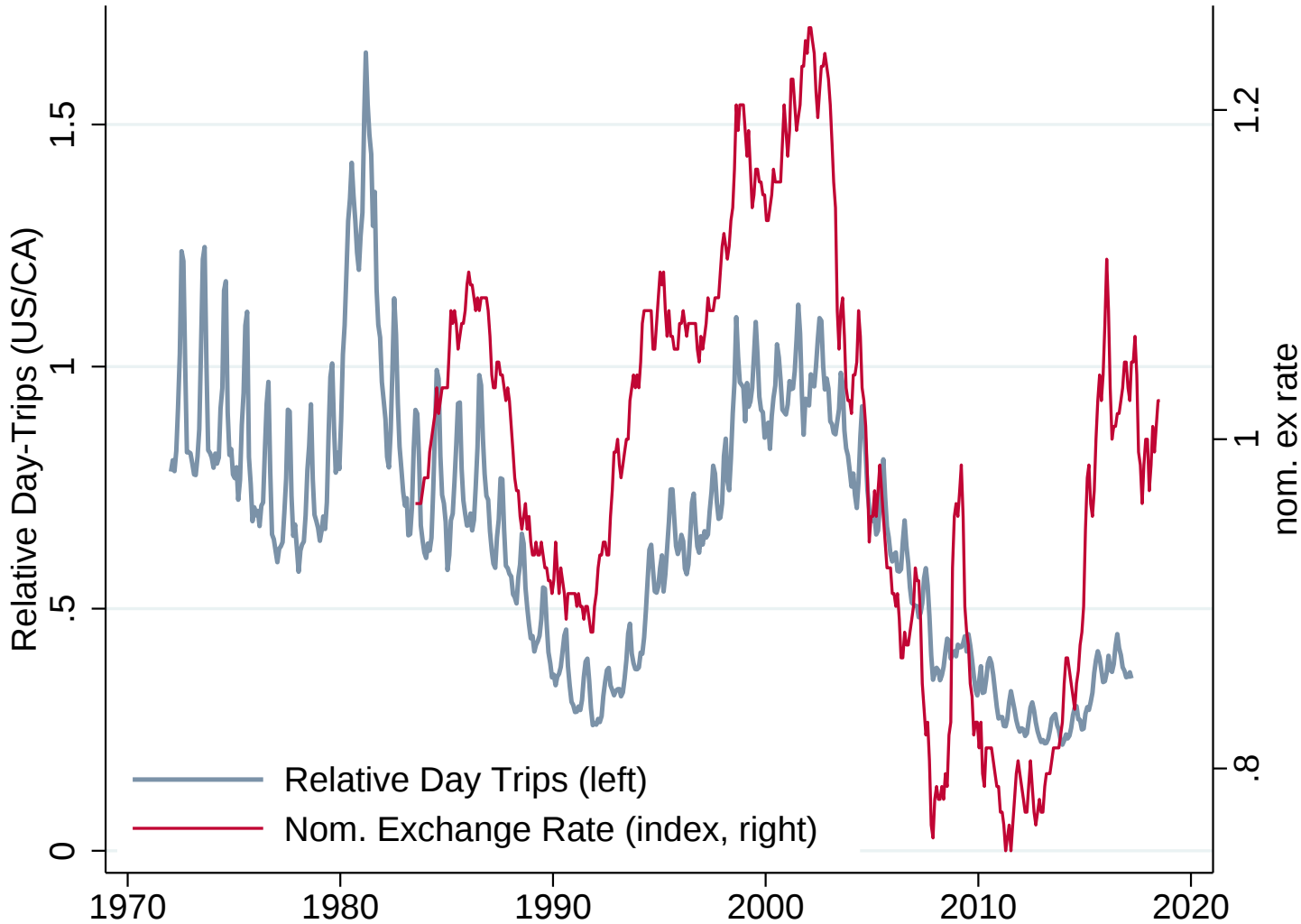
- Exchange rate changes: act as shocks to relative prices
  - plausibly exogenous with respect to both consumers and merchants
- Several papers have shown a relationship between *crossings* and the bilateral exchange rate

Variation in Border Crossings and Nom. Exchange Rates



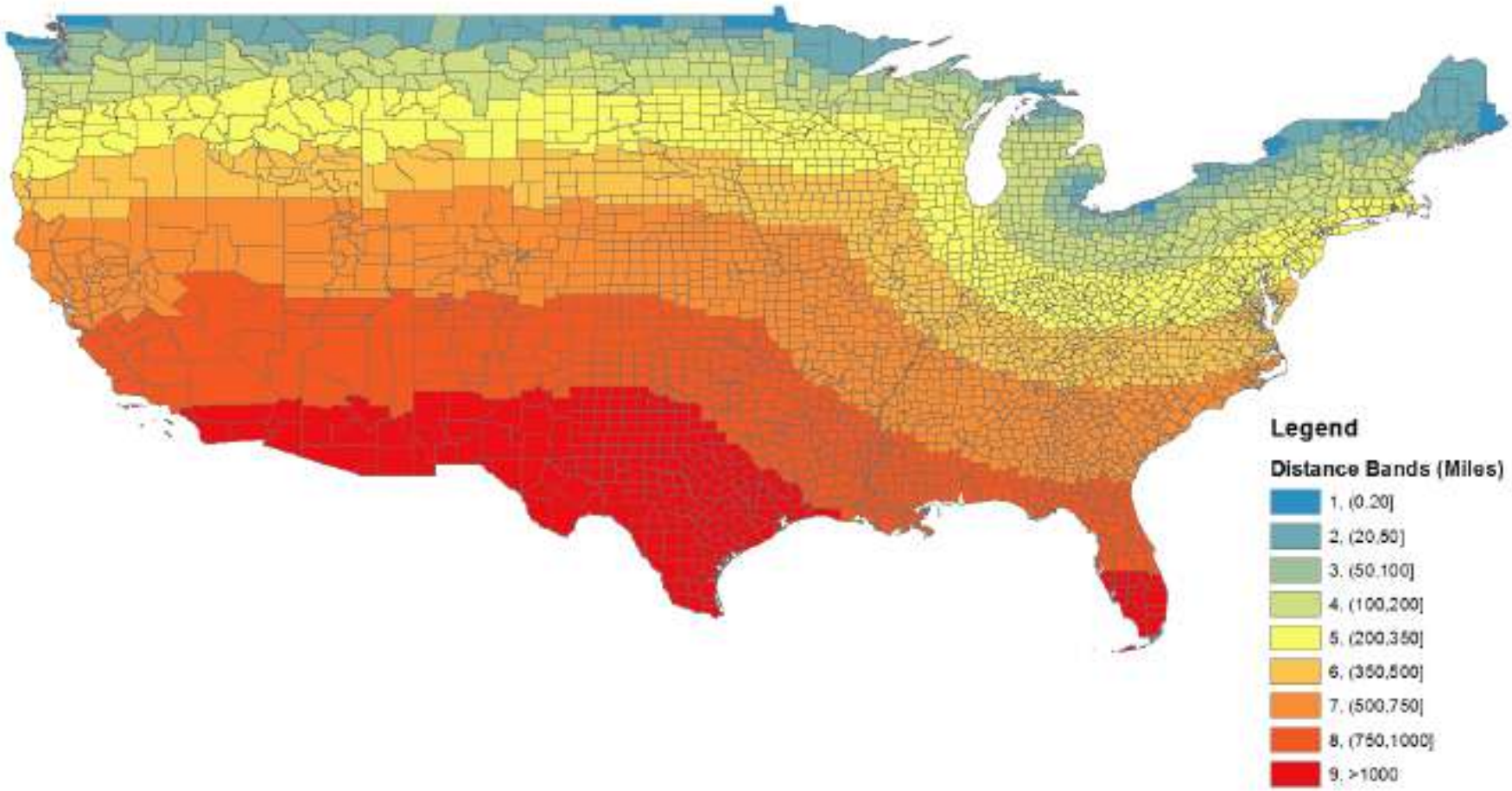
Updated from Chandra et al (2014)

Canadian Spending Responsiveness to Exchange Rates

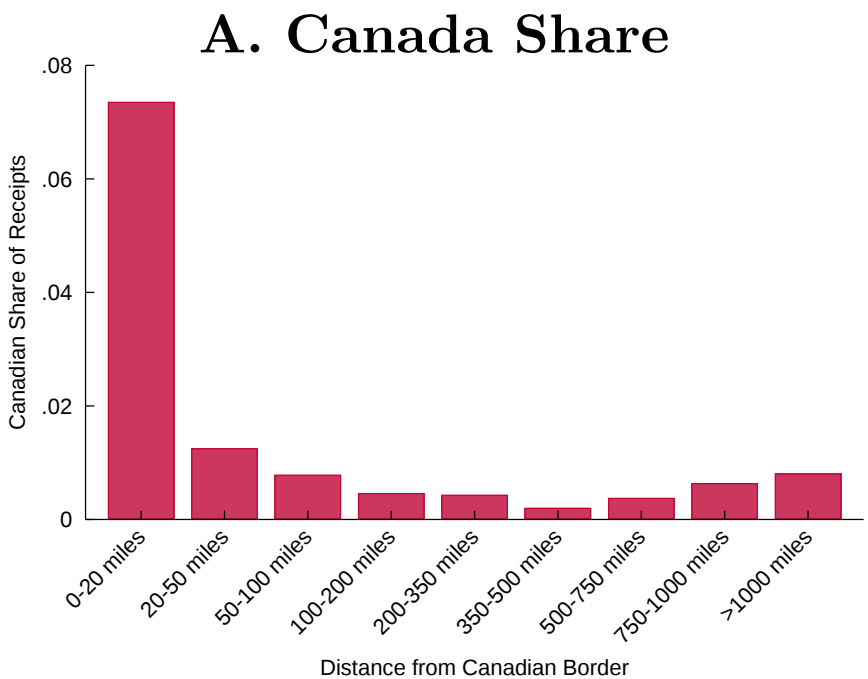
New: We look at the gradient of the responsiveness of spending based on distance from border

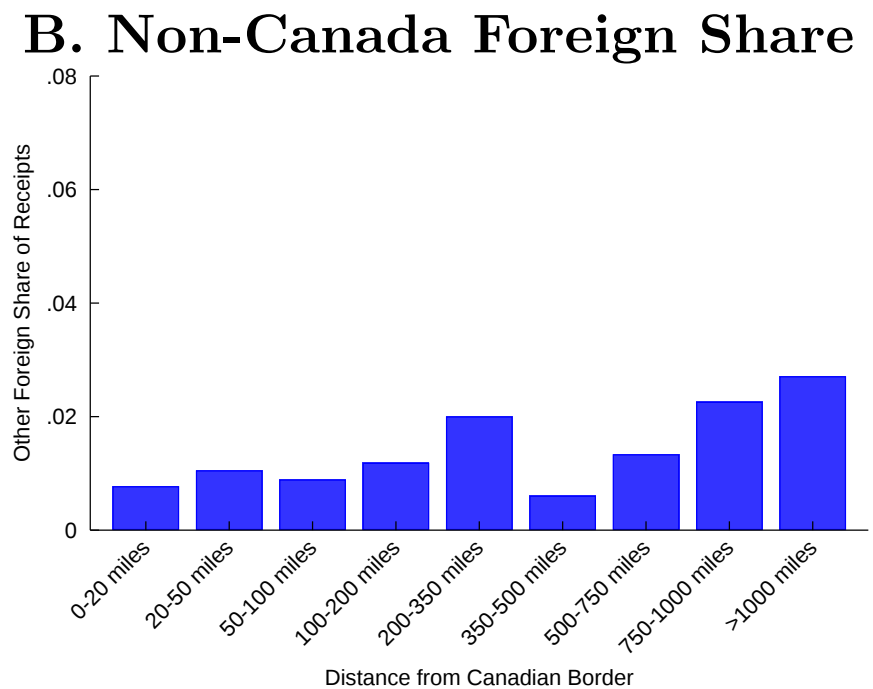
- We allocate merchants into nine (not equally spaced) bands based on distance from Canadian border
- For each distance band and industry, calculate monthly shares of Canadian vs other spending
- Merge in average monthly exchange rate
- Seasonally adjust
- Sample is 2013m1 to 2017m6

Distance Bands from Canadian Border



Share of Merchant Receipts by Distance Bands from Canadian Border





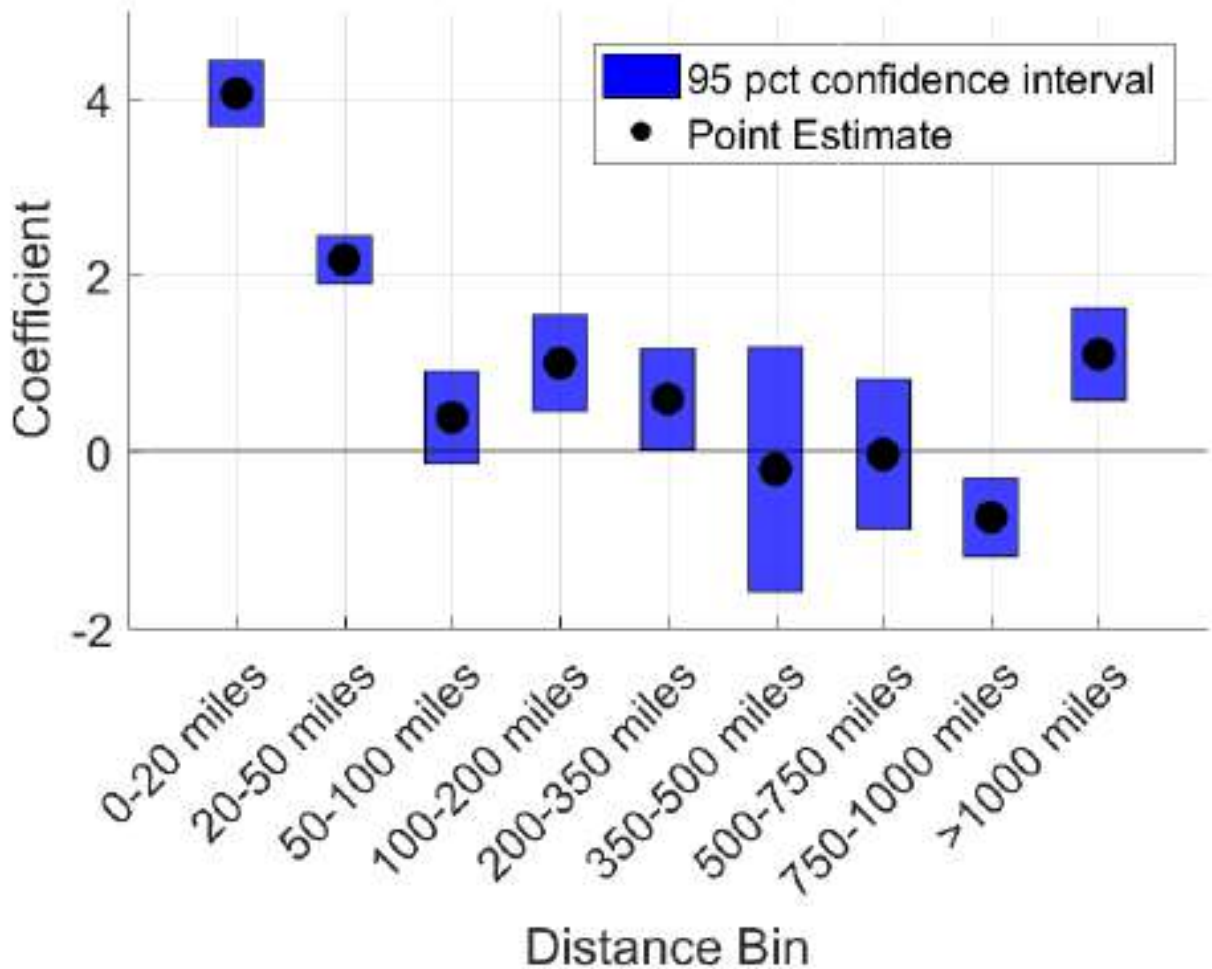
Exchange Rate Responsiveness

- Create shares of spending from Canada, U.S., and other foreign countries across Naics categories i, month/year m/y, and distance bands from Canada d.
- r^{CAN}_{idmy} is the (s.a.) Canadian share of receipts across merchants in industry i in distance band d.
- Letting $e^{\text{CAN}}_{m}y$ be the nominal exchange rate, we run the following:

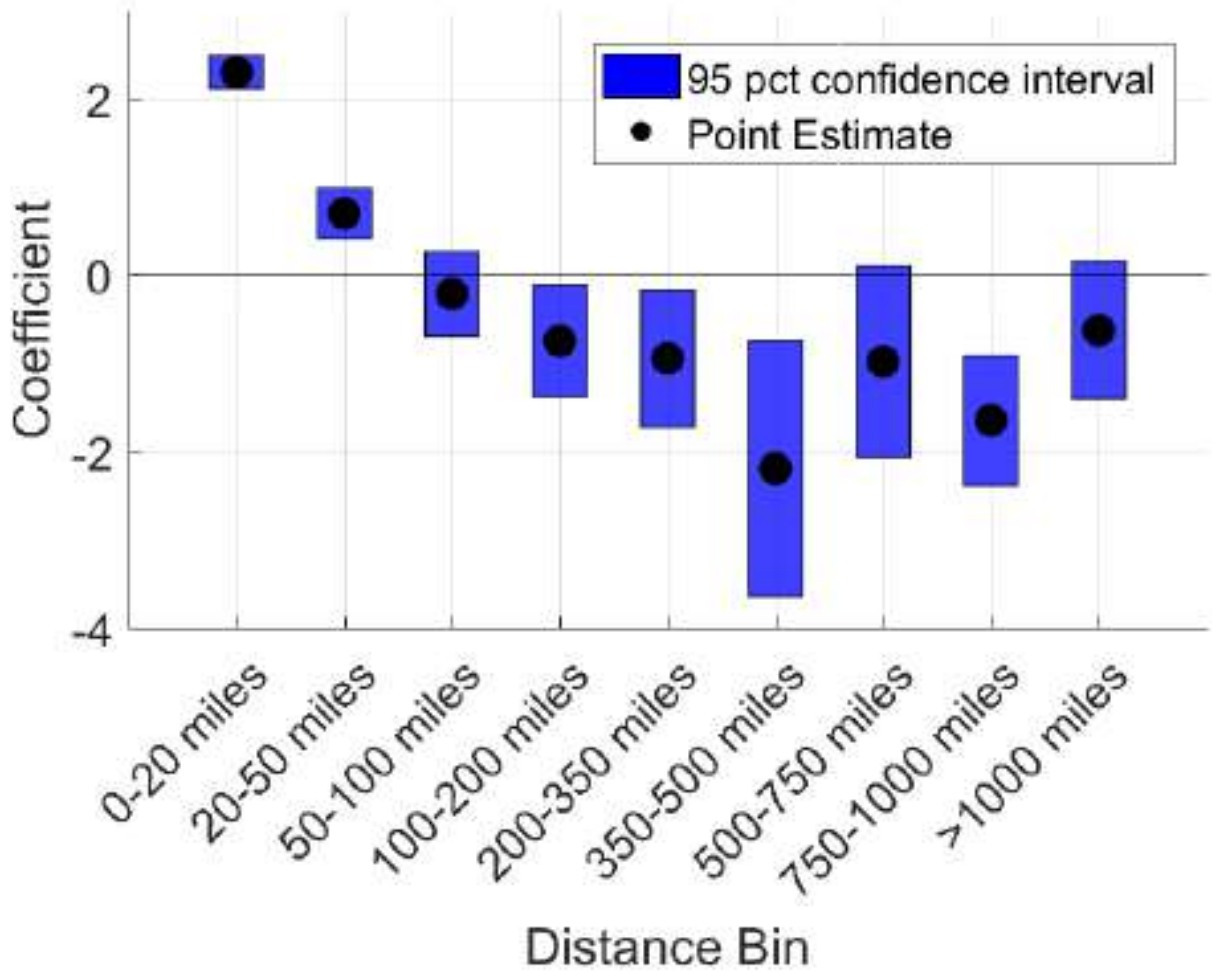
$$\ln(r^{\text{CAN}}_{idmy}) = \lambda_{id} \sum_{d=1}^{9} \mathbb{1}_{id} + \gamma_{id} \sum_{d=1}^{9} \mathbb{1}_{id} * \ln(e^{\text{CAN}}_{my}) \tag{3}$$

γ_{id} captures responsiveness of Canadian spending to changes in exchange rates based on the distance from border.

Exchange Rate Responsiveness by Distance: Share of Receipts

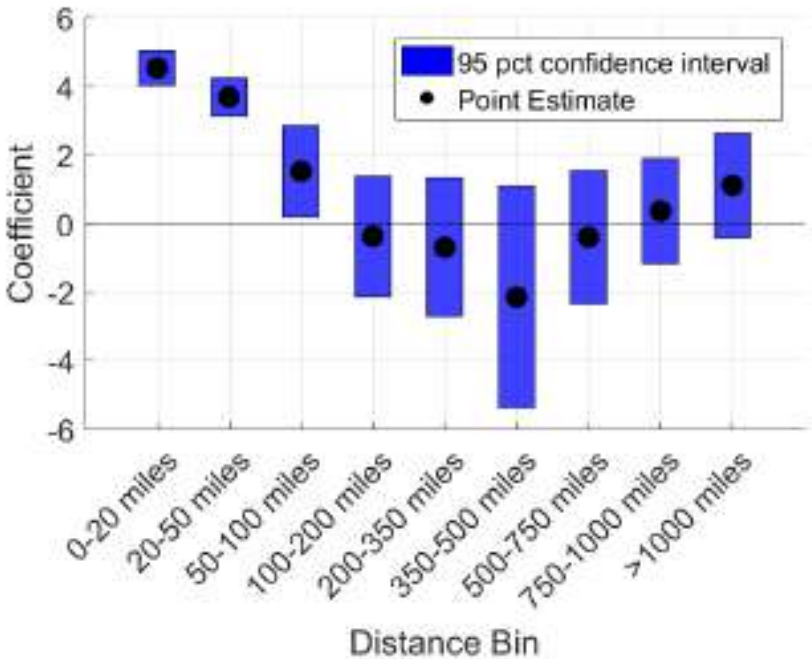


Exchange Rate Responsiveness by Distance: Share of Visits

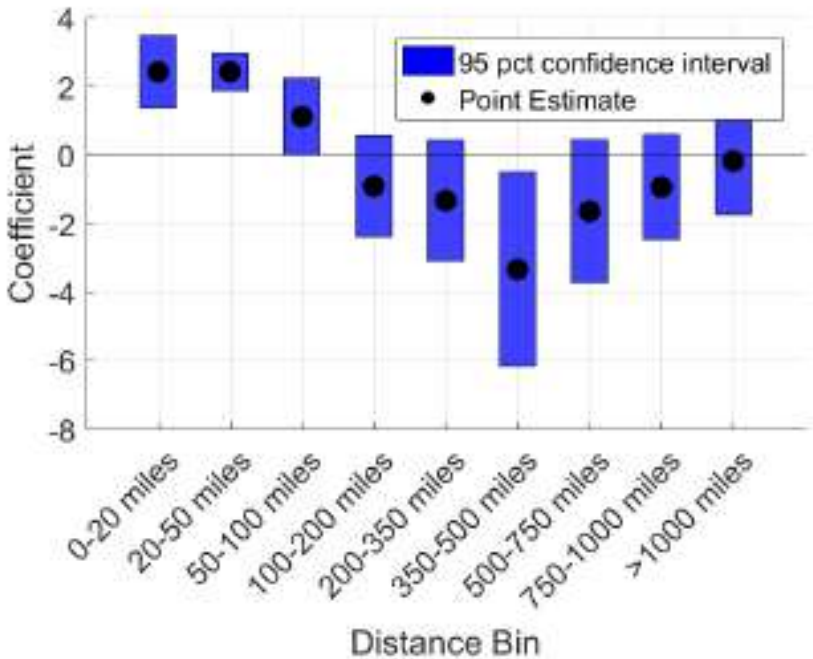


Responsiveness by Distance: Naics 445 Grocery Stores

A. Revenue Share

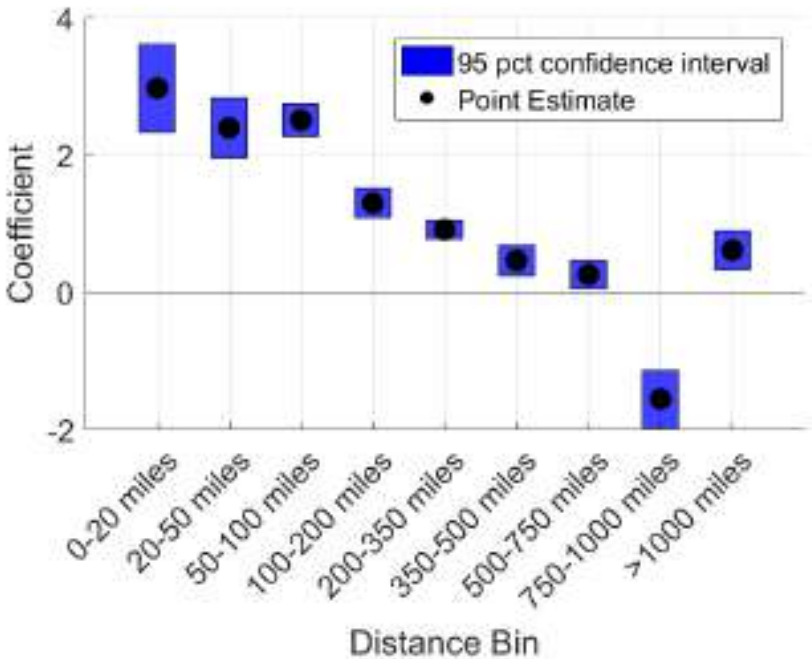


B. Visit Share



Responsiveness by Distance: Naics 721 Accommodation

A. Revenue Share



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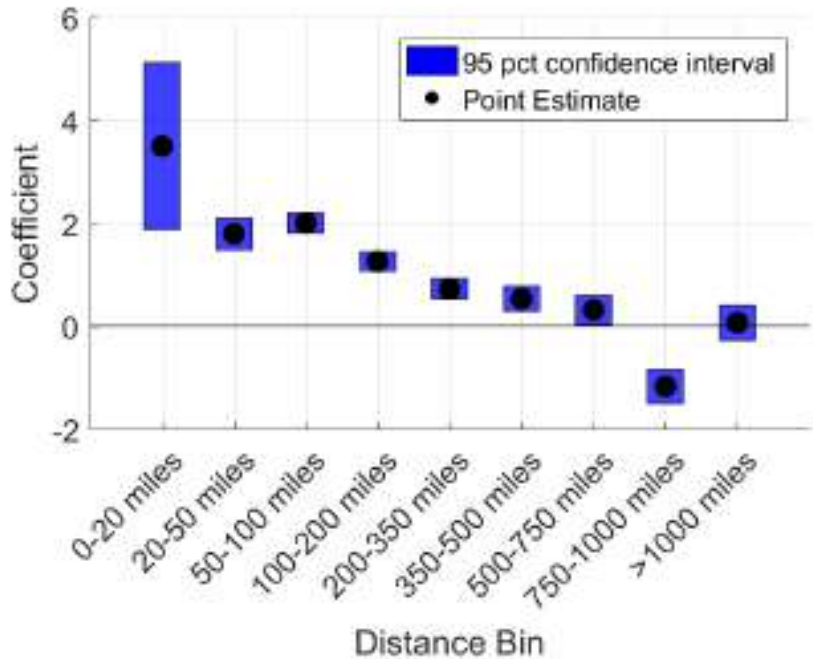


Next Steps

New research using quantitative spatial models captures economic and spatial linkages

- Fernando and Parro (2018), Allen and Arkolakis (2014), Monte et al (2018)

Two innovations to contribute to this literature

1. Disaggregated services flows (current models restricted to goods)
2. Estimates of elasticity of travel to relative price changes

Answering the following:

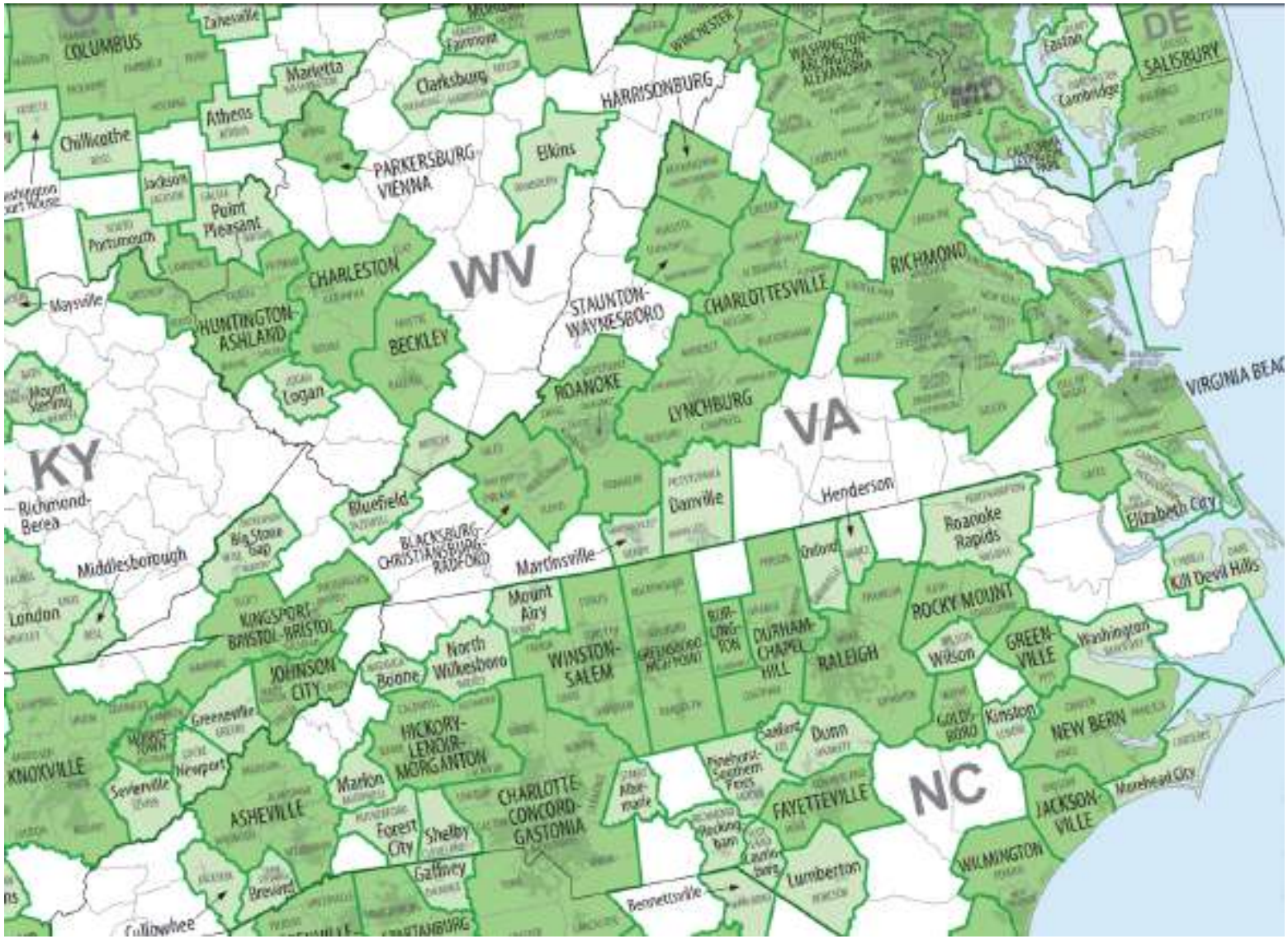
- Extent of sustained deviations from law of one price (geographic dispersion in prices) based on travel costs
- Effects of new high speed (low cost) transportation innovations (i.e. hyperloop, etc)

Conclusion

- Novel data permits a comprehensive picture of geographic patterns of services trade
- Analysis reveals tradability of many service industries
- Distance as important friction to trade, heterogeneous across industries
- Deviations in law of one price supported in part by transport costs
  - The extent that distance contributes to price dispersion likely varies by industry
- Geography and transportation networks will influence patterns of price dispersion

APPENDIX SLIDES

Core Based Statistical Areas



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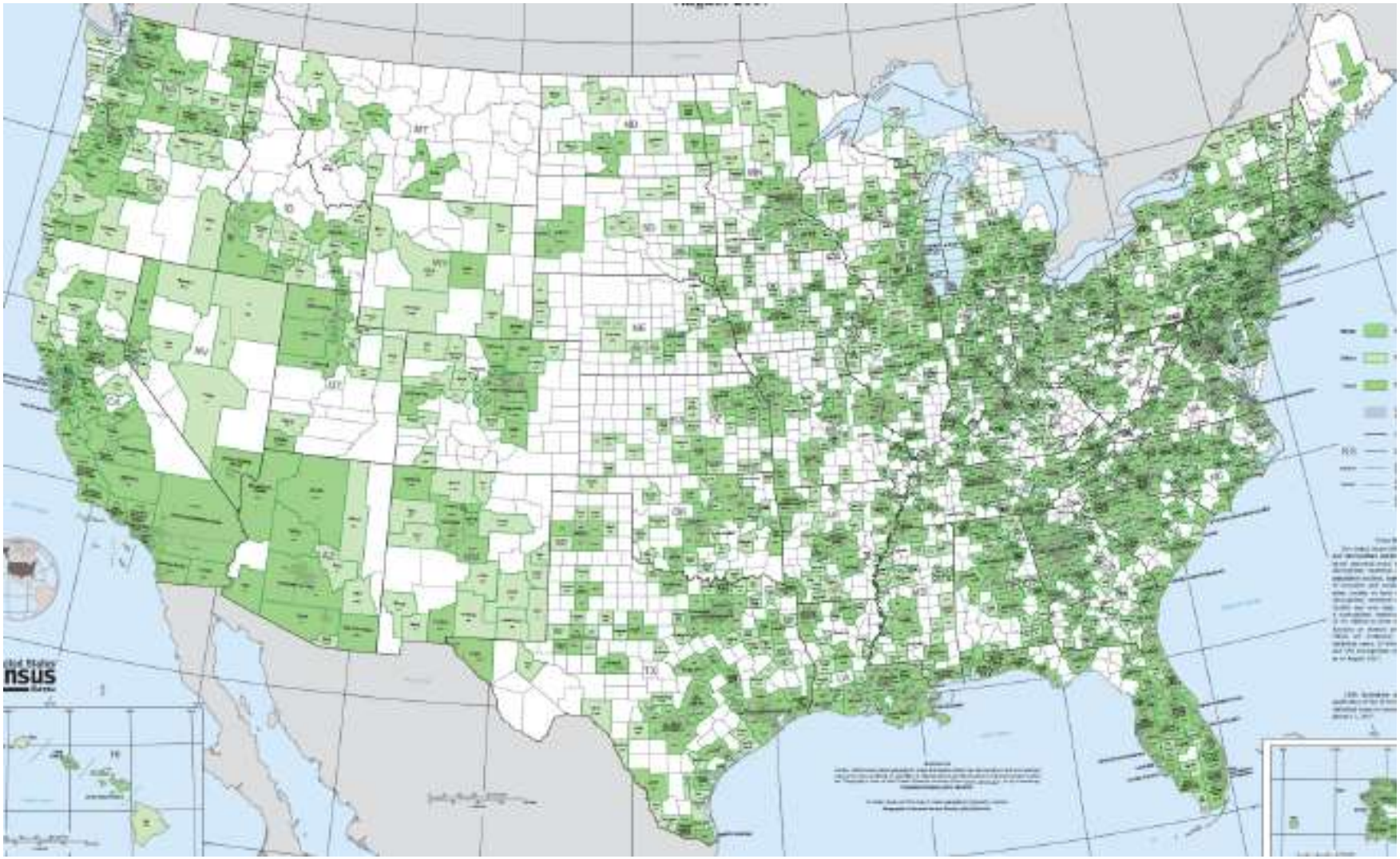
Core Based Statistical Areas



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City Home Location of Cards

Assign the most likely city of home location to cards based on spending patterns Use the following algorithm:

- Drop e-commerce merchants
-
- Transactions assigned varying likelihood weights based on industry of transaction
- Strong positive signal from location of grocery store transactions, negative signal from location of hotel transactions

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1. City Home Location of Cards: Details

	A	B	C	D	E	F
1	**Card ID**	**Merchant CBSA**	**Restaurant Count**	**Electronics Count**	**Medical Count**	**Home Dummy**
2	12345	New York City	50	10	10	1
3	12345	Albany	10	0	0	0
4	12345	Philadelphia	2	0	0	0
5	12345	Los Angeles	15	0	0	0

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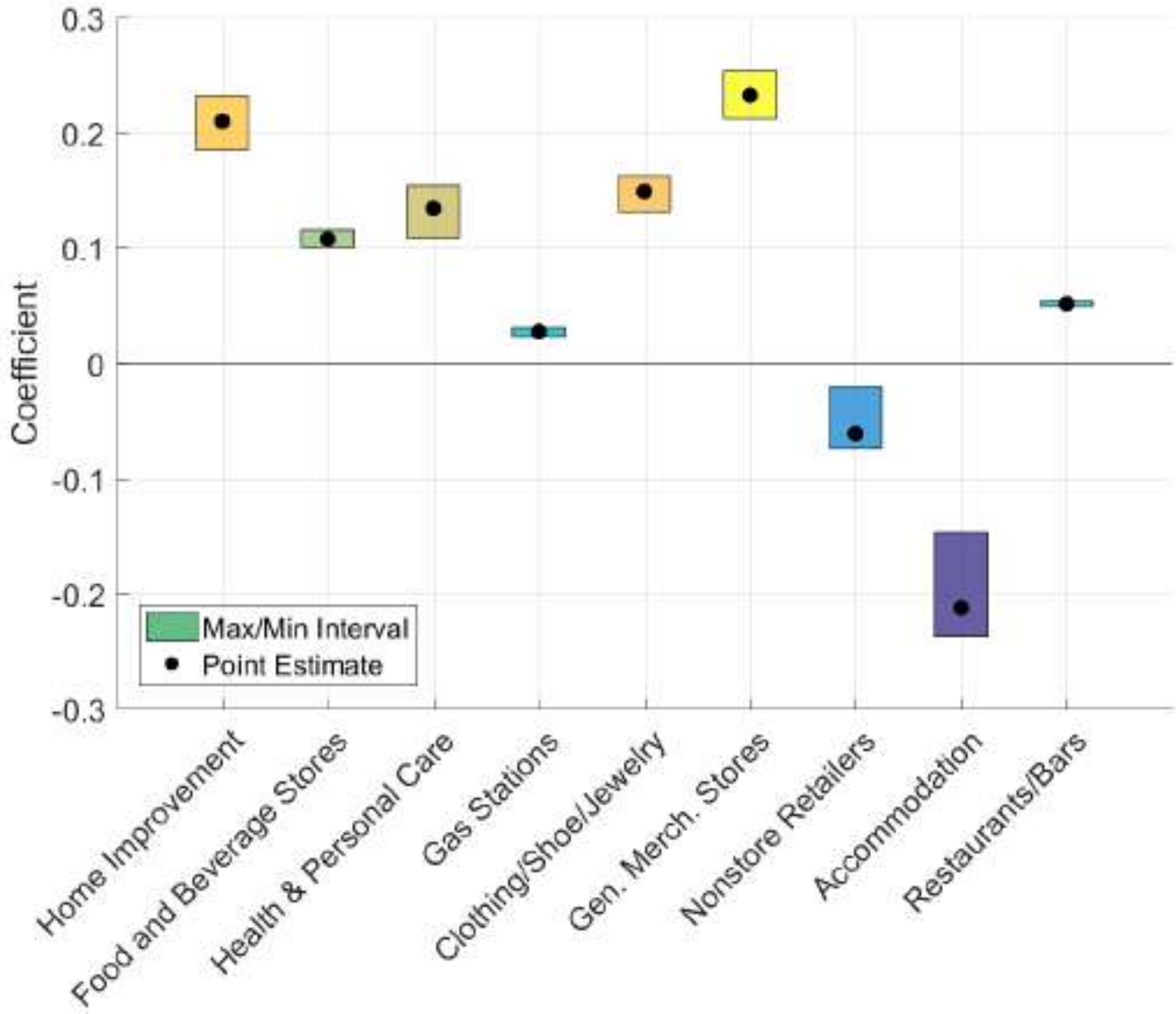
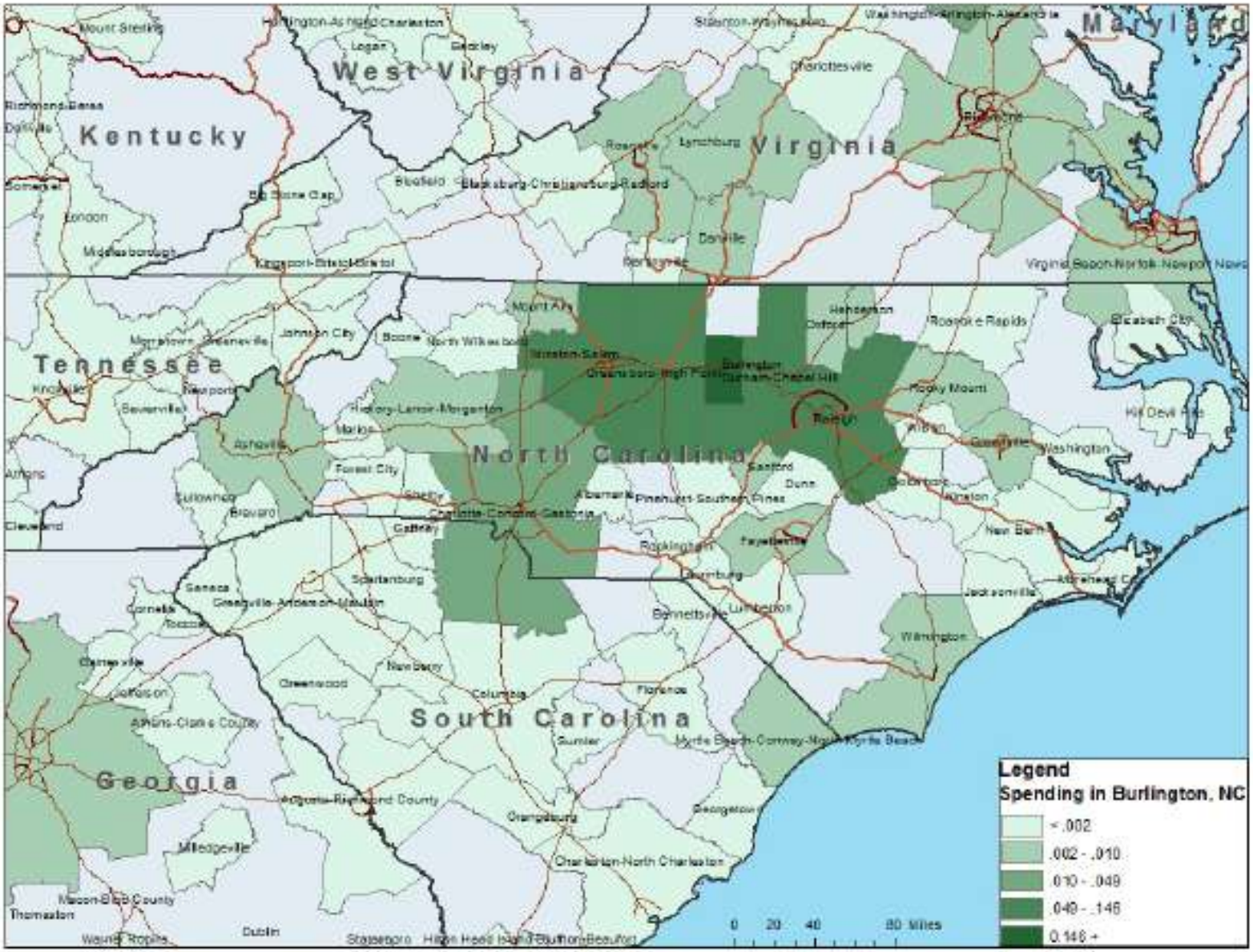
Selected Coefficient Estimates



Visual Illustration of Data



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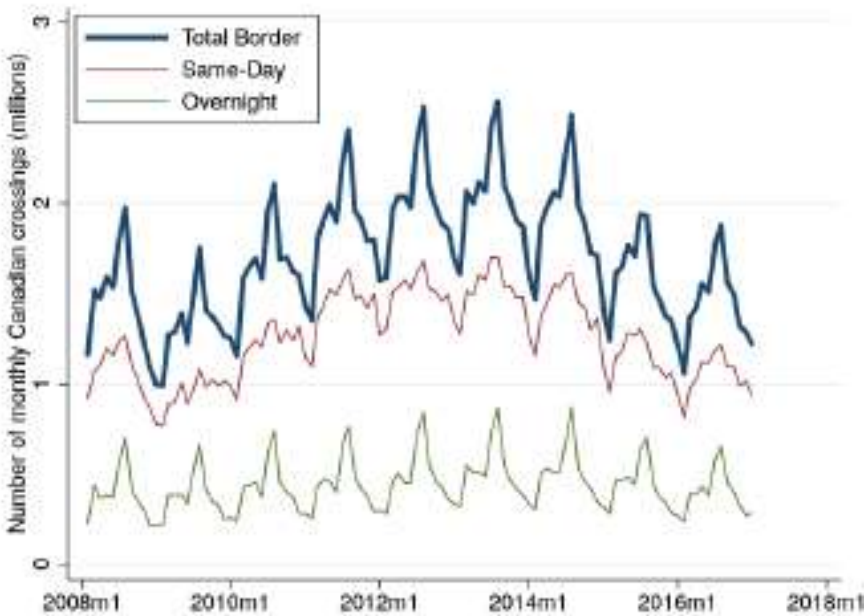
BEA Measurement of Travel Services

- I94 Customs Data on Monthly International Visitors
- Counts multiplied by avg expenditure per traveler from Survey of International Air Travelers (SIAT)
  - Broken down by country and rough expenditure items
  - Sample about 70,000 passengers per year (imports plus exports)
- SIAT does not include ground-based travelers –Statistics Canada shares information
- Canada day travelers are not counted as visitors

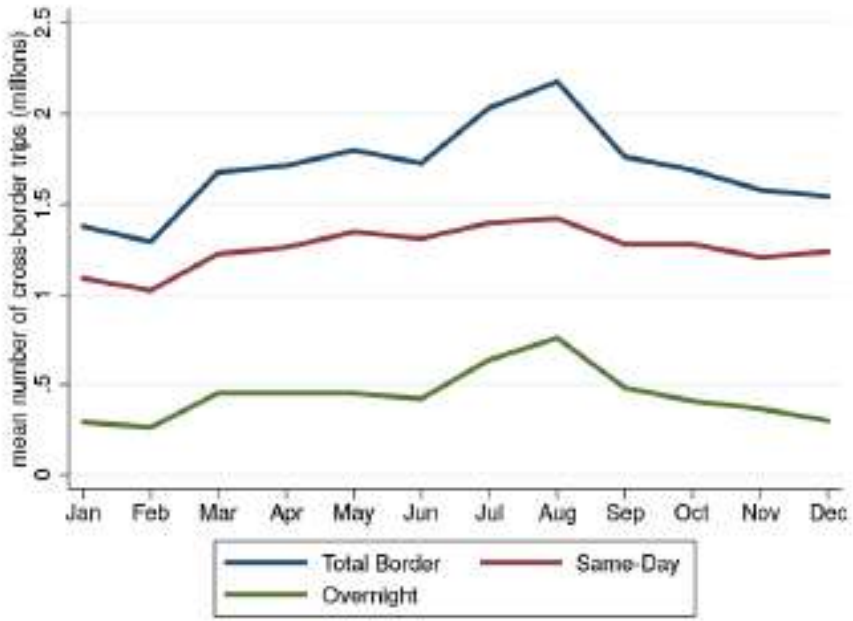
Back

Composition and Seasonality of Canadian Border Crossings

A. Canada-to-U.S. Border Crossings



B. Seasonal Pattern of Crossings



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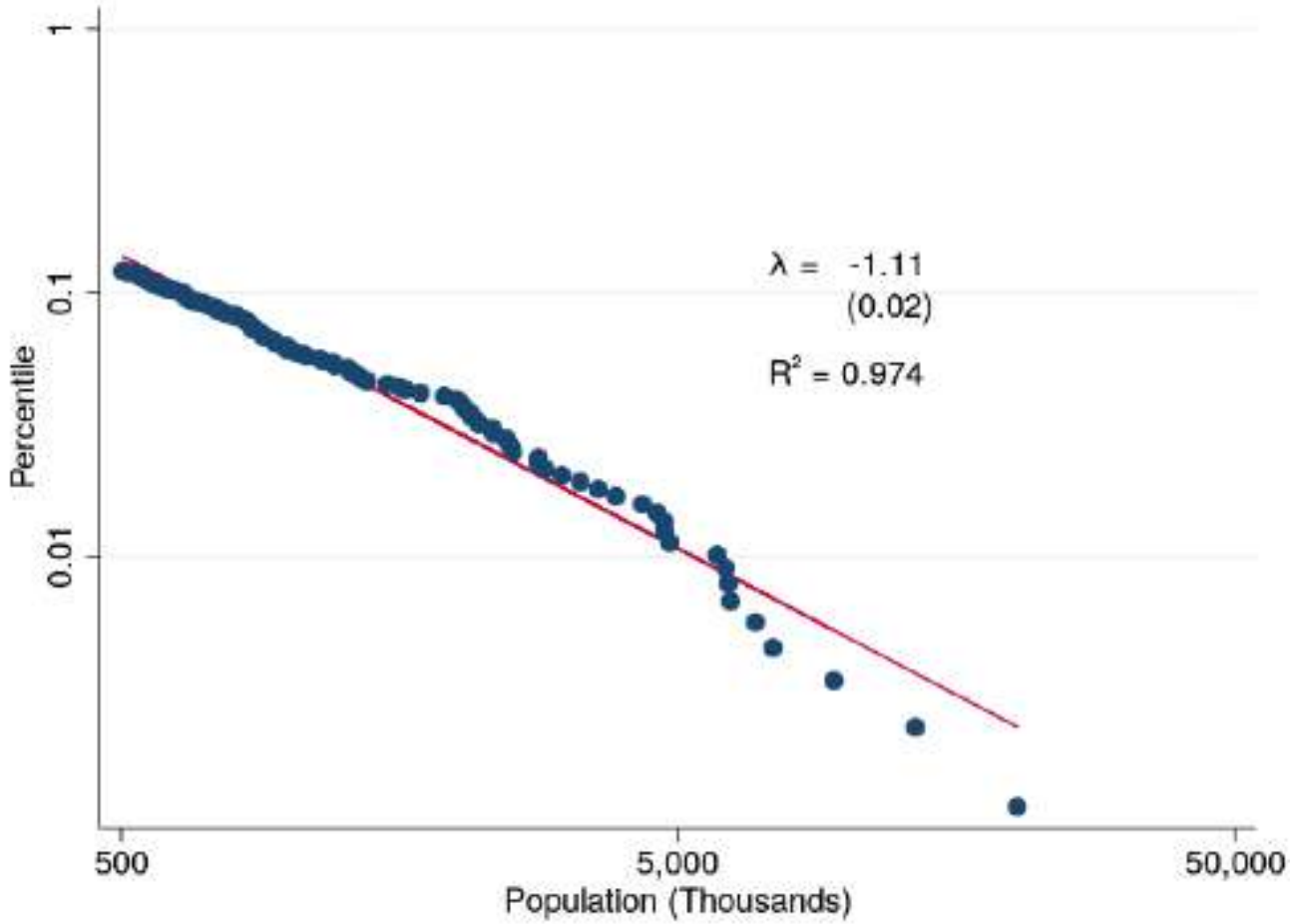
The Distribution of CBSA Size (Population)



Gravity Model: Distance Coefficients at CBSA Geographies

Sector	Sector Description	Distance Coefficient	Obsv	Adj. R^2
454	Nonstore Retailers	-0.70***	196,396	0.59
711	Performing Arts/Related	-1.09***	46,014	0.67
541	Professional/Scientific/Technical	-1.10***	252,271	0.59
442	Furniture and Home Furnishings	-1.20***	159,631	0.6
446	Health and Personal Care	-1.22***	143,577	0.59
443	Electronics and Appliances	-1.33***	217,142	0.67
451	Sporting Goods, Book/Music	-1.34***	317,126	0.64
713	Amusement/Gambling/Recreation	-1.36***	238,059	0.64
453	Misc. Store Retailers	-1.40***	464,524	0.66
448	Clothing/Shoe/Jewelry	-1.43***	337,491	0.68
721	Accommodation	-1.47***	466,247	0.71
452	Gen. Merchandise Stores	-1.53***	318,500	0.68
441	Motor Vehicle and Parts	-1.54***	402,959	0.57
444	Building Material & Garden Equip.	-1.62***	363,980	0.64
445	Grocery Stores	-1.66***	557,138	0.69
722	Restaurants & Bars	-1.85***	736,853	0.78
447	Gas Stations	-1.92***	680,605	0.77

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