USC University of Southern California

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Why do warehouses decentralize more in certain metropolitan areas?

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VREF Conference on Urban Freight 2016

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Overview

- Warehousing Decentralization
  - Why should we care?
  - Why do location patterns change?
  - What do we know about it?
- Research Framework
  - How do we measure?
  - What do we test?
- Results
  - How have they changed?
  - Which factors explain it?
- Discussion
  - What have we learned?

Warehousing Decentralization

Why should we care?

- Warehousing and distribution centers (W&Ds)
  - NAICS493 "Warehousing and Storages"
  - An intermediary that connects supply chain
  - Part of goods production and distribution system

- Warehousing decentralization?

"…the phenomenon of relocation and concentration of logistics facilities toward suburban areas outside city centre boundaries"

Dablanc and Rakotonarivo (2010)

Why should we care?

- Growth of W&D and foreign trade since 2000
  - W&D jobs 33% ↑ vs. All U.S. jobs 4% ↑ [1]
  - Foreign trade 40% in $ ↑ vs. U.S. population 10% ↑ [2]

- Key segments of domestic goods movement (US) [3]
  - Within metro-level – 51% in tons
  - By truck – 77% in tons

Data: 1) CBP 2003 & 2013; 2) USDOT Freight Facts and Figures, 2013; 3) FAF, 2015

Why should we care?

- W&Ds as truck trip generators
  - If W&Ds are located farther from markets
    - → Truck travel would increase (VMT)
    - → Impact would increase
  - E.g. Tokyo case (Sakai, et al. 2015)

- Negative externalities
  - Congestion, increased fuel consumption, air pollution
  - Noise, vibration, infrastructure damage
  - Environmental justice issues

Why do location patterns change?

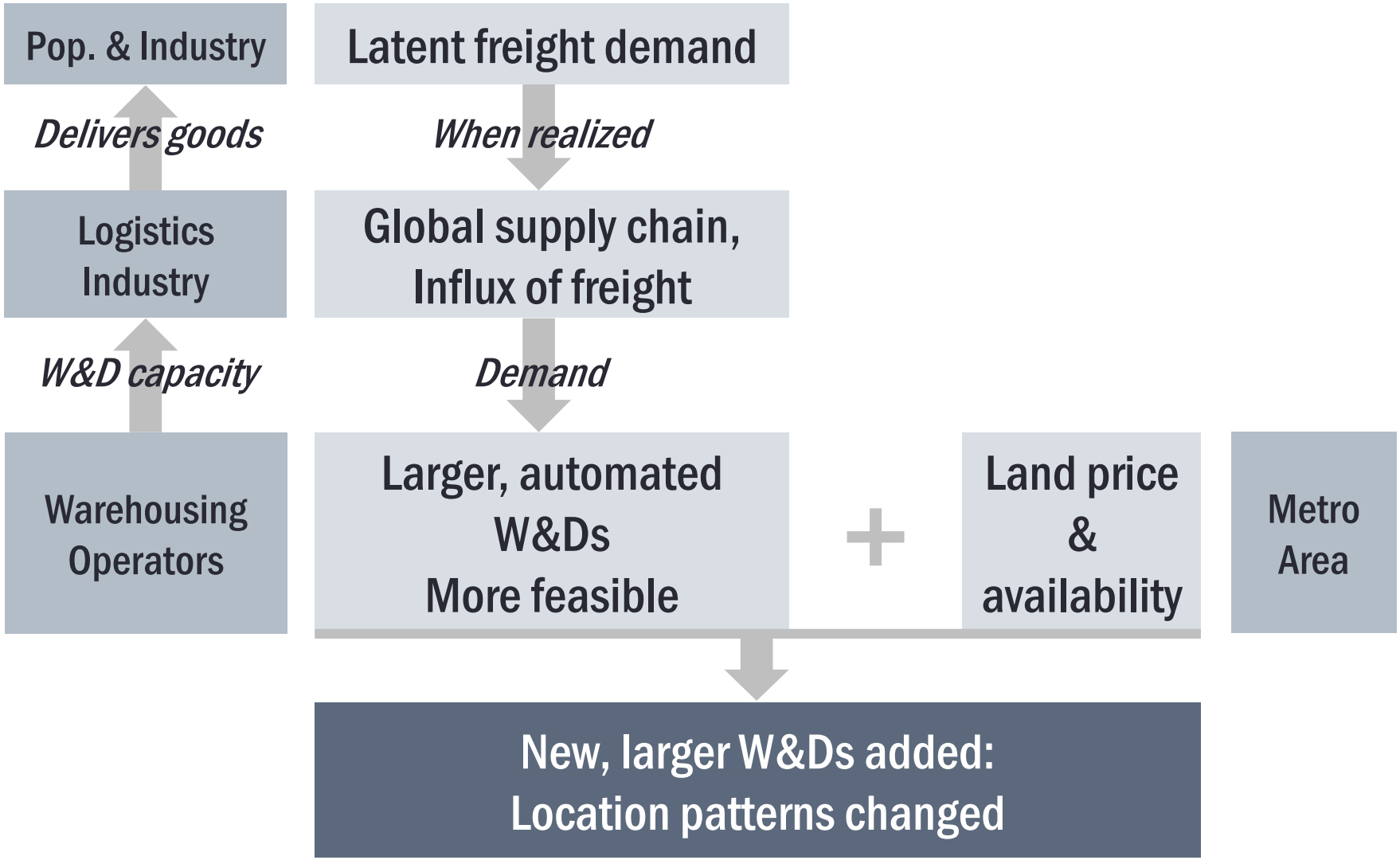
- Economic restructuring (Hesse and Rodrigue, 2004)
  - Globalized, geographically dispersed supply chains
  - Advances in transport tech. – reduced transport costs
  - Advances in logistics tech.– instant response, short dwell time
  - Access to national and global markets
  - Proximity to highways, rail and intermodal facilities
- More modernized and larger W&Ds (Dablanc and Ross, 2012)
  - **Ship large volumes of goods frequently and reliably**
  - Mega DC and automation
- Land price and availability
  - Low rent, large parcels, and favorable zoning

Is this really happening since 2000s?

- For
  - Distance to the geographical center of W&Ds has increased
    - Los Angeles, Atlanta, Toronto, and Paris (Tokyo)
  - W&Ds have suburbanized
    - In UK metro areas
- Against
  - Distance to the geographical center of W&Ds has decreased
    - Seattle (Dablanc, et al. 2014)
- Other measures
  - W&D concentrated in counties with airport or more highways
- No systematic testing of factors for decentralization

Research Framework

Rationale behind W&D location change



Considerations and Research Goals

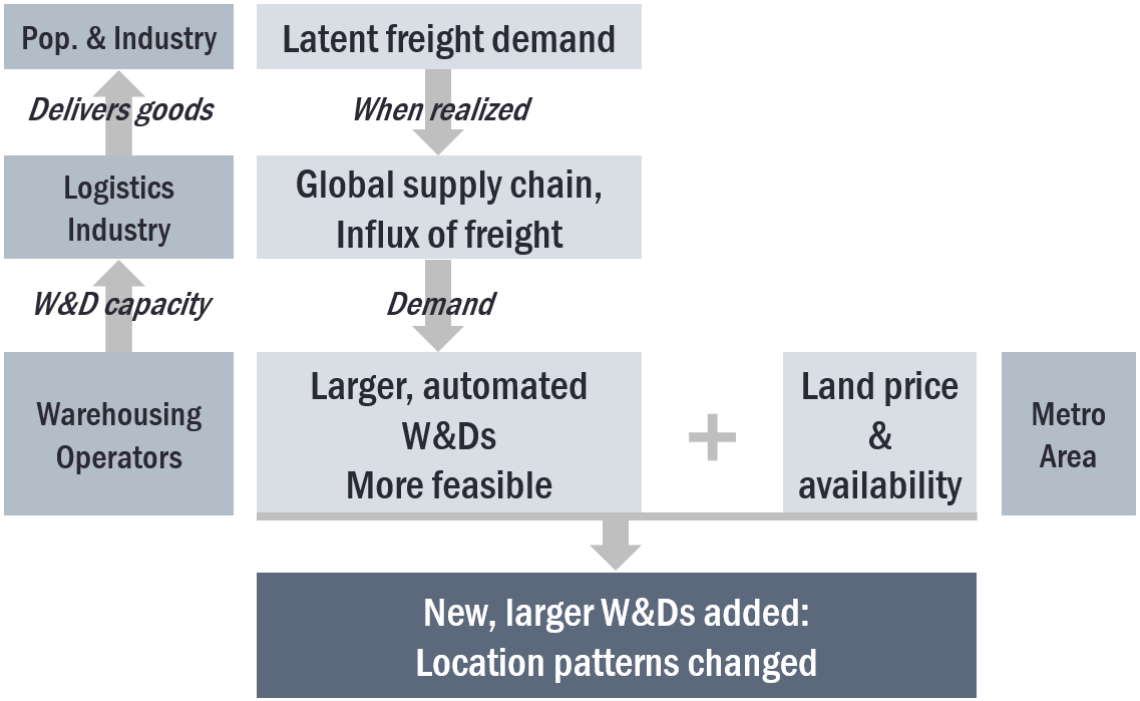
- Across metro areas: Chance of location change varies
  - Global supply chains via select metro areas
    - 78% of all container import through 10 container port systems
    - Much greater demand for larger W&Ds!
  - Land more restricted in certain places
    - Different level/distribution of land rent across metro areas

- Research Goals
  - To identify metro-level factors for W&D location change
  - To test if metro-level heterogeneity results in different patterns of W&D location change
  - To test if temporal changes in factors result in different patterns

General Model 1

Freight flows and W&D size – Cross-section (OLS)

- ΔW&D SIZE $_{(i, \text{from } t \text{ to } t+1)}$ = F (FLOWS $_{(i,t)}$, POP $_{(i,t)}$)



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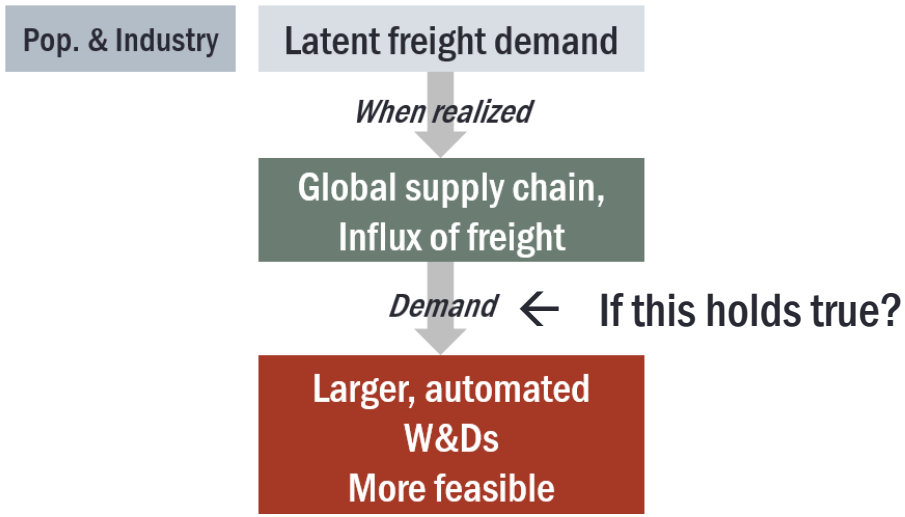
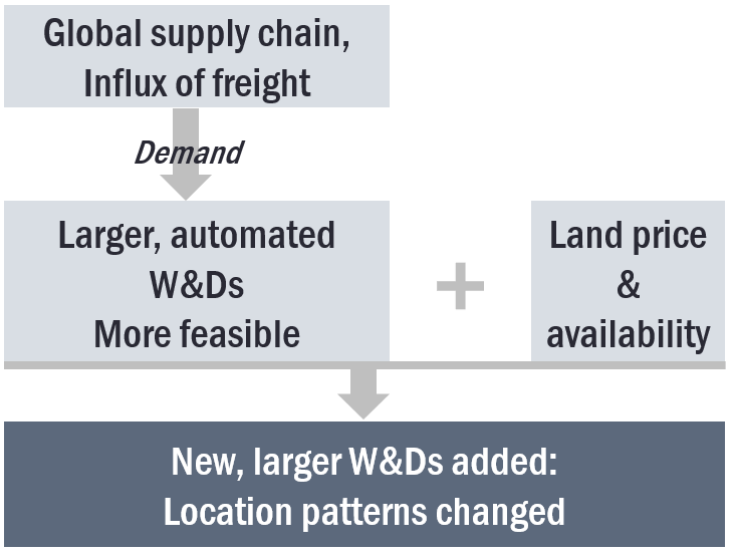


General Model 2

Heterogeneity Across Metro Areas – Cross-section (OLS)

(1) ΔW&D DIST $_{(i, \text{ from } t \text{ to } t+1)}$ = F (SIZE $_{(i,t)}$, LAND $_{(i,t)}$)

(2) ΔW&D DIST $_{(i, \text{ from } t \text{ to } t+1)}$ = F (FLOW $_{(i,t)}$, LAND $_{(i,t)}$)



(1)

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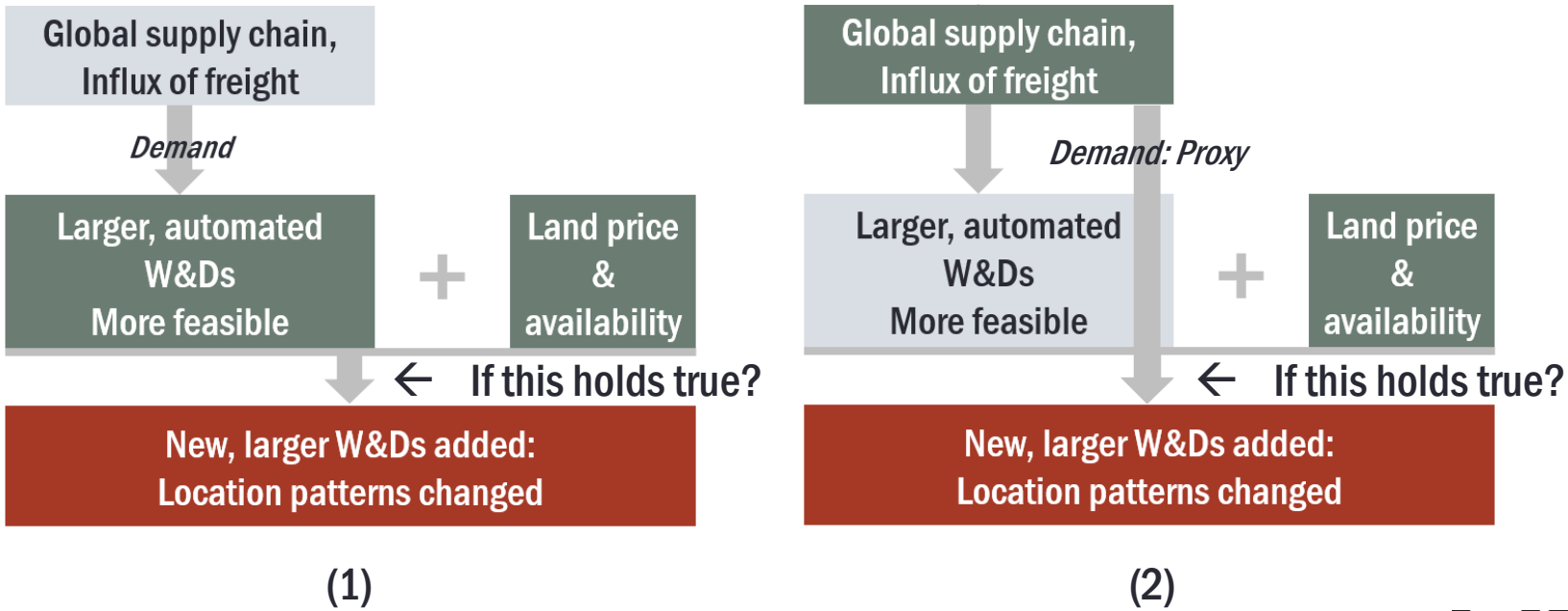


Measurement

- W&D distribution
  - Average distance from the CBD to all W&Ds by metro area
  - Average distance from all employment to all W&Ds by metro area
  - ΔW&D distribution = Ave. distance in 2013 – Ave. distance in 2003
  - W&D distribution $_{(t)}$ = Ave. distance $_{(t)}$ (t = 2003, 2008, 2013)

- W&D size
  - SIZE = W&D jobs / W&D establishments
  - Expectation: (+) Larger W&Ds → MORE decentralization

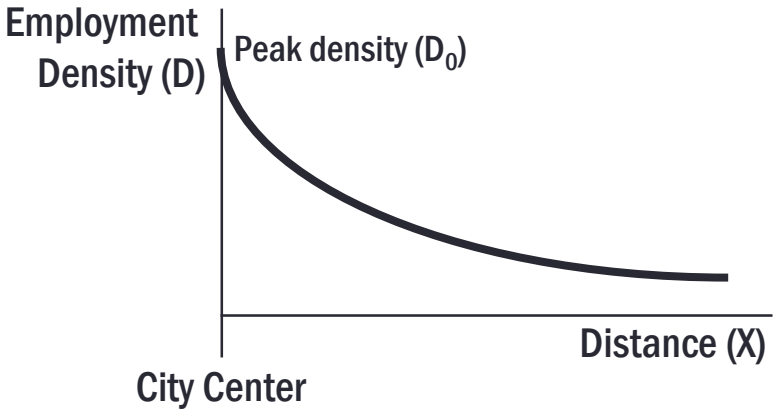
- Freight flows (million tons)
  - Commodity Flow Survey (CFS), 2002, 2007, 2012
  - Expectation: (+) Greater freight flows → MORE decentralization

Measurement – Land Rent

- Spatial distribution of land rent approximated by <u>negative exponential curve</u> of employment density by ZIP Code

  - $D_{(x)} = D_0 * e^{-\beta * x + u}$ *Logarithm Transformation* → $\log(D_{(x)}) = \log(D_0) - \beta * x + u$

    → $Y = a - b * X$



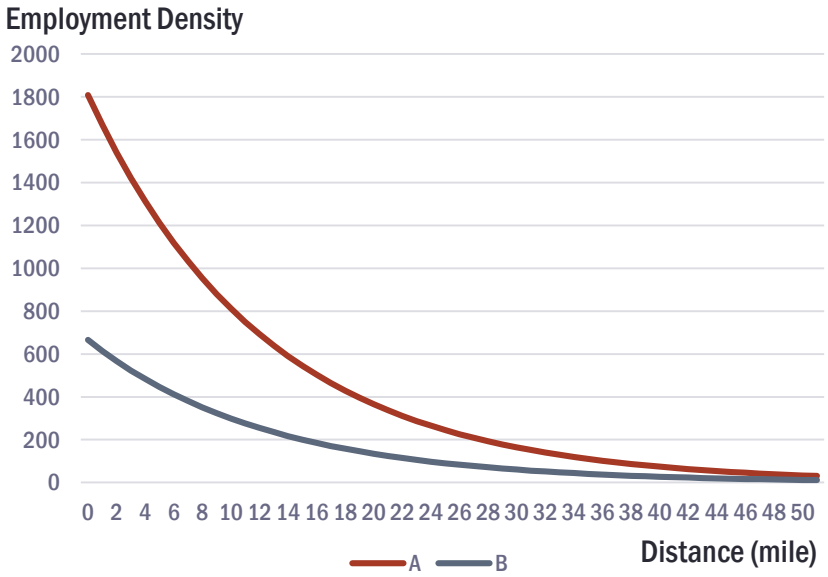
  - Intercept (peak density) = $\log(\hat{D}_0)$
  - Slope (density gradient) = $\hat{\beta}$

(Clark, 1951; McDonald, 1989; Anas, Arnott, and Small, 1997)

Measurement – Land Rent

Controlling for "Gradient"

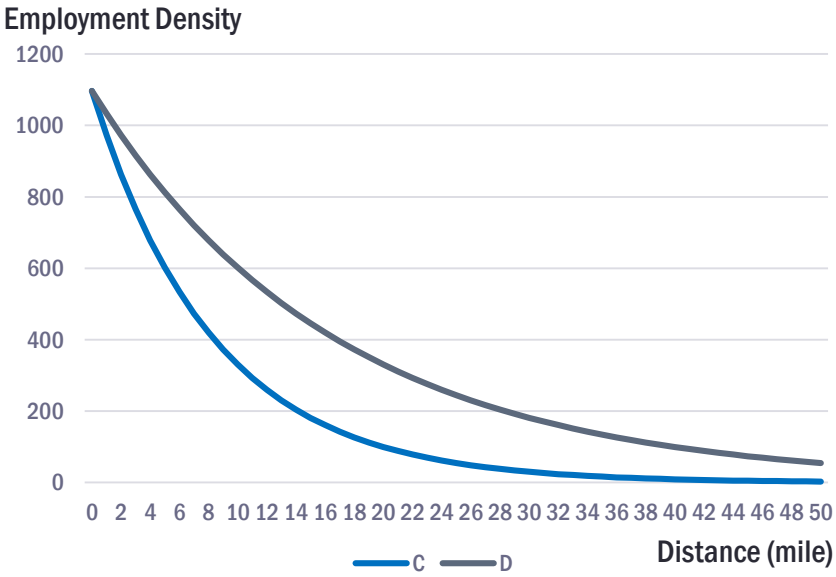
Greater "Peak Density" → MORE decentralization



	A)	B)
Peak density	7.5	6.5
Gradient	0.08	0.08

Controlling for "Peak Density"

Steeper "Gradient" → LESS decentralization



	C)	D)
Peak density	7.0	7.0
Gradient	0.12	0.06

Data

ZIP Code Business Patterns

Location of WDCs

- ZIP Code Business Patterns (2003-2013)
  - A subset of CBP
  - Business Register: records of known establishments
  - Annual N of establishments, employment, and payroll
  - 6 digit NAICS codes; USPS ZIP Codes; cover entire U.S.

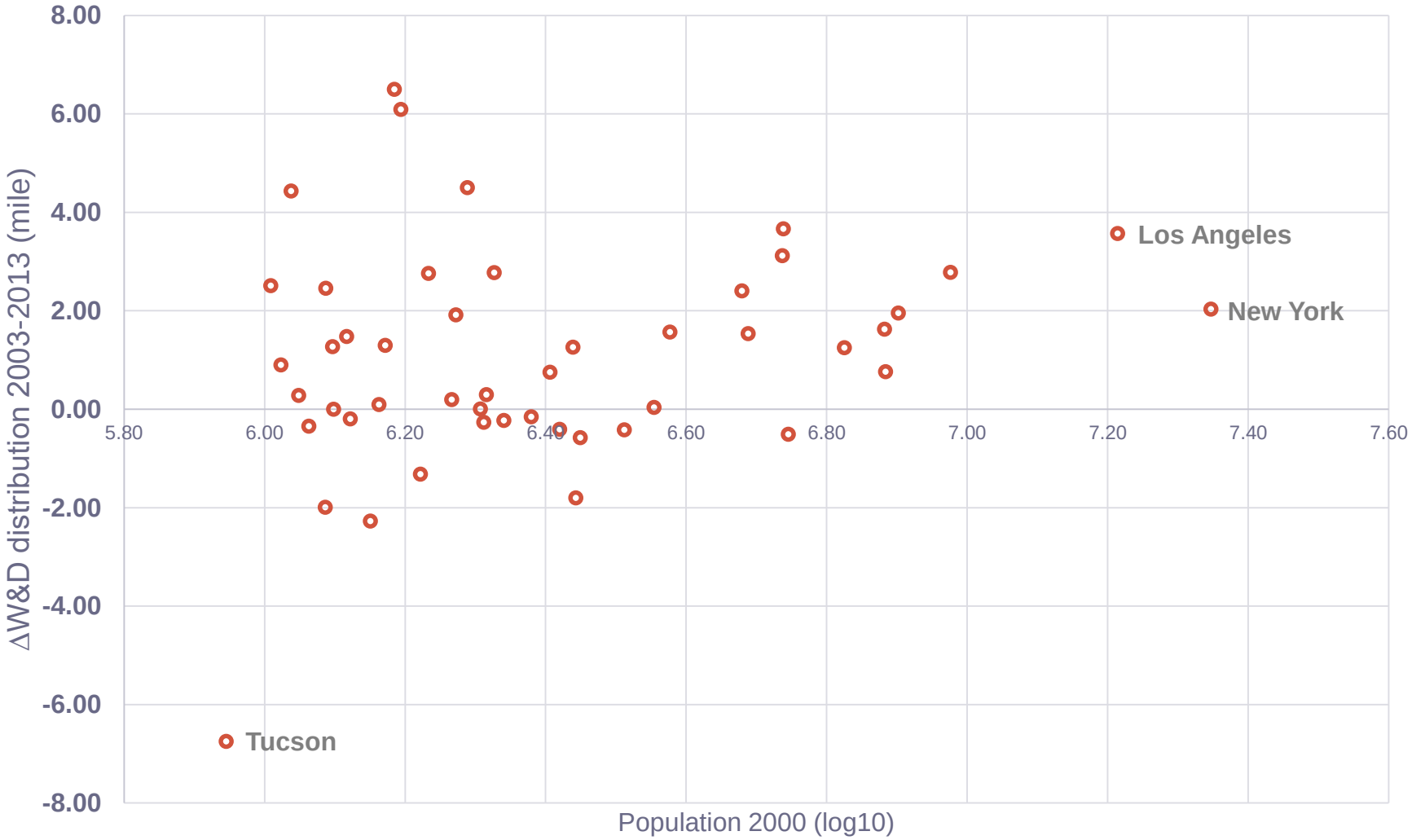
- Limitations
  - A large spatial unit; *TeleAtlas* centroids pinpoint location
  - Aggregated addresses, not geographically delimited
  - Size correlates with density, not with political boundaries

Results

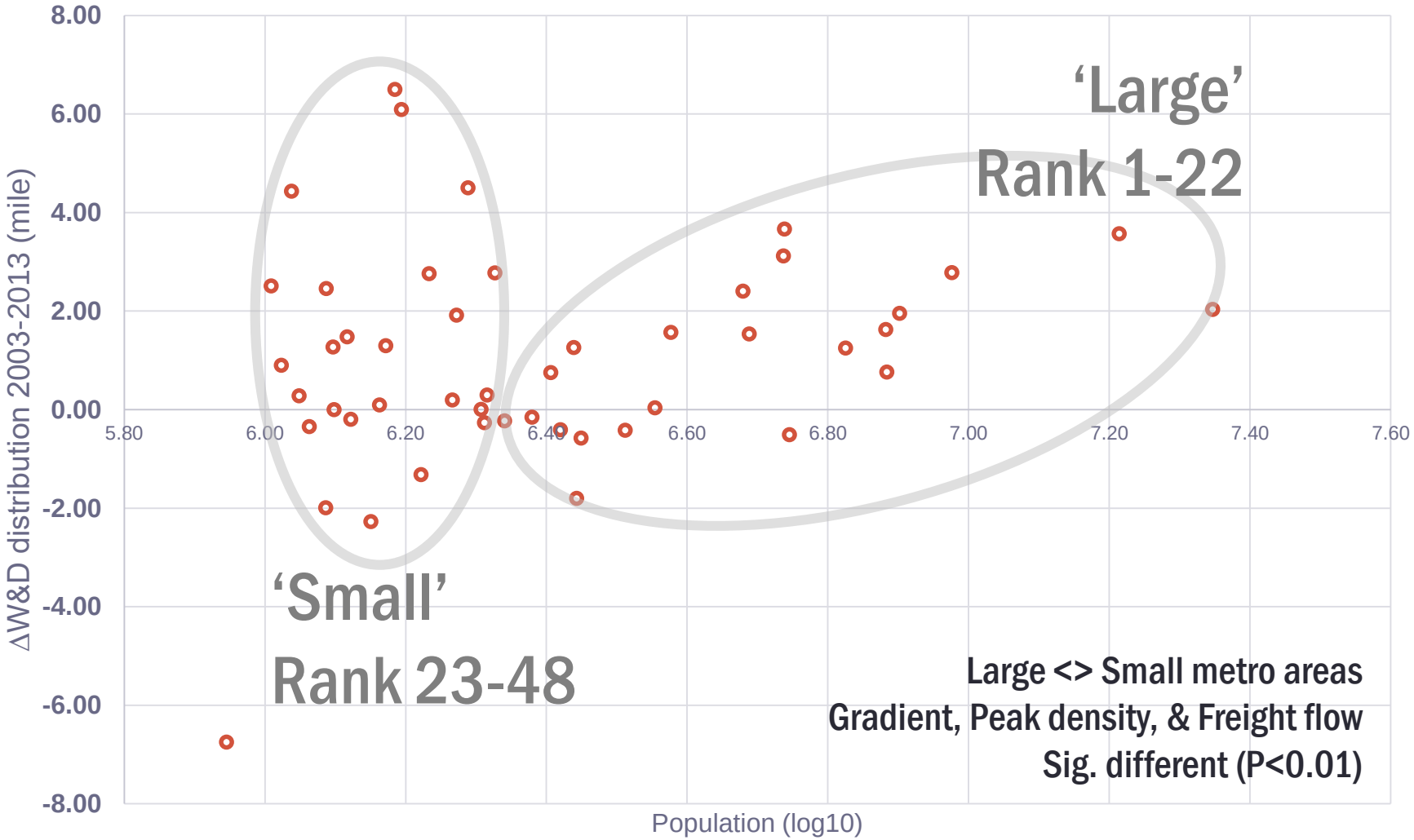
Sample Metropolitan Areas (N=48)

	Combined Statistical Areas & Metropolitan Statistical Areas
Rank 1-22 (N=22)	New York, Los Angeles, Chicago, Washington, Boston, San Francisco, Dallas, Philadelphia, Houston, Atlanta, Miami, Detroit, Seattle, Phoenix, Cleveland, Denver, St. Louis, Pittsburgh, San Diego, Portland, Orlando, Tampa
Rank 23-48 (N=26)	Indianapolis, Charlotte, Kansas City, Columbus, Milwaukee, Cincinnati, Salt Lake City, Las Vegas, San Antonio, Nashville, Raleigh, Austin, Louisville, Greensboro, Virginia Beach, Grand Rapids, New Orleans, Richmond, Greenville, Buffalo, Birmingham, Rochester, Tulsa, Albany, Dayton, Tucson

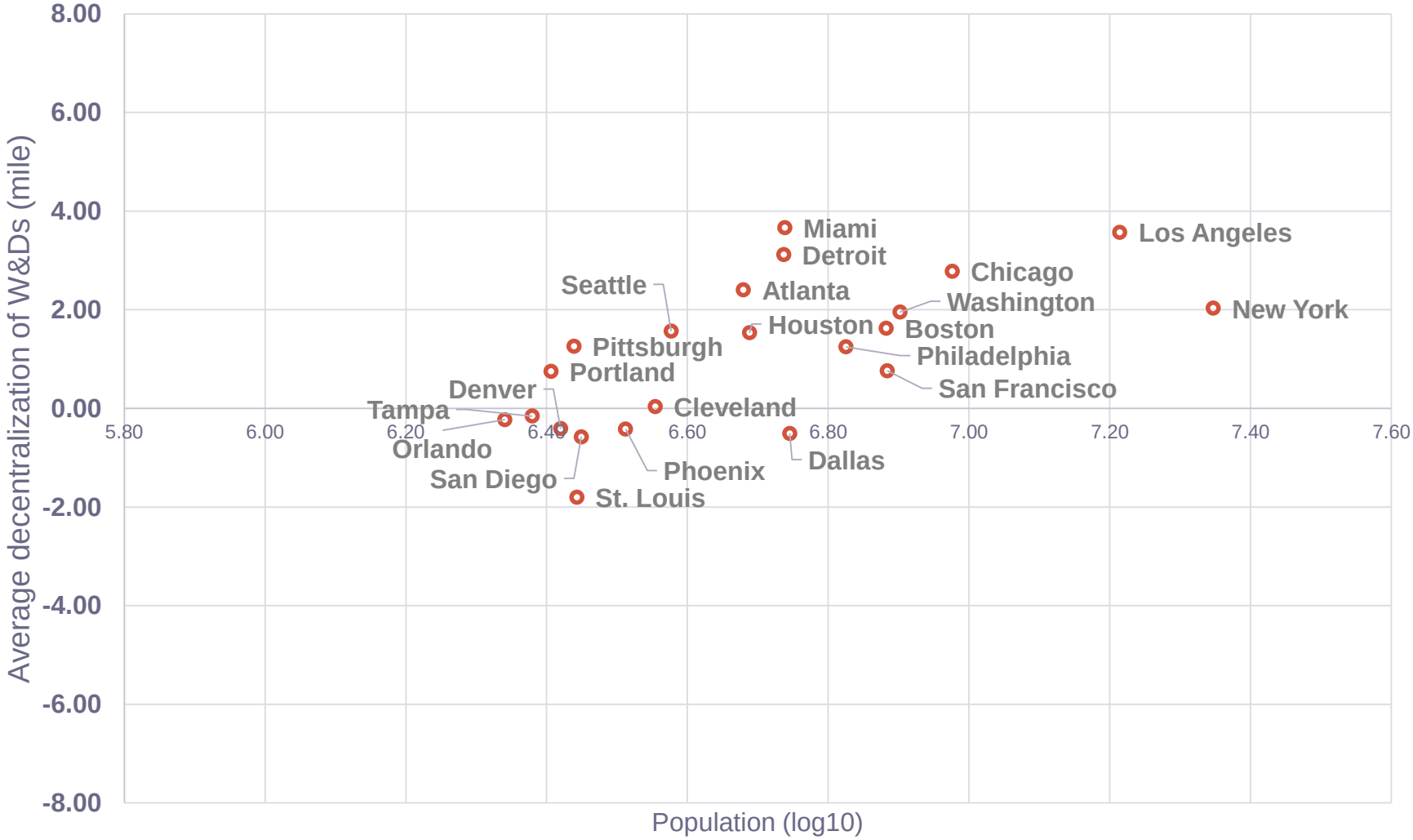
W&D decentralization



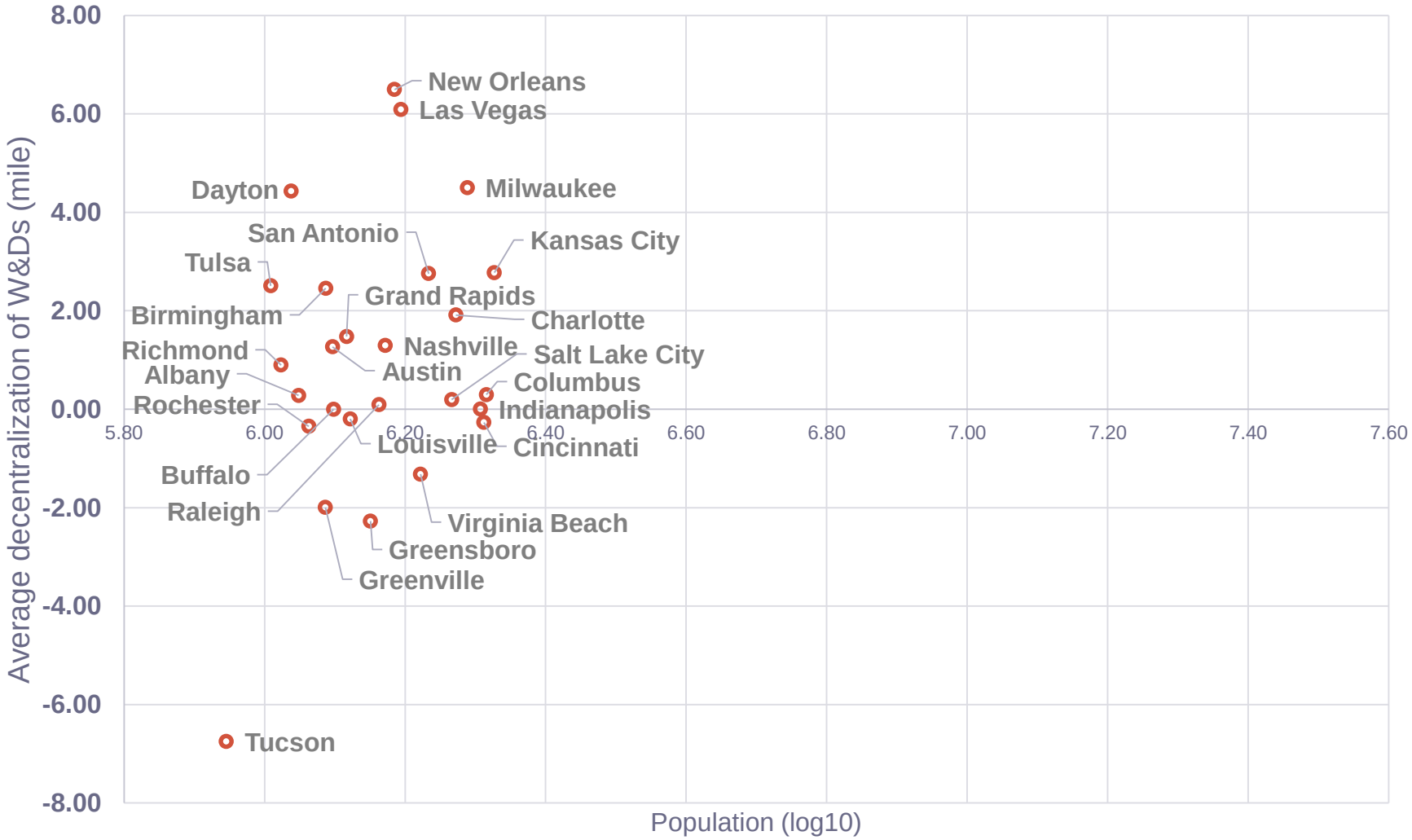
Non-linear W&D decentralization



W&D decentralization (Rank 1-22)



W&D decentralization (Rank 23-48)



Bivariate correlation table

Bivariate correlation ΔW&D distribution 2003-2013	All metro areas N=48	Metro areas Rank 1-22	Metro areas Rank 23-48
Population 2000 (log)	0.23	0.65	0.28
W&D Size (Employees per W&D) 2003	0.16	0.20	0.16
Total freight flow (M-ton) 2002	0.32	0.47	0.49
Gradient (β)	-0.06	-0.48	0.10
Peak Density (log(D_0))	0.22	0.19	0.32

Model 2 results

OLS (1): ΔW&D DIST $_{(i,\ from\ t\ to\ t+1)}$ = F (LAND $_{(i,t)}$, SIZE $_{(i,t)}$, FLOW $_{(i,t)}$)

OLS (2): ΔW&D DIST $_{(i,\ from\ t\ to\ t+1)}$ = F (LAND $_{(i,t)}$, FLOW $_{(i,t)}$)

ΔW&D Distribution 2003-2013	(1) SIZE and FLOW		(2) FLOW	
	Std. Coef.	Sig.	Std. Coef.	Sig.
Gradient 2003	-0.566	**	-0.580	**
Peak density 2003	0.271	*	0.283	**
Freight flow 2002	0.164	**	0.161	**
W&D Size 2003	0.124			
Small	-1.389		-1.250	
Small*Gradient 2003	0.649		0.662	
Small*Peak 2003	0.874		0.799	
Small*Flow 2002	0.403	*	0.415	*
Small*W&D Size 2003	0.050			
Constant	.		.	
R^2	0.364		0.344	
N	48		48	

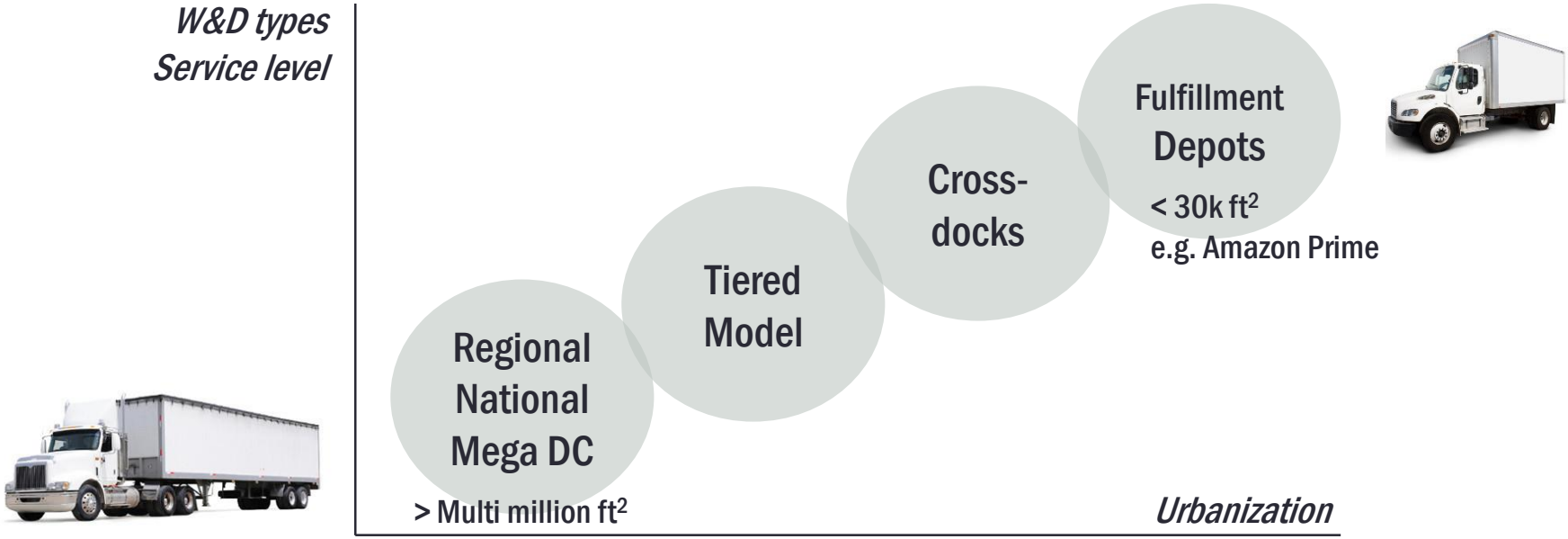
** P<0.01; * P<0.05; + P<0.1

Summary

ΔW&D Distribution 2003-2013	Relationship	Exp. Power	As expected?
Gradient 2003	–	Moderate	Yes
Peak density 2003	+		Yes
Freight flow 2003	+		Yes
W&D size 2003	N/S	N/S	No

Discussion

- W&D SIZE
  - Jobs per establishment?
  - W&D SIZE in ft^2



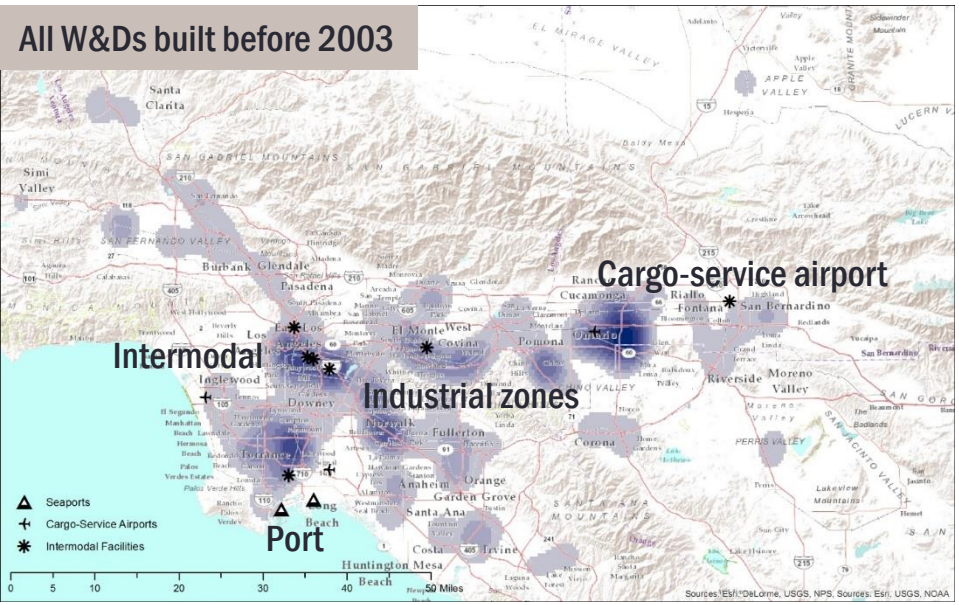
Source: Benjamin Conwell, Cushman & Wakefield

- Different location patterns: outward/inward movement

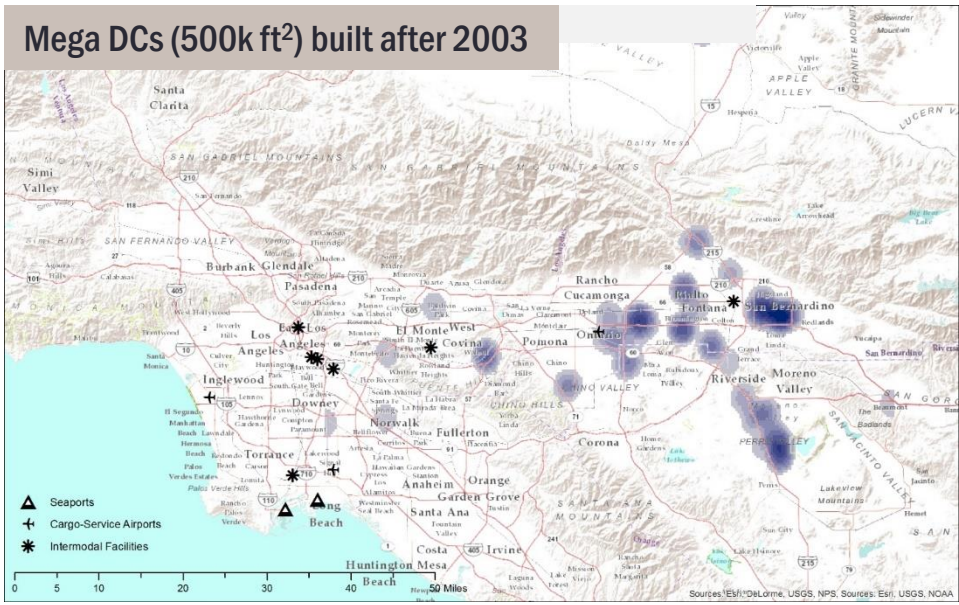
Future research

- Sub-metropolitan factors for W&D location?
  - Land rent/availability, access to market/labor, proximity to freight infrastructure, proximity to similar sector, and land use regulation
  - Discrete location choice factors in Los Angeles
  - Different types of W&Ds at different time periods

All W&Ds built before 2003



Mega DCs (500k ft^2) built after 2003



Thank you!

W&Ds have decentralized to the urban peripheries

to transport large volumes of goods frequently and reliably.

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