



**USC** University of  
Southern California

# Warehouse Location Choice

A Case Study in Los Angeles, CA

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# Research Objectives

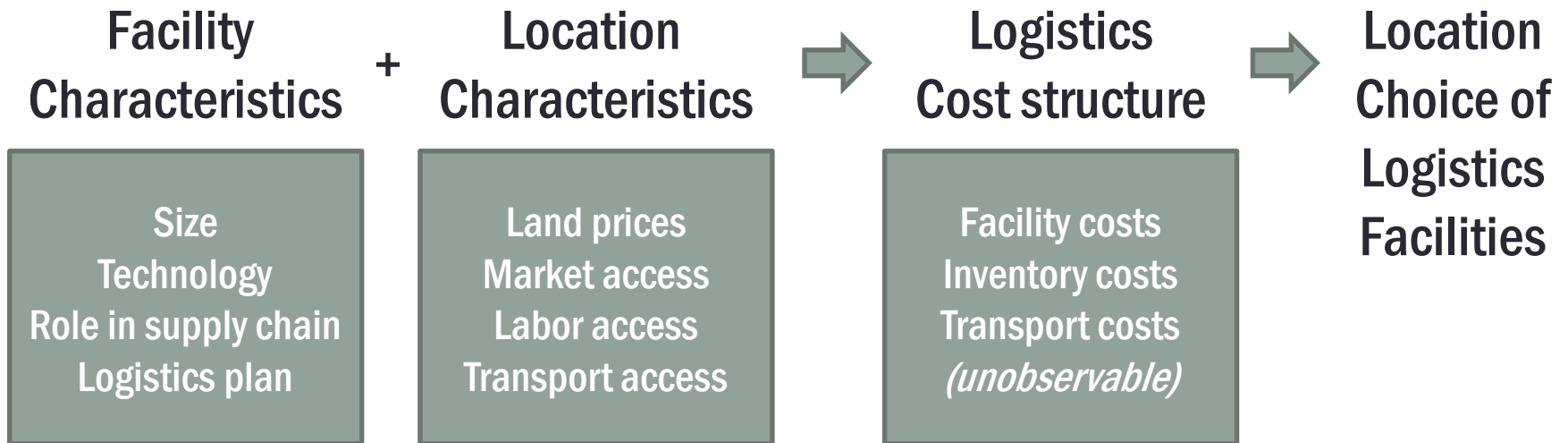
- ❑ Understand **how and why** warehouses have decentralized from central urban areas to the periphery
- 1. Look at warehousing location choice **factors**
- 2. Evaluate **changes** in location & **changes** location choice factors
  - Focus on **large warehouses'** location change/choice

# 1. Warehousing Location Choice

# Warehousing Location Choice

- ❑ Warehouse?
  - An intermediary that connects supply chain
  - Part of the logistics industry

## ❑ Warehouse Location Choice



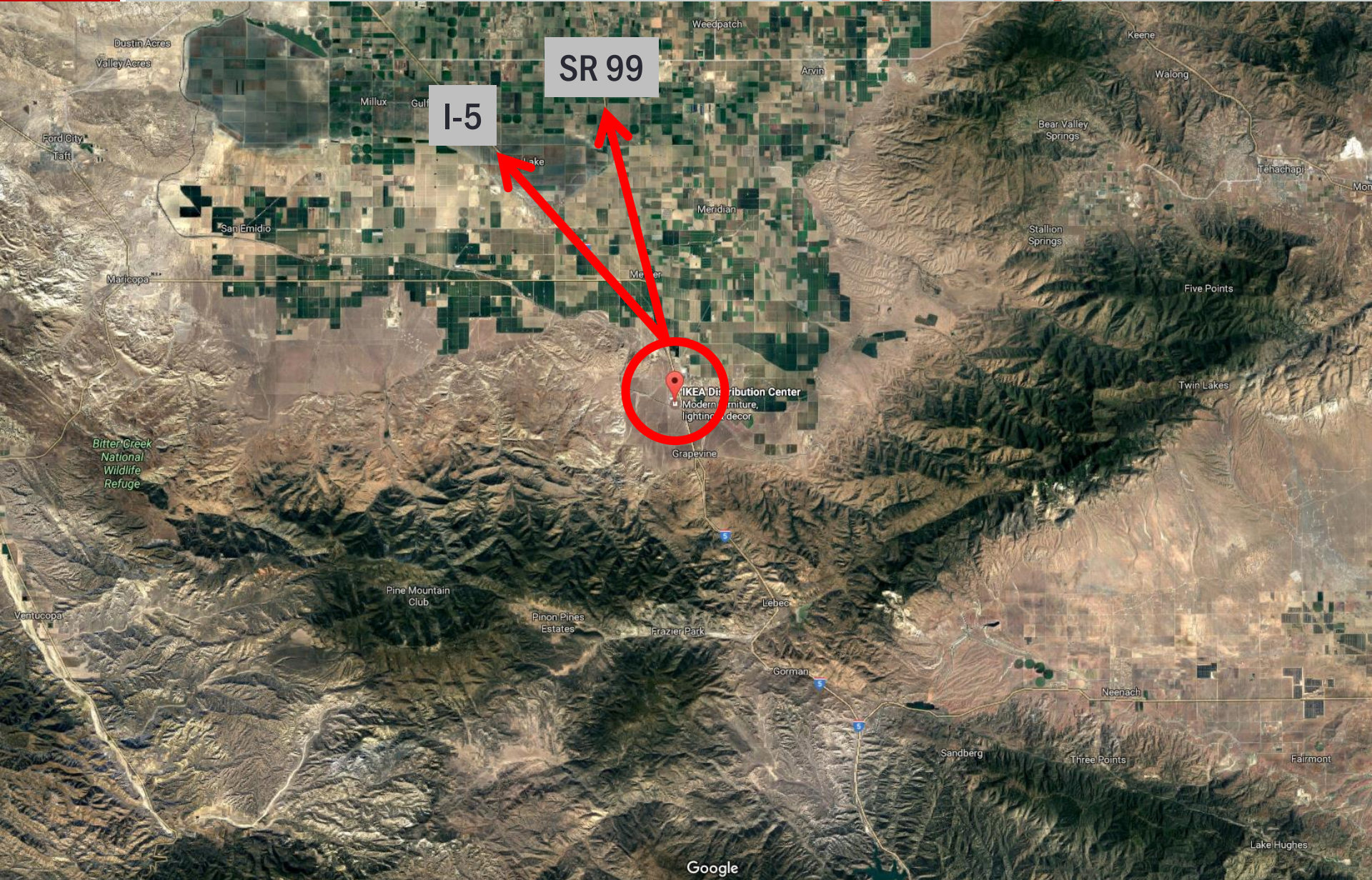
# Ikea Distribution Center (2001)



This DC and another in Seattle WA cover the entire West Coast

Built in 2001  
1.8 million ft<sup>2</sup>

# Ikea Distribution Center (2001)

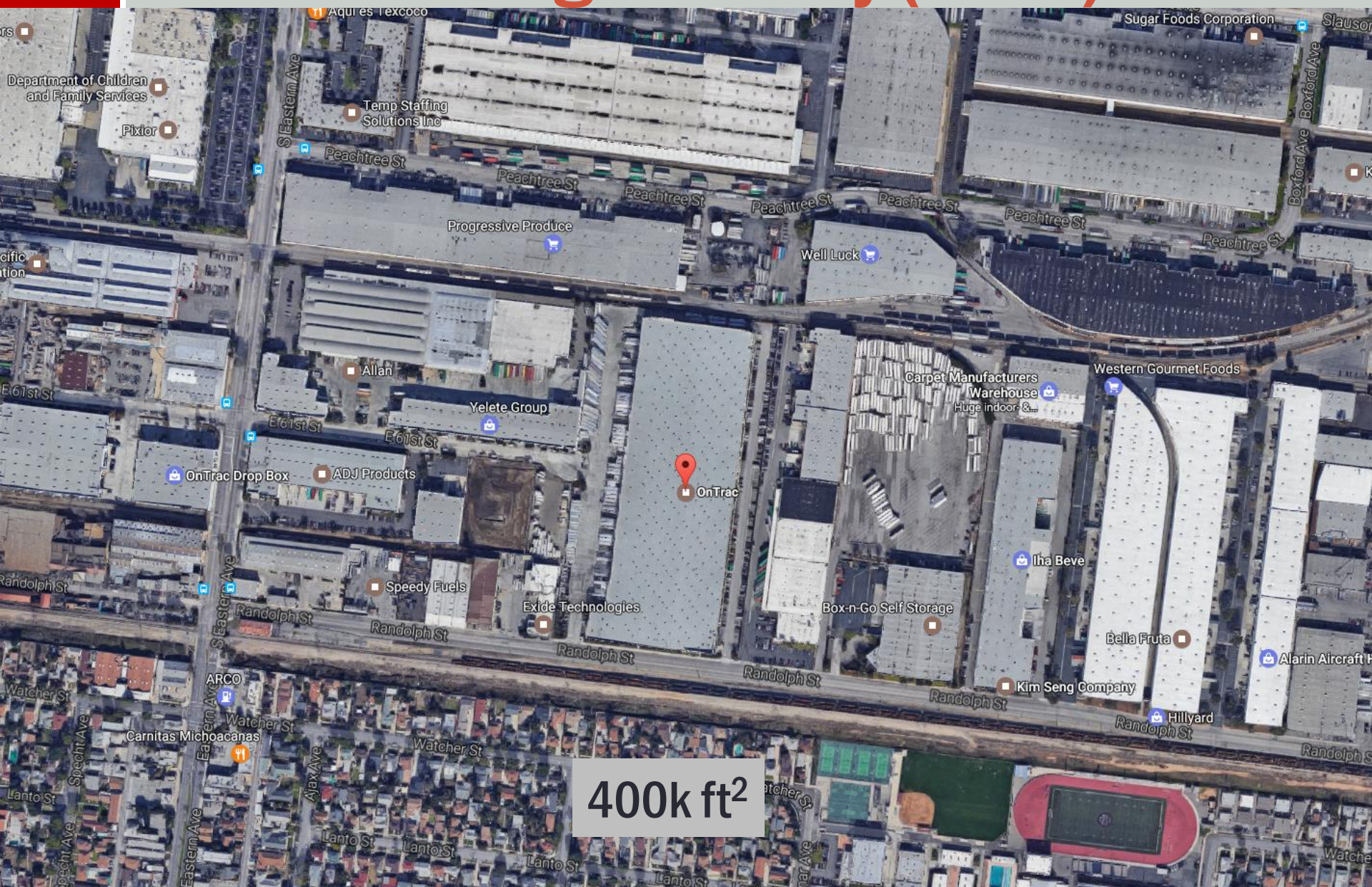


# Ikea Distribution Center (2001)



110 miles via I-710 & I-5  
2-3 hour driving from POLA

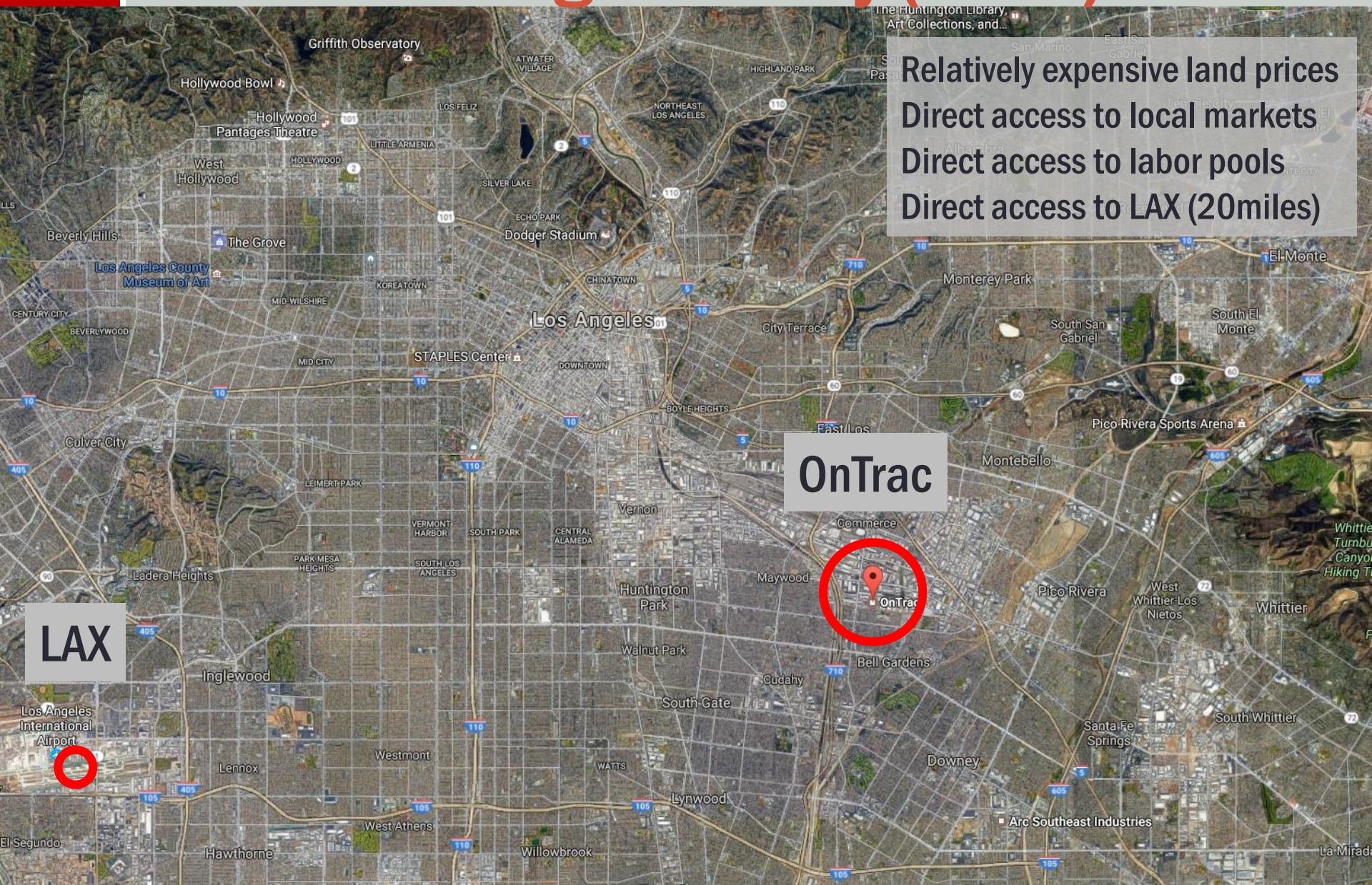
# OnTrac Package Delivery (2009)



400k ft<sup>2</sup>



# OnTrac Package Delivery (2009)



- Relatively expensive land prices
- Direct access to local markets
- Direct access to labor pools
- Direct access to LAX (20miles)

**OnTrac**

**LAX**

## 2-1. Changes in Location

“...relocation and concentration of logistics facilities  
toward suburban areas outside city centre boundaries”

Dablanc and Rakotonarivo (2010)

# Why do they decentralize?

- ❑ Economic restructuring
  - Globalized, geographically dispersed supply chains
  - Adv. in info/transport tech. – reduced transport costs
  - Adv. 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 warehouses
  - To transport larger volumes of goods more frequently and reliably
  - Mega distribution center and automation
- ❑ Land price and availability
  - Low rent, large parcels, and favorable zoning

# Why should we care?

- ❑ Warehousing decentralization and clustering
  - Location shifts from central areas to suburban/exurban areas
  - Concentration: counties with rich transport infrastructure
- ❑ Warehouse as a truck trip generator
  - If farther from markets, more travel miles, greater impact
  - Congestion, increased fuel consumption, air pollution, noise, vibration, infrastructure damage, environmental justice
- ❑ Warehouse as mobile sources
  - Diesel particulate matter from trucks at warehouses/DCs

# Research Gap

Evaluation of	Comparison	Hypothesis Test	Literature?
Distribution changes	From t-1 to t	$H_0: D_t - D_{t-1} = 0$	Multiple locations: Several Multidimensional aspect: No Statistical testing: Just a few
Location choice factors	Cross-section	$H_0: \beta \text{ of factor } i = 0$	Multiple locations: Just a few Facility characters: Limited Location character: Several
Changes in location choice factors	From t-1 to t		None

# Data

# Warehousing Location and Character.

## ❑ CoStar

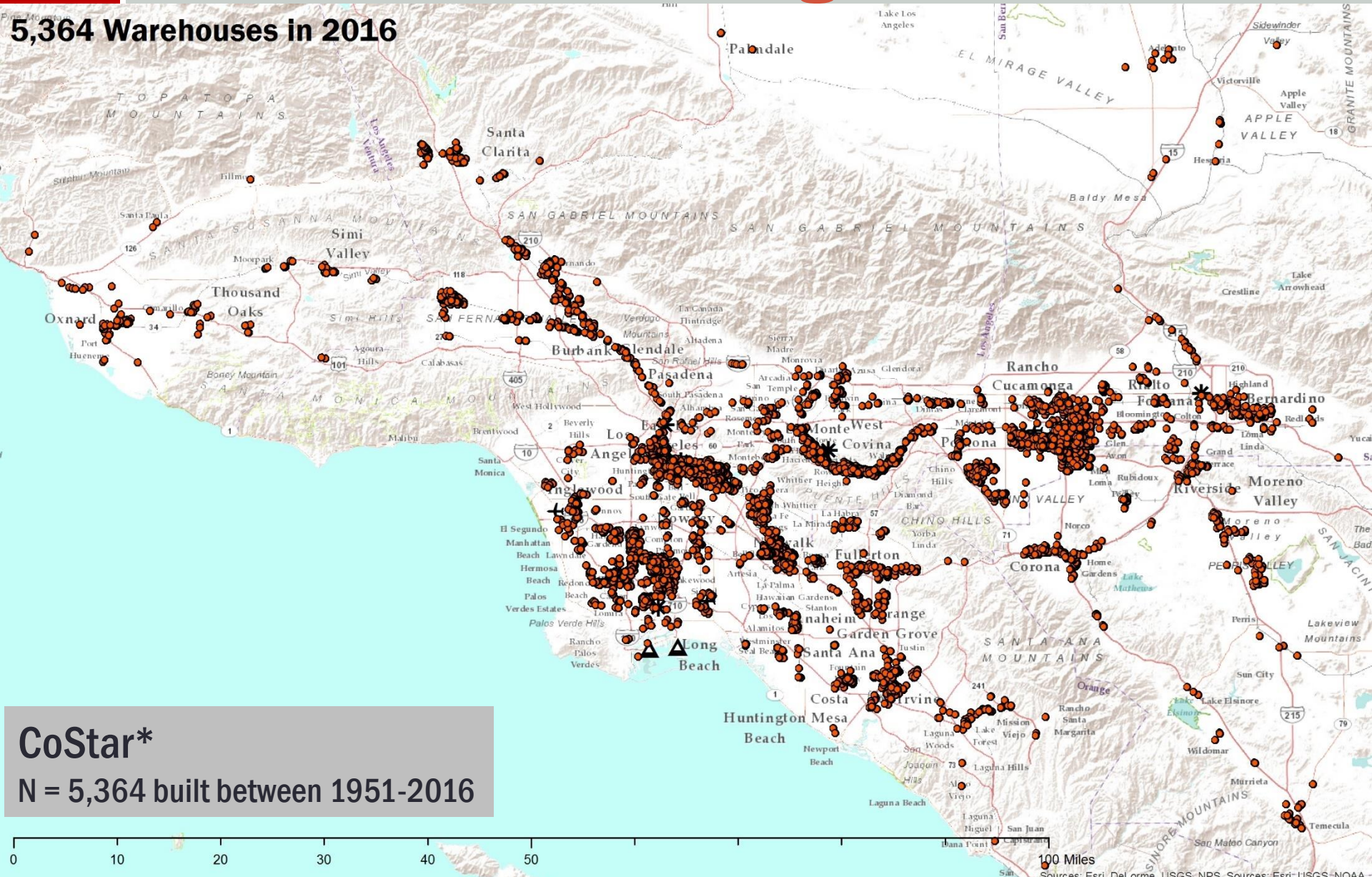
- Industrial real estate listings
- Warehouses, truck terminals, distribution centers, or cold storages
- Address, rentable building area (RBA), year of construction, N of loading docks, N of floors
- No retrospective analysis; if demolished, left market: not available

## ❑ What we have:

- 5,364 facilities (existed in 2016)
- RBA > 30,000 ft<sup>2</sup>
- Year of construction between 1951 and 2016

# Warehouses in Los Angeles

5,364 Warehouses in 2016



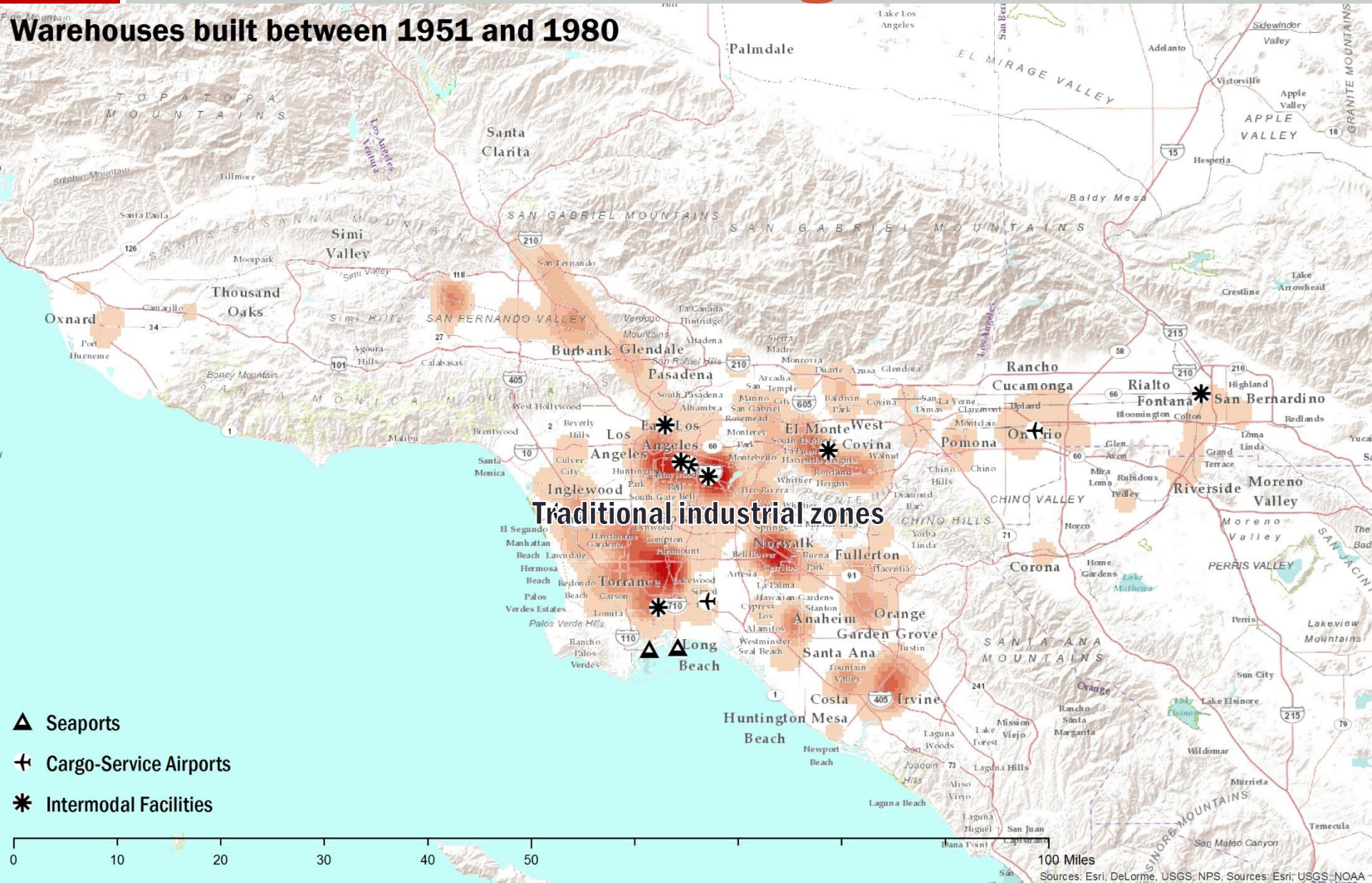
CoStar\*

N = 5,364 built between 1951-2016



# Warehouses in Los Angeles

Warehouses built between 1951 and 1980

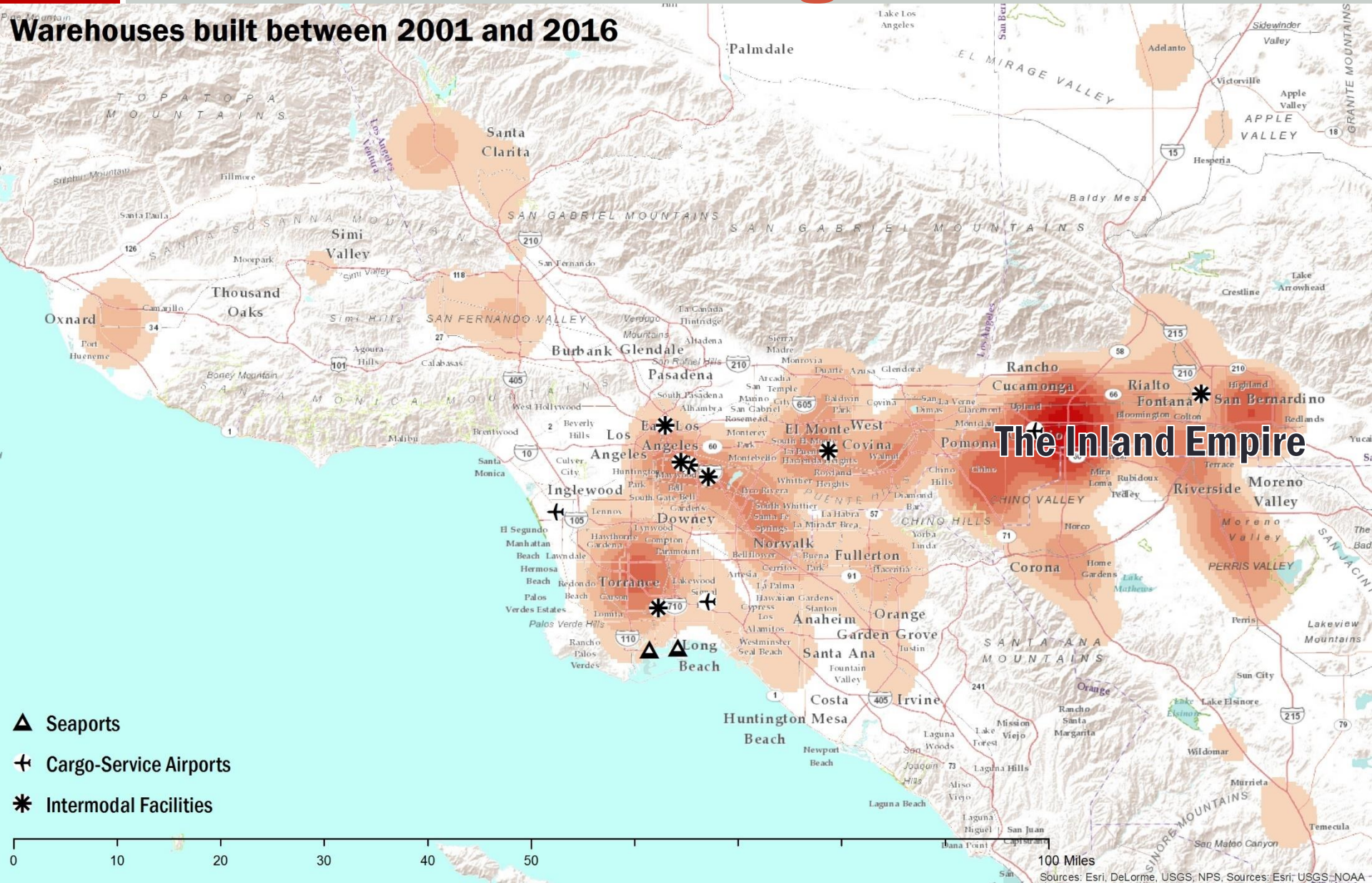


Traditional industrial zones

- ▲ Seaports
- ✈ Cargo-Service Airports
- \* Intermodal Facilities

# Warehouses in Los Angeles

## Warehouses built between 2001 and 2016

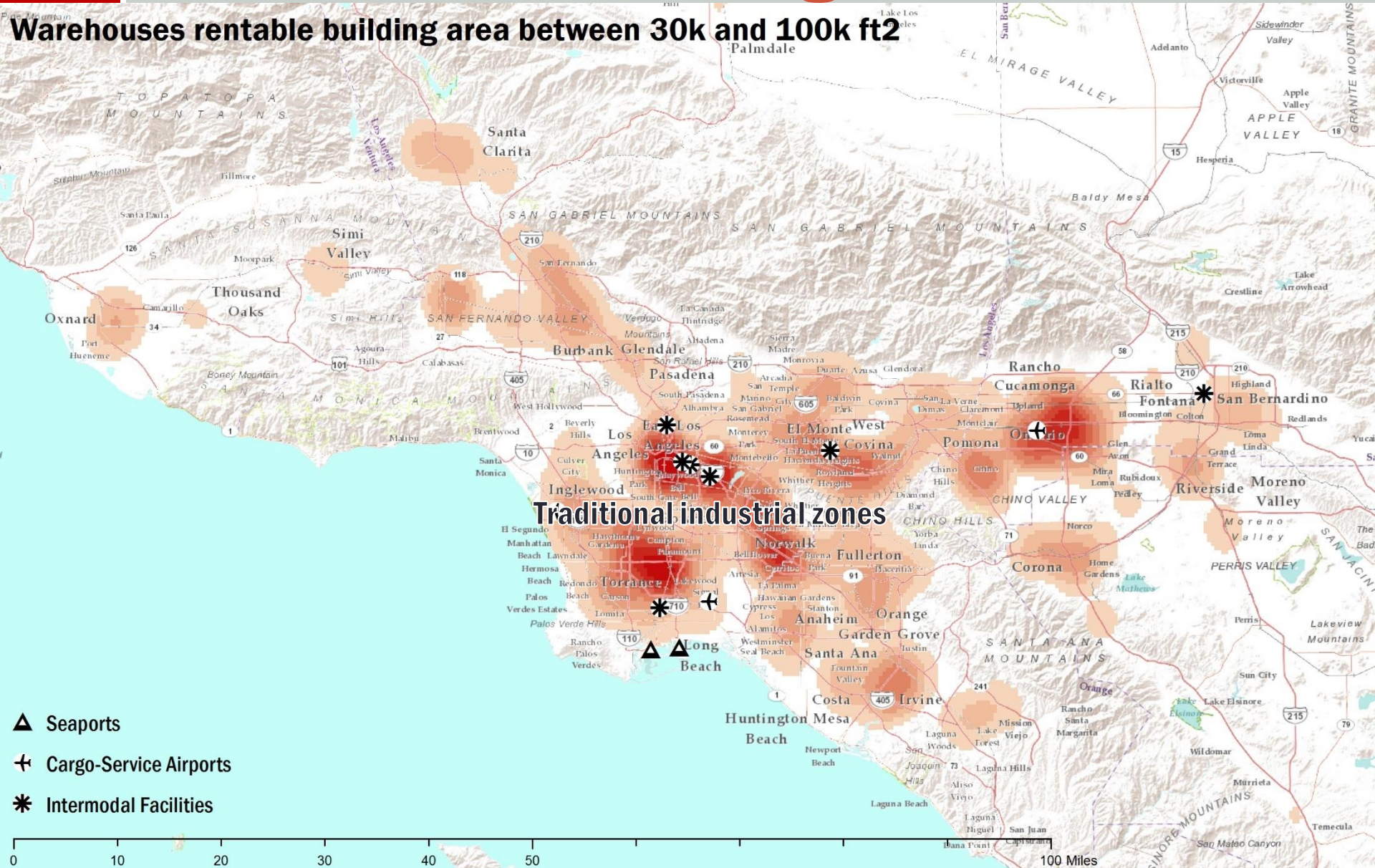


**The Inland Empire**

- ▲ Seaports
- ✈ Cargo-Service Airports
- \* Intermodal Facilities

# Warehouses in Los Angeles

Warehouses rentable building area between 30k and 100k ft<sup>2</sup>



Traditional industrial zones

- ▲ Seaports
- + Cargo-Service Airports
- \* Intermodal Facilities

# Warehouses in Los Angeles

Warehouses rentable building area over 300k ft<sup>2</sup>

- Evident decentralization
- Correlation between size and built year

The Inland Empire

- ▲ Seaports
- ✈ Cargo-Service Airports
- \* Intermodal Facilities



## 2-2. Changes in Location Factors

# Research Approach – Discrete Choice

- ❑ Structure – Firm location choice
  - The choice of a location entails an unobservable profit  $X$
  - **Facility** and **Location** characteristics jointly influence the profit
  - Choice of A over B is made if/only if  $\text{Profit A} > \text{Profit B}$
  - Multinomial models
- ❑ Design of choice sets
  - Cannot evaluate every single choice
  - Independence of irrelevant alternatives (heterogeneity between choices)
  - Cluster analysis using location characteristics (Ward's linkage)
  - Location characteristics to describe each location choice
  - From 660 census tracts (minimum 1 facility) to **seven choice sets**

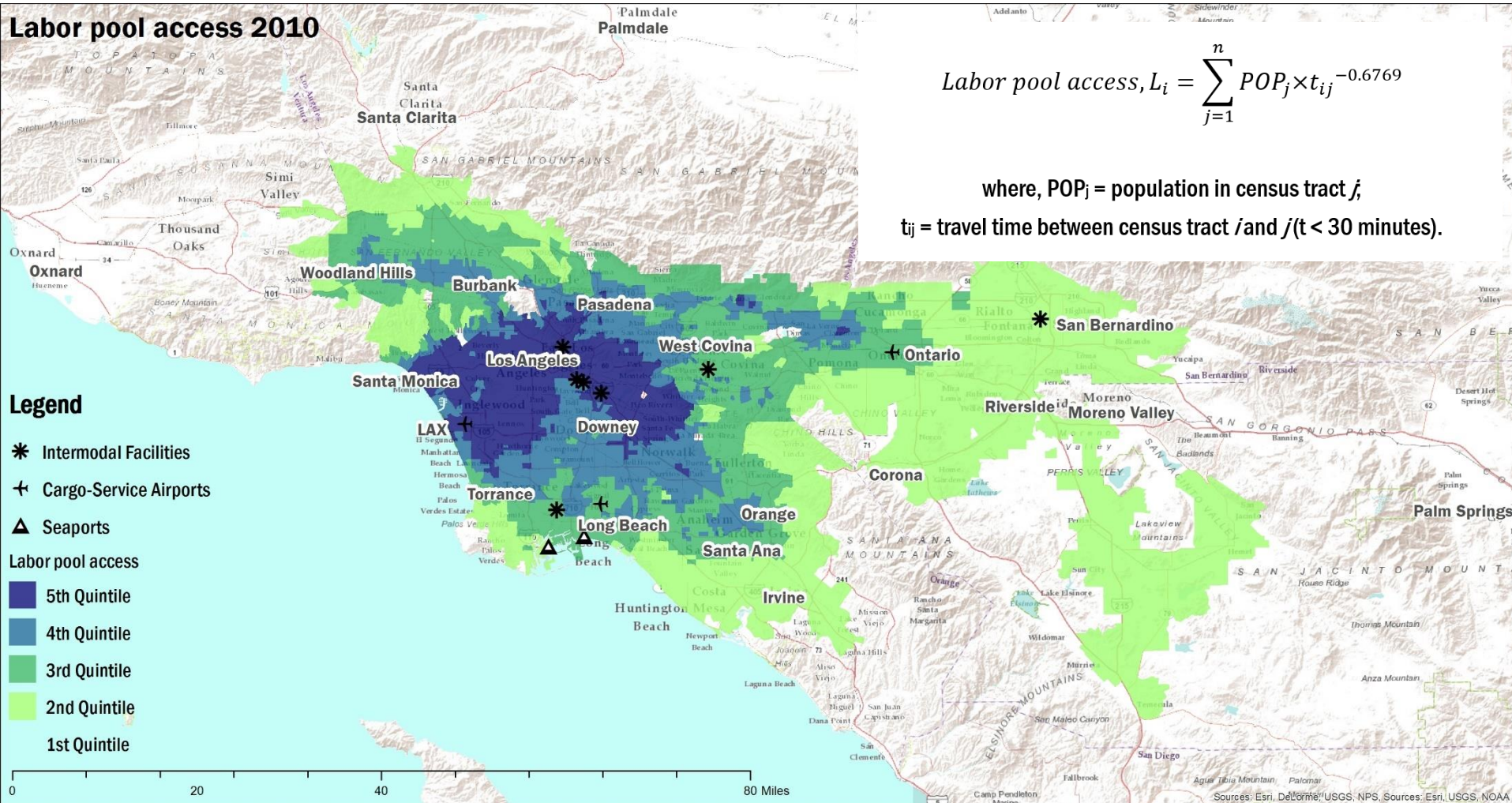
# Design of Location Choice Sets

Location factors	Definition
Land price	Population and employment densities in 2010, as proxies (Clark, 1951; McDonald, 1989)
Labor pool access	Sum of population (2010) with an inverse travel-time weight within 30 min driving distance
Proximity to local markets	Driving time to the <u>nearest</u> employment sub-centers (Giuliano and Small, 1991)
Proximity to Transport nodes	Driving time to the <u>nearest</u> airport, seaport, intermodal terminals Distance to the nearest highway ramps

\*Travel time is calculated based on the SCAG Regional Transportation Plan 2012 database  
Using ArcGIS Network Analysts

# Location Characteristics

## Labor pool access 2010



$$\text{Labor pool access, } L_i = \sum_{j=1}^n \text{POP}_j \times t_{ij}^{-0.6769}$$

where, POP<sub>j</sub> = population in census tract *j*,  
 t<sub>ij</sub> = travel time between census tract *i* and *j* (t < 30 minutes).

### Legend

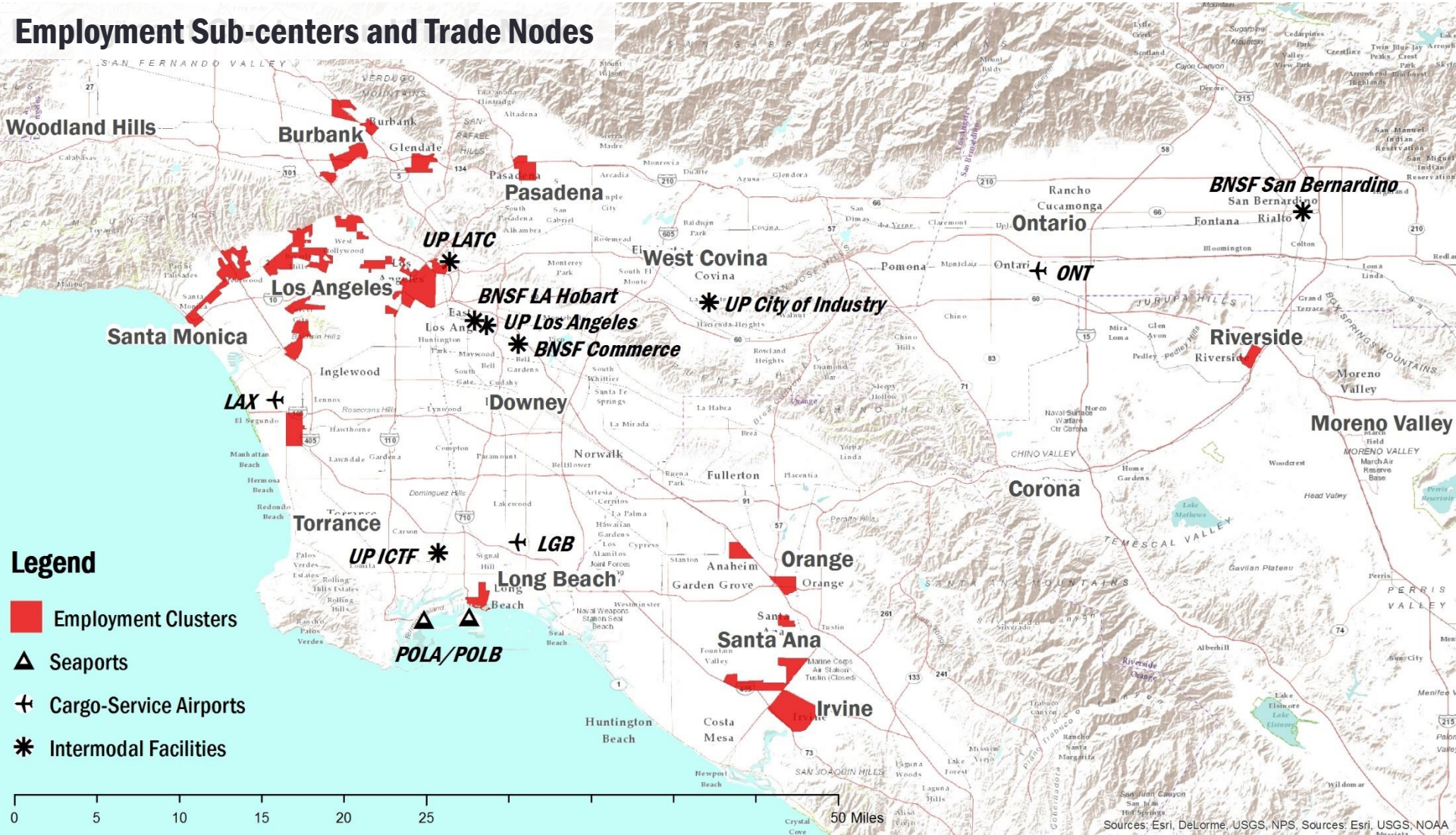
- \* Intermodal Facilities
- ✈ Cargo-Service Airports
- ▲ Seaports
- Labor pool access
- 5th Quintile
- 4th Quintile
- 3rd Quintile
- 2nd Quintile
- 1st Quintile

Sources: Esri, DeLorme, USGS, NPS, Sources, Esri, USGS, NOAA

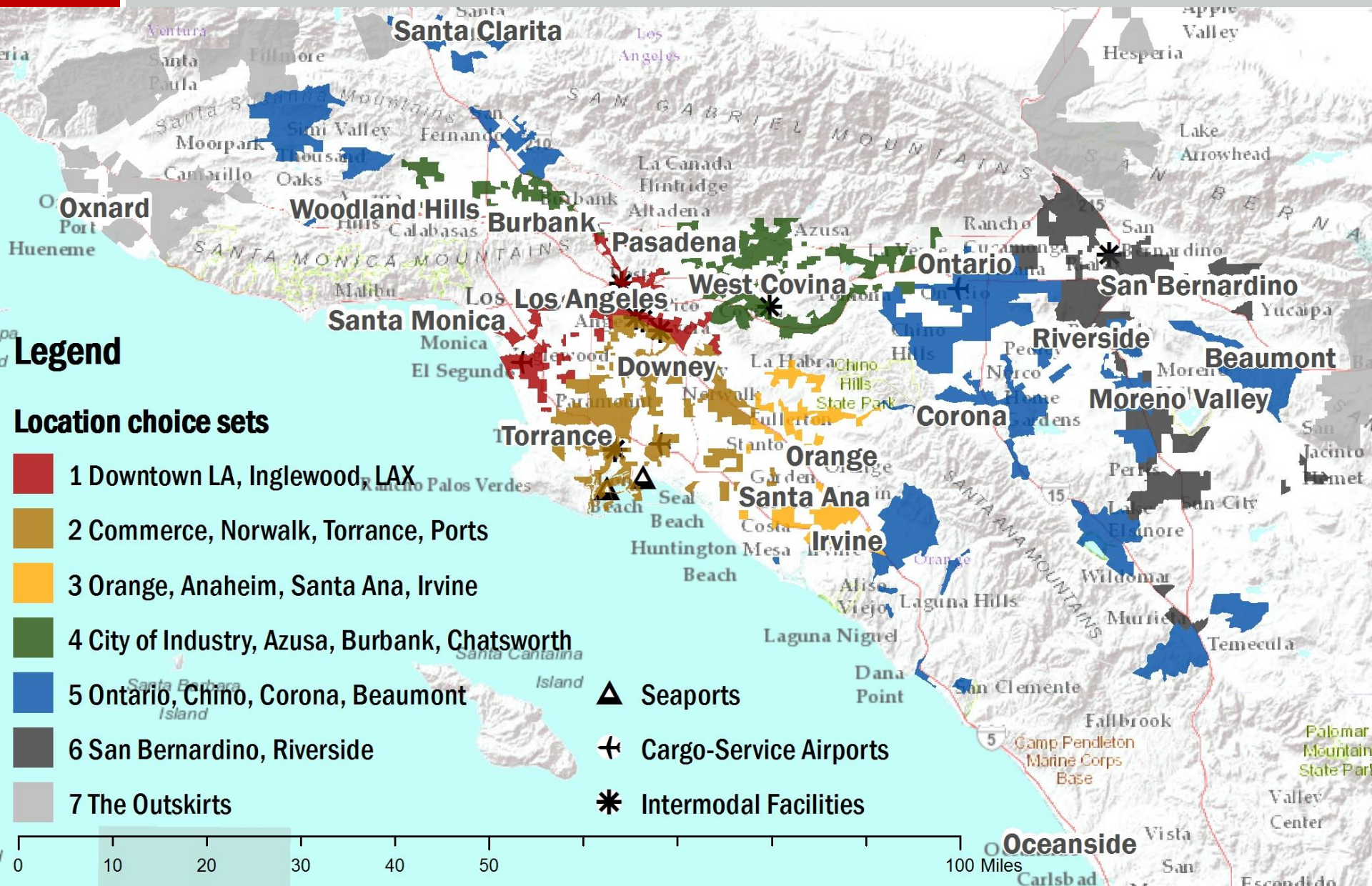


# Location Characteristics

## Employment Sub-centers and Trade Nodes



# Location Choice Sets



## Legend

### Location choice sets

- 1 Downtown LA, Inglewood, LAX
- 2 Commerce, Norwalk, Torrance, Ports
- 3 Orange, Anaheim, Santa Ana, Irvine
- 4 City of Industry, Azusa, Burbank, Chatsworth
- 5 Ontario, Chino, Corona, Beaumont
- 6 San Bernardino, Riverside
- 7 The Outskirts

- Seaports
- Cargo-Service Airports
- Intermodal Facilities

# Characteristics of Location Choice Sets

Loc. Sets	Location (N)	Land price	Labor pool access	Proximity to local market	Proximity to trade node
1	Downtown LA, East LA, Culver City, Inglewood, LAX (99)	High	High	Very close	Very close
2	Commerce, Vernon, Norwalk, Carson, Torrance, Ports (147)	Average	High	Far	Very close
3	Orange, Anaheim, Santa Ana, Irvine (50)	Average	Low	Average	Far but to seaports
4	[BASE] City of Industry, Azusa, Burbank, Chatsworth (132)	Average	Average	Average	Average
5	Ontario, Chico, Corona, Beaumont (114)	Low	Low	Far	Far
6	San Bernardino, Riverside (62)	Low	Low	Far but Riverside	Far but to inter-modal
7	The outskirts (56)	Very low	Very low	Very far	Far

# Research Approach – Discrete Choice

## □ General model

- Probability of a facility (i) to be located in 1 of 6 choice sets (j) over the base outcome (#4) is a function of facility characteristics (X)

- Multinomial logit

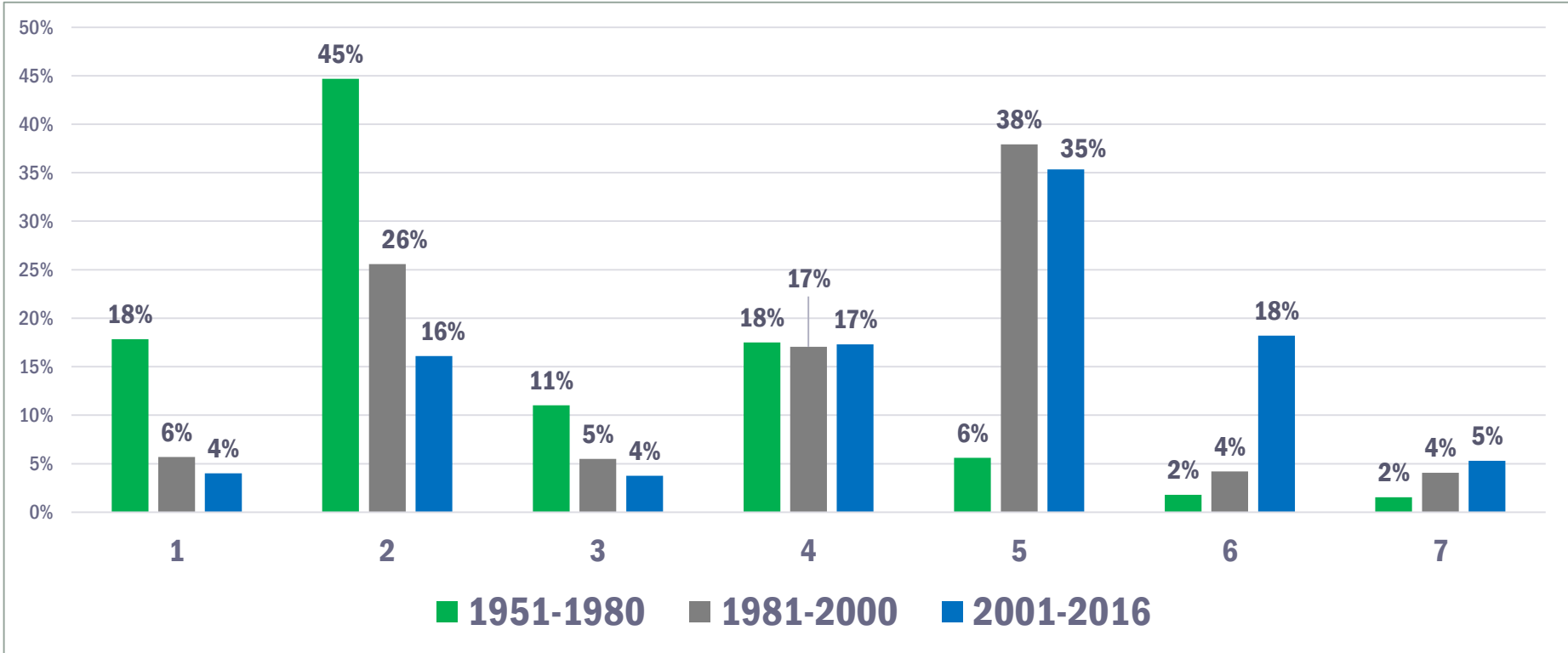
$$p_{ij} = Pr(y_i = j) = F_j(X_i, \theta)$$

- **Var1:** Rentable building area as a continuous variable
  - As a proxy for economies of scale
- **Var2:** Built year as a categorical variable: 3 periods
  - 1) 1951-1980; 2) 1981-2000 (base); 3) 2001-2016
- **Stepwise models**
  - Var1
  - Var1 + Var2

\*Count data model

# Results

# Share of Warehouses by Built Year



Downtown LA  
Inglewood  
LAX

Commerce  
Norwalk  
Torrance  
Ports

Orange  
Anaheim  
Santa Ana  
Irvine

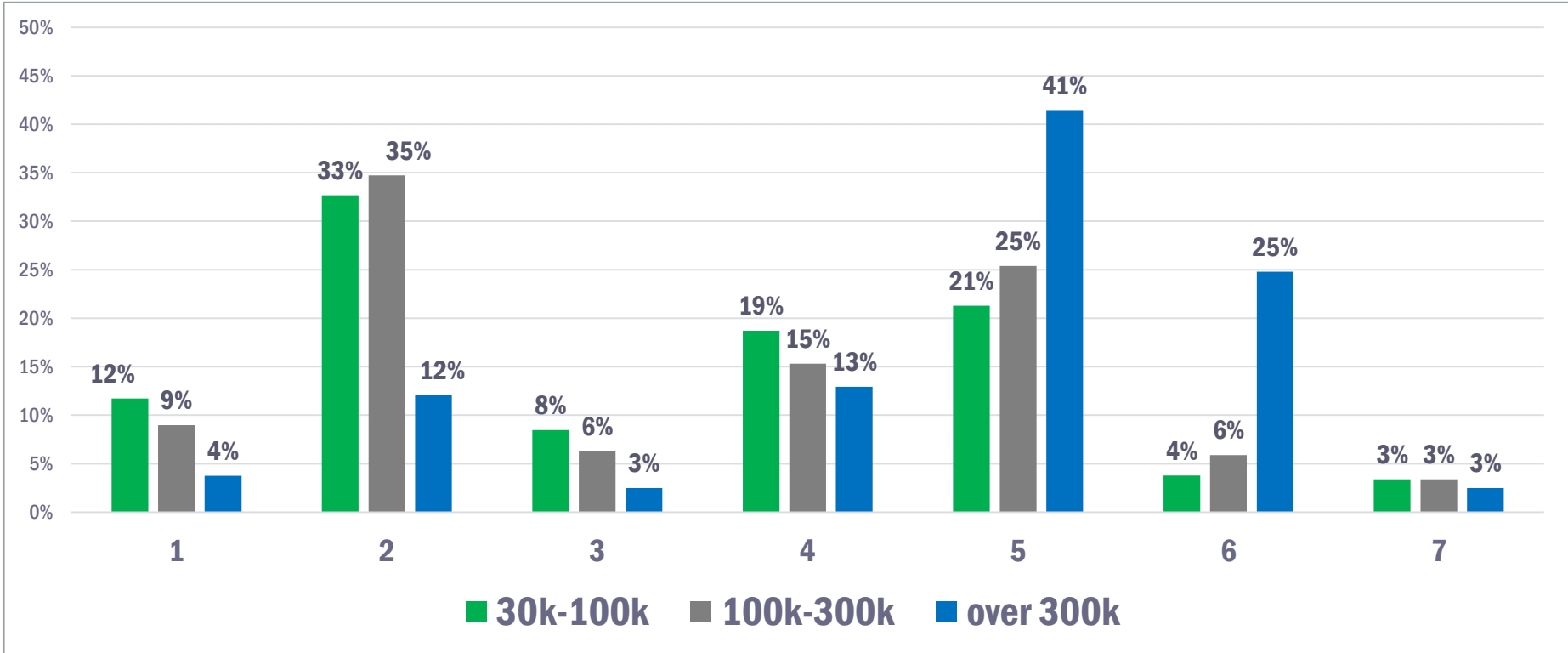
City of Industry  
Azusa  
Burbank  
Chatsworth

Ontario  
Chino  
Corona  
Beaumont

San Bernardino  
Riverside

The  
Outskirts

# Share of Warehouses by Size



Downtown LA  
Inglewood  
LAX

Commerce  
Norwalk  
Torrance  
Ports

Orange  
Anaheim  
Santa Ana  
Irvine

City of Industry  
Azusa  
Burbank  
Chatsworth

Ontario  
Chino  
Corona  
Beaumont

San Bernardino  
Riverside

The  
Outskirts

# Multinomial Logit Results

Multinomial			Model 1 $\beta$	Model 2 $\beta$	
1 Downtown LA-LAX	SIZE	Log(RBA)	-0.304 **	-0.213 **	
	YEAR	1951-1980		1.098 **	
		1981-2000	(base period)		
		2001-2016			-0.326
		Constant	2.872 **	1.282	
2 South LA-Port	SIZE	Log(RBA)	0.008	0.087	
	YEAR	1951-1980		0.541 **	
		2001-2016			-0.497 **
		Constant	0.505	-0.571	
3 Orange-Anaheim	SIZE	Log(RBA)	-0.186 *	-0.115	
	YEAR	1951-1980		0.662 **	
		2001-2016			-0.375
		Constant	1.226	0.150	
4 City of Industry	(base outcome)				

(\*\* if P < 0.01; \* if P < 0.05)



# Multinomial Logit Results

Multinomial			Model 1 $\beta$	Model 2 $\beta$
5 Ontario-Corona	SIZE	Log(RBA)	0.414 **	0.318 **
	YEAR	1951-1980		-1.900 **
		2001-2016		-0.172
		Constant	-4.369 **	-2.796 **
6 SB-Riverside	SIZE	Log(RBA)	1.005 **	0.757 **
	YEAR	1951-1980		-0.773 **
		2001-2016		1.184 **
		Constant	-12.669 **	-10.073 **
7 The outskirts	SIZE	Log(RBA)	0.046	-0.040
	YEAR	1951-1980		-0.991 **
		2001-2016		0.263
		Constant	-2.175	-0.987
Pseudo R2			0.020	0.089
Log likelihood			-9,050.6	-8,410.28
N			5,364	5,364

(\*\* if P < 0.01; \* if P < 0.05)

# Multinomial Logit Results

Multinomial			$\beta$	Sig.
5 Ontario-Corona	SIZE	Log(RBA)	0.318	**
	YEAR	1951-1980	-1.900	**
		2001-2016	-0.172	
		Constant	-2.796	**

## Ontario, Chico, Corona, Beaumont

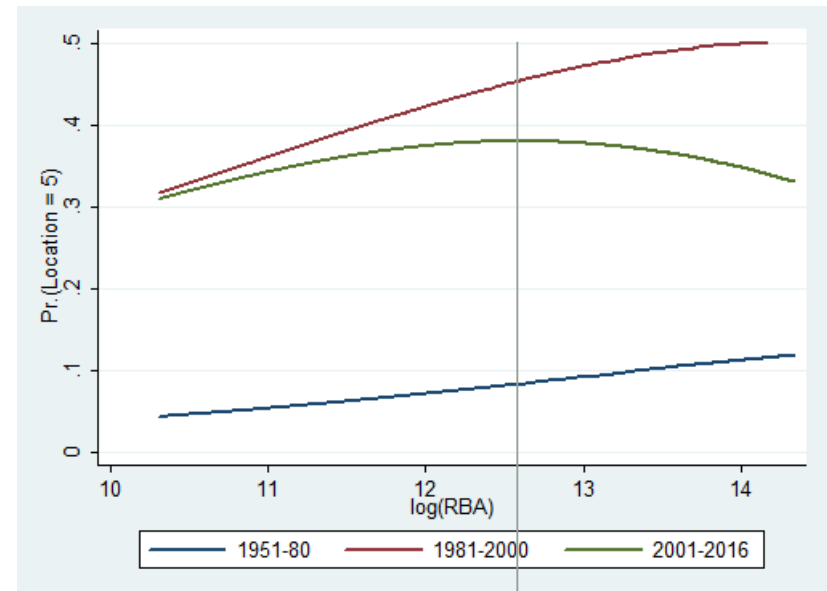
Land Price Low

Labor pool access Low

Proximity to local markets Far

Proximity to trade nodes Far

Marginal effect



Exp(12.6) = 300k ft<sup>2</sup>



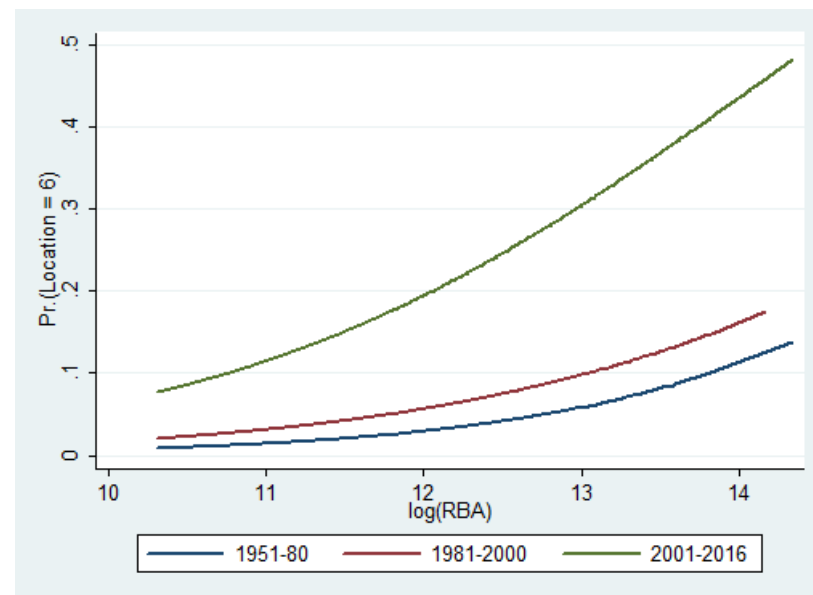
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Volvo Center of Excellence

# Multinomial Logit Results

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6 SB-Riverside	SIZE	Log(RBA)	0.757	**
	YEAR	1951-1980	-0.773	**
		2001-2016	1.184	**
		Constant	-10.073	**

San Bernardino, Riverside	
Land Price	Low* Lower than #5
Labor pool access	Low* Higher than #5
Proximity to local markets	Far but Riverside
Proximity to trade nodes	Far but to intermodal

Marginal effect



# Summary of Results

- ❑ **Discrete choice model: compared to be locating in #4:**
  - Different location choice by size and built year
  - Larger warehouses are more likely to be in #5 and #6.
  - Newer warehouses are more likely to be in #5 and #6.
  - #5, popular since 1981-2000; whereas #6, popular since 2001
- ❑ **Changes in factors? (relative to #4)**
  - Land prices (-)
  - Labor pool access (-); Local market access (-); Transport access: (-)
- ❑ **Cost rebalances?**
  - Facility & inventory costs: (-) (land prices, scale economies)
  - Transport costs: (+)

# Discussion

- ❑ **Transportation costs**
  - **Many operational aspects to consider at the facility level**  
(Vehicle types, shipment origin/destination, routing, time of operation)
  - **Shipment consolidation through centralized facilities**
  - **Gains from operational efficiency might offset negative impacts**  
(Kohn and Brodin, 2008; Dhooma and Baker, 2012)
  
- ❑ **Expansion and concentration of large-scale warehouses**
  - **Major truck travel generator**
  - **Concentration of negative impacts**
  - **Environmental justice**

# Conclusion and Future Research

## □ Conclusion

- Recent warehouses have prioritized lower land prices and economies of scale over labor pool, local market, and transport access
- Cost tradeoffs between land prices and transport costs

## □ Future Research

- Truck VMT?
- The rise in e-commerce, instant delivery and warehouse location

# Thank you!

## Sanggyun Kang

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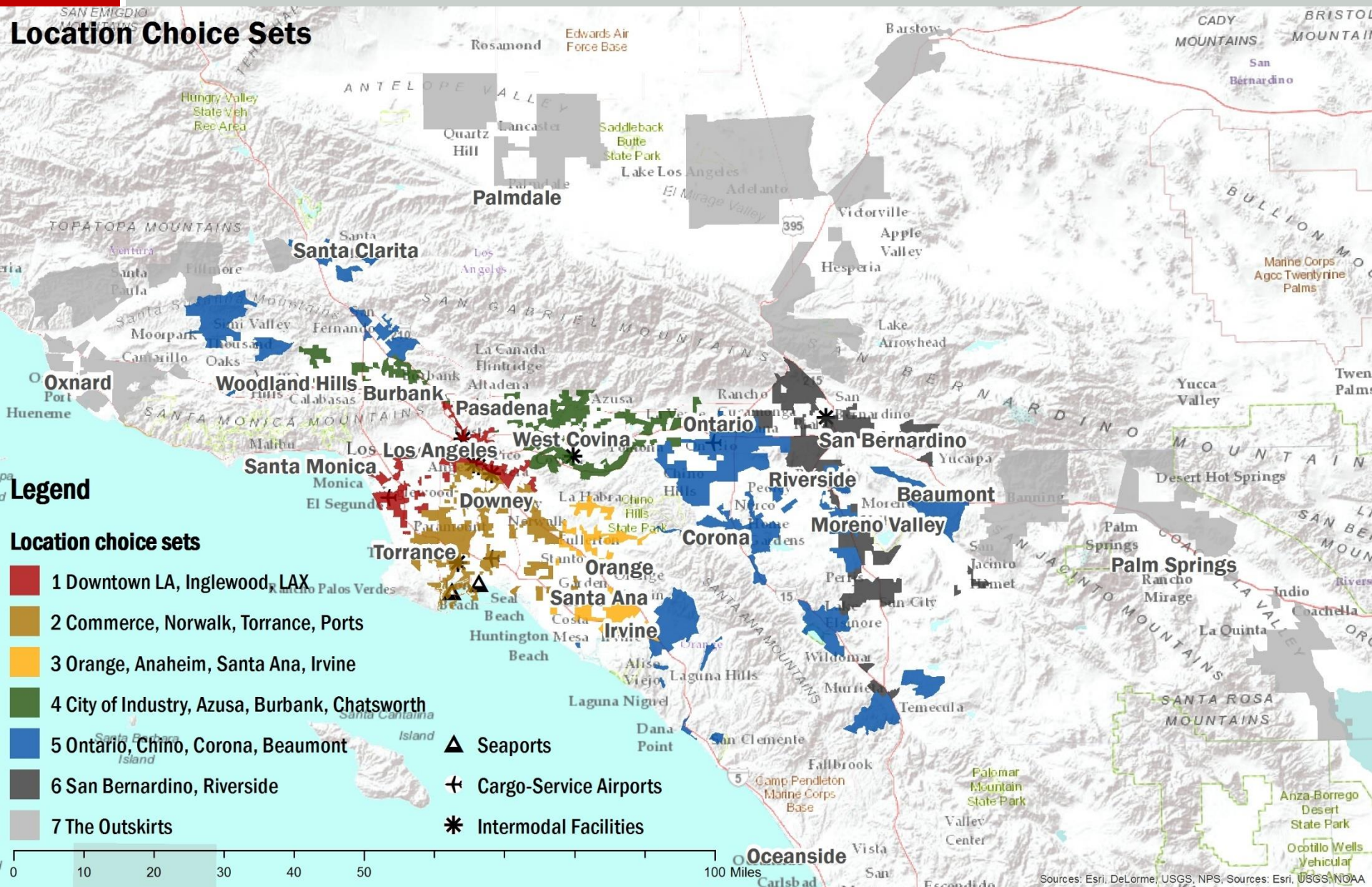
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Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA