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E-commerce, Warehousing and Distribution Facilities in California: A Dynamic Landscape and the Impacts on Disadvantaged Communities

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UNIVERSITY OF CALIFORNIA

E-commerce, Warehousing and Distribution Facilities in California: A Dynamic Landscape and the Impacts on Disadvantaged Communities

A Research Report from the University of California Institute of Transportation Studies

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16. Abstract

This work addresses the distribution of warehouses and distribution centers (W&DCs) influenced by e-commerce, through spatial analysis and econometric modelling. Specifically, this work analyzes the concentration of W&DCs in various metropolitan planning organizations (MPOs) in California between 1989 and 2016-18; and studies the spatial relationships between W&DC distribution and other demographic and environmental factors through econometric modeling techniques. The work conducts analyses to uncover common trends in W&DC distribution. The analyses used aggregate establishment, employment, and other socio-economic information, complemented with transportation related variables. The results: 1) confirm that the weighted geometric centers of W&DCs have shifted slightly towards city central areas in all five MPOs; 2) W&DCs show a non-decreasing trend between 2008 and 2016; and 3) areas with more serious environmental problems are more likely to have W&DCs. A disaggregate analyses of properties sold and leased in one of the study regions shows a trend where businesses are buying or leasing smaller facilities, closer to the core of consumer demand. Among other factors, the growth of e-commerce sales, and expedited delivery services, which require proximity to the customers, may explain these trends. The study results provide insights for planners and policy decision makers, and will be of interest to practitioners, public and private entities, and academia. Caltrans, MPOs, and affiliated institutions of the National Center for Sustainable Transportation will directly benefit from the results as they want to avoid equity issues brought by the fast development of e-commerce, and its potential impact on W&DC distribution.

17. Key Words Warehouses, freight terminals, logistics, e-commerce, freight traffic, urban sprawl, social equity, disadvantaged communities	**18. Distribution Statement** No restrictions.

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E-commerce, Warehousing and Distribution Facilities in California: A Dynamic Landscape and the Impacts on Disadvantaged Communities

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January 2020

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Executive Summary

Several factors including facility automation, reduced transportation costs, increased demand, and e-commerce have changed the logistics landscape in the last few decades. These, among other factors, have affected the way companies operate, and how they design their distribution networks, thus affecting decisions regarding the location of logistics facilities along the supply chain, especially, the warehouses and distribution centers (W&DCs).

Considering the factors that companies have traditionally considered when deciding the locations of these facilities (e.g., proximity to transportation infrastructure, land value and availability) resulted in the logistics sprawl phenomenon. This was the case in Southern California and the booming of the Inland Empire. However, there is evidence that because of some of the current market changes (retail and distribution channels), companies may need to locate closer to the customers, with an opposite effect to the previous sprawl behavior. The extent of this phenomenon is not clear, in terms of its magnitude or the potential impacts. To this effect, the objectives of this research are: 1) to understand the changes in the geographic distribution of freight facilities (warehouses and distribution centers [W&DCs]), and identify trends in those changes; 2) to quantify the casual interrelations between the various stakeholders (e.g., facilities, disadvantaged and low-income communities); and, 3) to discuss the potential impacts on vehicles miles traveled (VMT) and the associated environmental impacts due to changes in facility location and distribution patterns.

This research concentrates on spatial aggregate analyses (centrographic and spatial correlation) and disaggregate analyses (e.g., market analysis and evaluation of properties sold and leased) of the distribution of W&DCs. The aggregate analyses concentrated on the counties under the 5 largest Metropolitan Planning Organizations (MPOs): the Southern California Association of Governments (SCAG), Metropolitan Transportation Commission (MTC), Sacramento Area Council of Governments (SACOG), San Joaquin Council of Governments (SJCOG), and San Diego Association of Governments (SANDAG). The study analyzes the relationship between W&DCs and communities of concern using the environmental score (CalEnviroScreen 3.0) provided by the Office of Environmental Health Hazard Assessment (OEHHA), on behalf of the California Environmental Protection Agency (CalEPA). Disaggregate analyses focused on the real estate markets in Southern California. These include the Los Angeles (Los Angeles and Ventura County), Inland Empire (Riverside and San Bernardino County), Orange (Orange County), and San Diego (San Diego County) markets.

The aggregate analyses show an obvious increase over the last decade of W&DCs number in the four MPOs, with spatial concentrations closer to the downtown areas in recent years, especially in MTC and SCAG. Moreover, the study found spatial correlation between W&DCs and other industry establishments (e.g., manufacturing, warehousing, food services), especially in the SJCOG.

The analyses of the interrelations between the concentration of facilities and the CalEnviroScreen 3.0 showed a positive but small correlation between the number of W&DCs in a zip code area and the environmental indexes. This trend shows that W&DCs are likely to be sited in areas with serious pollution concern for all MPOs, though it is not clear whether W&DCs are the main cause of such pollution. These areas with higher environmental scores are more likely to be disadvantaged areas, also defined by the OEHHA. The correlation between an area having W&DCs and higher environmental indexes was most significant in SCAG, where there are many areas with higher environmental scores or with serious environmental pollution. However, MTC, SACOG, and SANDAG are regions with much fewer areas with serious environmental problems.

The disaggregate analyses for the Southern California markets, confirmed the general trends. In recent years, the median distance from facilities to the downtown areas have decreased, as well as the median facility sizes transacted (sold or leased). Moreover, the number of transactions in areas closer to the downtowns has increased compared to those further away (though larger facility transactions). Specially, during the last decade. It is expected that the changes in the distribution of W&DCs may intensify congestion in and around facilities, and environmental emissions). For example, If the amount of cargo is considered constant (though demand is increasing, especially for e-commerce), the use of more and smaller facilities will result in more freight traffic. While newer and cleaner vehicle technologies will be able to mitigate some of the impacts, increased traffic will have a negative effect on congestion, energy consumption, and accessibility, especially at the curb level.

The econometric modeling showed that some of the factors explaining the location of W&DCs are characteristic of areas identified as disadvantaged communities. The number of W&DCs positively correlated with indexes of environmental impact, although not for all criteria pollutants.

Overall, the dynamic landscape must be considered and further explored in planning efforts. Regional and local authorities must evaluate land use, building, and air quality strategies to mitigate such impacts.

Glossary

CalEPA	California Environmental Protection Agency
CS	CalEnviroScreen
DAC	disadvantaged communities
IE	Inland Empire
MPO	Metropolitan Planning Organization
MTC	Metropolitan Transportation Commission
NAICS	North American Industrial Classification Standards
OEHHA	Office of Environmental Health Hazard Assessment
POLA	Port of Los Angeles
PM	particulate matter
SACOG	Sacramento Area Council of Governments
SANDAG	San Diego Association of Governments
SCAG	Southern California Association of Governments
SJCOG	San Joaquin Council of Governments
W&DCs	warehouse and distribution centers
ZINB	zero-inflated negative binomial

Introduction and Background

In the last few decades, several factors have changed the logistics landscape, including facility automation, reduced transportation costs, increased demand, and e-commerce. E-commerce levels constitute only about 11% of total retail sales; in 2016, e-retail sales experienced a 15.1% increase from 2015 with a steady year over year growth (U.S. Census Bureau, 2017). However, the growth in e-commerce has already generated fundamental changes in the way companies do their logistics and manage their supply chains, from single-channel (i.e., in-store or online) to omni-channel distribution systems.

In traditional (single-channel in-store) distribution, retail and other stores located in urban areas, closer to customers, provided the channel for access to these products. Customers traveled to these locations (by individual trips or as a trip chain with others stops) during their daily activities. However, e-commerce (online retailing and omni-channel distribution) have erased spatial and temporal boundaries for shopping activities, and products are now available from any location and can be delivered to or purchased anywhere and anytime. Companies have adapted to customer requirements and implemented telecommunication systems offering a distribution and delivery service with no historical precedent (Visser and Nemoto, 2003). Today, there are companies that can reliably deliver products ordered online in less than one hour, and at very low (or even zero) cost to the customers. However, this fast pace and express delivery system have resulted in the distribution of smaller batches and retailing occurring at higher frequencies and shorter distances. Moreover, the distribution systems have to serve multiple demands of products from different consumers in alternate locations, times, and schedules. Table 1 compares the main characteristics between traditional and online retailing.

Although there may be circumstances where online retailing is environmentally beneficial compared to traditional retailing, the full impacts of the logistics decisions allowing for expedited delivery services are not completely understood (Weltevreden and Rietbergen, 2007; UPS, 2016). One of these decisions regards the location of logistics facilities along the supply chain, especially, the warehouses and distribution centers (W&DCs).

Recent research identified the factors that companies have traditionally considered when deciding on the locations of these facilities, such as proximity to transportation infrastructure, and value and availability of land and labor. In some locations, these factors pushed facilities further from the core of the markets, in a phenomenon known as logistics sprawl (Jaller et al., 2017), and there was a trend to open mega facilities with large capacities. This was the case in Southern California and the booming of the Inland Empire. However, the logistics decisions made in response to increased trends in e-commerce may have been changing these patterns during the last decade (Jaller and Pineda, 2017). Moreover, there is evidence of changes in supply chain decisions where e-fulfillment centers for rush deliveries are locating closer to denser areas (Jaller et al., 2017). The extent of this phenomenon is not clear, in terms of its magnitude or the specific communities affected by increased freight activity. Nevertheless, there is already a concentration of freight facilities in specific locations in California (see Figure

1, for example), and the movement of vehicles (mostly diesel trucks) to and from these facilities is affecting disadvantaged and low-income communities.

Table 1. Comparison between traditional retailing and online commerce

	Retail stores (inbound) delivery	In-store consumer purchase	Online retailing
Frequency of purchase	Low/Medium	Low/High	High
Volume or quantity of products	Large quantities	Medium/Small quantities	Small quantities
Goods flow	Delivered to retail stores and customers buy them there		Delivered to the customer's home, work, or alternative points
Supply chain	Push demand	Push demand	Pull demand
Information and communication tech.	B2B information to fulfill inventories (ERP)		B2C information and tracking of orders -> B2B
Delivery trucks/vehicles types	Larger trucks or trailers	Passenger vehicles	Medium and smaller trucks or vans, bicycles, or foot
Maximization of space (FTL/LTL)	FTL (homogeneous loads)	N/A (heterogeneous loads)	LTL (heterogeneous loads)
Location of delivery points	Urban and suburban	Urban and suburban	Residential, urban, and highly dense areas
No. delivery points in a tour	Few/One stops	Few/One stops	Many stops
Delivery failures	N/A	N/A	Many/Few

Source: Adapted from (Visser and Lanzendorf, 2004). Abbreviations: B2B, business to business; ERP, enterprise resource planning; B2C, business to consumer; FTL, full truckload; LTL, less than truckload.

In Southern California, for example, the counties under the Southern California Association of Governments (SCAG) lead the state in the number of W&DCs. In 2014, there were 1.2 billion sq. ft. of W&DCs, and around 62% of the area (approximately 4,900 buildings) were facilities larger than 50,000 sq. ft., mainly serving non-port related services (SCAG, 2016). Activities at port-related warehouses focus mainly on transloading, deconsolidation, and some value-added services. Many national and international companies have facilities in the area, especially in the Inland Empire region. Moreover, data from real estate firm CBRE shows that e-commerce has been responsible for large lease transactions in the country (see Figure 2), and evidence from e-retailers indicates that they are opening different types of facilities in different locations.

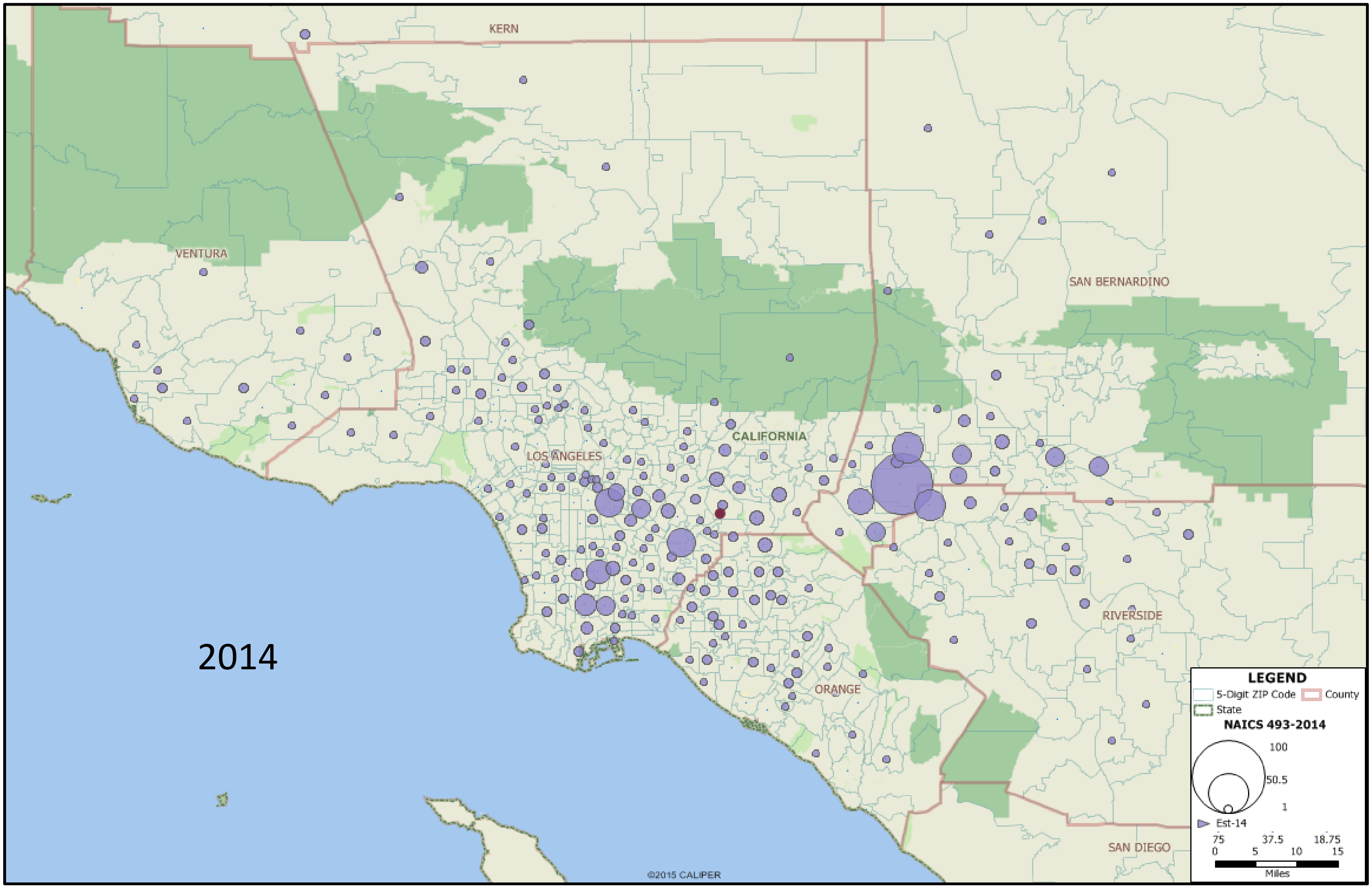

Figure 1. Concentration of warehouses and distribution centers in Southern California (2014)

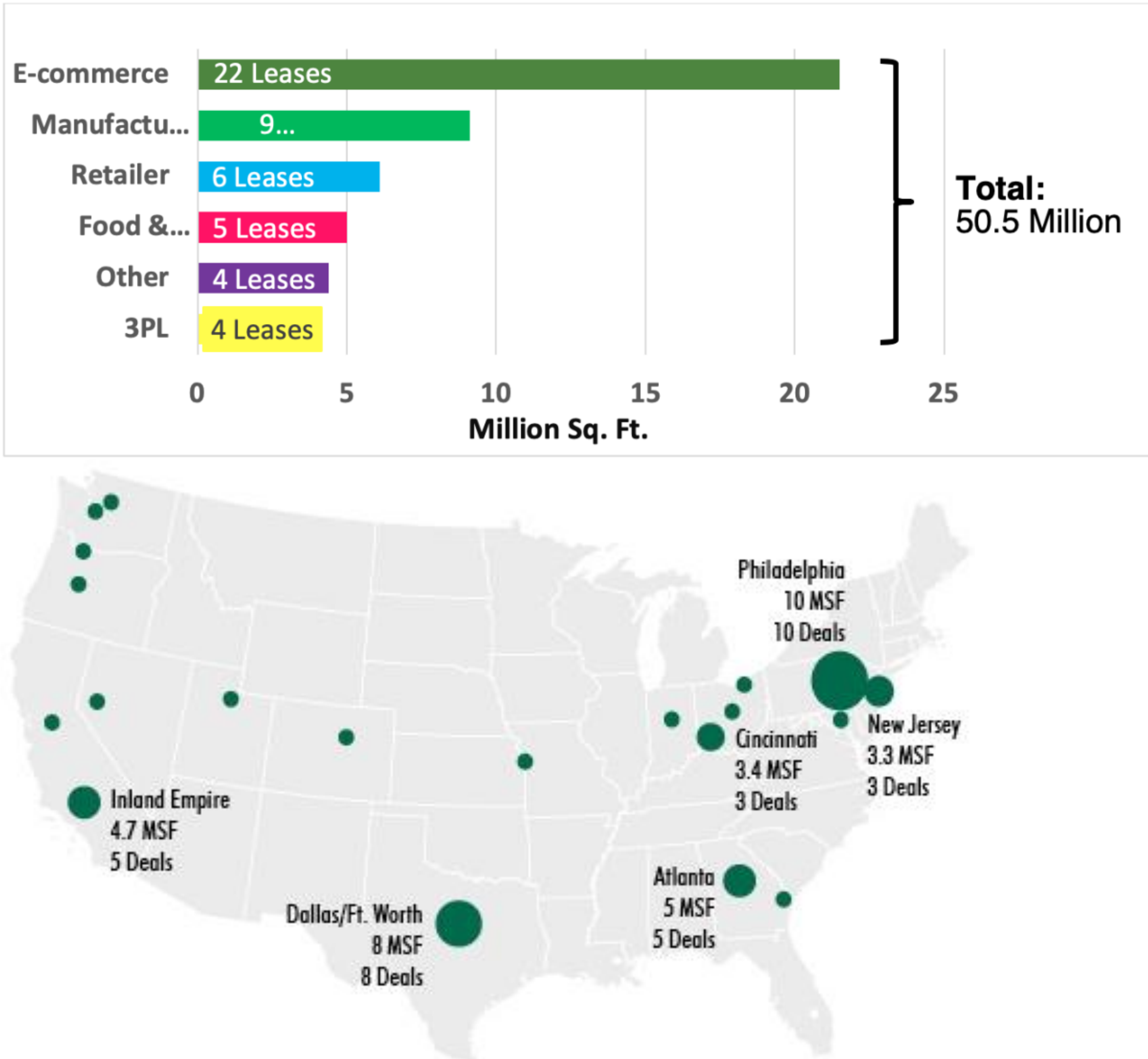

Figure 2. 50 Largest U.S. Leases by CBRE (a real estate firm), according to Industry Type (top panel) and Market (bottom panel). Abbreviations: 3PL, Third-party logistics; MSF, million square feet. Source: (CBRE, 2018).

The objectives of this research are as follows:

- to understand the changes in the geographic distribution of freight facilities (warehouses and distribution centers [W&DCs]), and identify trends in those changes;
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This document is organized as follows. Study Area and Data describes the study area and the data used for the analyses. Methodology discusses the methodology, describing the spatial aggregate and disaggregate analyses. Empirical Results summarizes the empirical results, and discusses the findings. The report ends with a Conclusions.

[1] W&DCs include industrial/warehouse, distribution facility, cross dock trucking terminal, and bulk warehouses.

Study Area and Data

This study focuses on spatial aggregate and disaggregate analyses of the distribution of W&DCs, using aggregate and disaggregate data. The aggregate analyses concentrated on the counties under the 5 largest MPO regions: SCAG, MTC, SACOG, SJCOG, and SANDAG (see Figure 3). Disaggregate analyses focused on the real estate markets in Southern California. These included the Los Angeles market (Los Angeles and Ventura County), Inland Empire (Riverside and San Bernardino County), Orange (Orange County), and the San Diego (San Diego County).

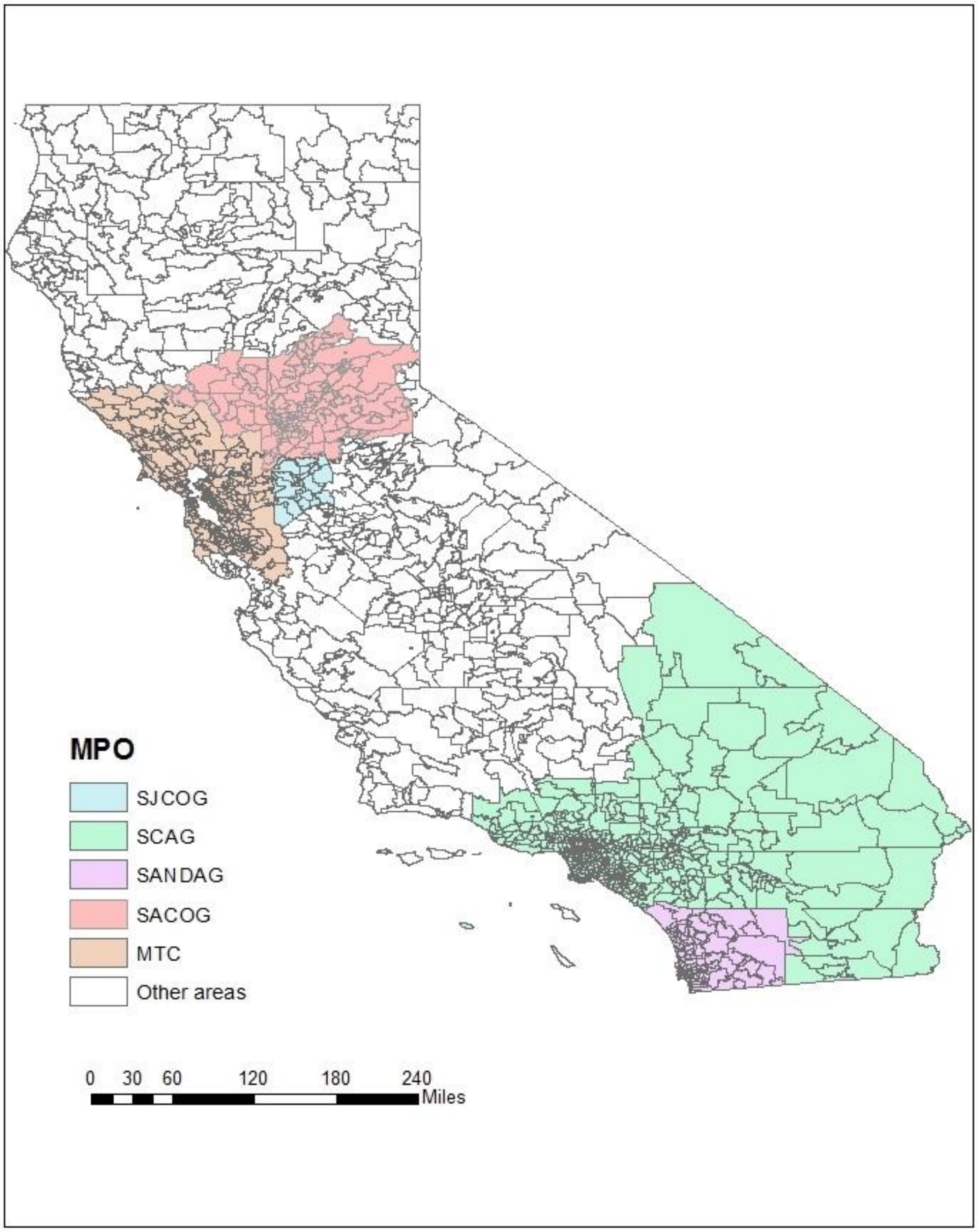

Figure 3. Selected MPOs in California: SCAG, MTC, SACOG, SANDAG and SJCOG

Aggregate data at the zip code level included demographic and socio-economic characteristics, number of W&DCs, transportation and logistics infrastructure characteristics, and environmental score from CalEnviroScreen 3.0. CalEnviroScreen 3.0 was provided by the Office of Environmental Health Hazard Assessment (OEHHA), on behalf of the California Environmental Protection Agency (CalEPA). Disaggregate information included real estate transactions for properties leased and sold in the area provided by Costar Group Inc.

Demographic and Socio-economic Information

We used Census zip-code level data provided by Maptitude software for California. The datasets included information on population, median household income, gender, race, median house value, and commute mode split (percentage of travelers and/or number of trips using particular types of transportation), among other variables. There are 1,810 zip codes in California. To provide an illustration of the demographic information, Table 2 shows a descriptive summary.

Table 2. Descriptive summary of demographic information

MPO		SCAG	MTC	SACOG	SANDAG	SJCOG
Number of zip codes		607	303	158	114	32
Mean value per zip code	Population	30,080	23,980	15,570	27,540	21,600
	Median household income (dollars per year)	61,850	84,250	59,260	66,920	57,650
	Gender (percentage of population that is male)	49.68%	49.74%	49.73%	52.65%	50.74%
	Race (percentage of population that is white)	62.9%	63.94%	76.35%	73.65%	65.47%
	Median house value (dollars)	$405,900	$612,500	286,100	432,800	233,400
	Adults using public transit mode (per 1000)*	37.62	83.69	16.47	22.81	12.28

* Commute travel

Number of W&DCs

We used the Zip Code Business Pattern (ZBP) database to gather information about the number of facilities and employment levels for each of the locations in the study area. The ZBP provides the number of establishments between 1998 and 2016 for each industry in the North American Industrial Classification Standards (NAICS). Specifically, the W&DC data of interest relates to those establishments within NAICS 493 (Warehousing and Storage). We also used data for other industry sectors (see Table 3).

Infrastructure

We gathered information about the transportation infrastructure related to the highway network and the location of seaports, airports, and intermodal facilities. We used the highway layer in Maptitute software; the Intermodal facilities locations from the Intermodal Association of North America (IANA)[2]; and the seaports and airports from the California Department of Transportation (Caltrans).[3] Using these locations, we estimated the distance from each zip code (centroid) to these (closest) facilities.

Table 3. NAICS Industry Classification

NAICS classification	Description
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
72	Accommodation and Food Services

Environmental Score

The Office of Environmental Health Hazard Assessment (OEHHA), on behalf of the California Environmental Protection Agency (CalEPA), provides an environmental score or CalEnviroScreen (CS). The score combines indexes for pollution burden and population characteristics at the level of census tracts. Table 4 lists the components of every category, and the score is calculated following the process in Table 5 (Office of Environmental Health Hazard Assessment (OEHHA), 2017). There was a geographic mismatch between the CS and the scope of the study. Because the CS was at the census tract level, the team estimated the CS for every zip code by compiling the same data in tracts covered by the zip codes. Table 6 summarizes all the scores for the zip codes in each of the MPO areas. Using all these environmental scores, the authors estimated the CS for each zip code.

Real Estate Transactions

We exported the industrial properties data from the Costar Group Inc. dataset. "Industrial property" is one of the property level categories in the Costar system, among other property types, such as multi-family, retail, and office. Industrial buildings are used for assembly, processing, manufacturing, storage, maintenance, and distribution, among other logistics and manufacturing activities. The secondary classifications of industrial properties include distribution, manufacturing, truck terminal, service, and warehouses.In Southern California, properties are grouped in four markets based on location: the Los Angeles (Los Angeles and Ventura County), Inland Empire (Riverside and San Bernardino County), Orange (Orange County), and San Diego (San Diego County) markets.

[2] https://www.intermodal.org/resource-center/intermodalsystem
[3] http://www.dot.ca.gov/hq/tpp/offices/ogm/fact_sheets_index.html#airports

Table 4. Categories of CalEnviroScreen

Category	Sub category	Component	Abbreviation
Pollution burden	Exposure indicator	Ozone	OZONE
		PM 2.5 concentration	PM25
		Diesel PM	DIESEL
		Pesticide use	PEST
		Toxic releases	RSEIHAZ
		Traffic	TRAFFIC
		Drinking water	DRINK
	Environmental effects	Cleanup sites	CLEANUPS
		Groundwater threats	GWTHREATS
		Hazardous waste facilities	HAZ
		Impaired water bodies	IWB
		Solid waste sites	SWIS
Population characteristics	Sensitive population	Asthma	ASTHMA
		Cardiovascular disease	CVD
		Low birth weight	LBW
	Socioeconomic factor indicator	Educational attainment	EDU
		Housing burden	HOUSINGB
		Linguistic isolation	LING
		Poverty	POV
		Unemployment	UNEMP

Table 5. Calculation of CalEnviroScreen Score for a Census tract

	Pollution Burden		Population Characteristics	
	Exposure Indicators	Environmental Effects Indicators*	Sensitive Population Indicators	Socioeconomic Factor Indicators
Component Score	80.40	(0.5 × 40.70) =20.35	97.66	81.16
Average of Component Score	100.75 ÷ (1 + 0.5) = **67.17** *Pollution Burden is calculated as the average of its two component scores, with the Environmental Effects component half-weighted.*		178.82 ÷ 2 = **89.41** *Population Characteristics is calculated as the average of its two component scores.*	
Scaled Component Scores (Range 0-10)	(67.17 ÷ 81.19**) × 10 = **8.273** *The Pollution Burden percentile is scaled by the statewide maximum Pollution Burden scores.*		(89.41 ÷ 96.43***) × 10 = **9.272** *The Population Characteristics percentile is scaled by the statewide maximum Population Characteristics scores.*	
CalEnviroScreen Score	8.273 x 9.272= **76.71** A score of **76.71** puts this census tract in the 95-100 percentile or **top 5%** of all CalEnviroScreen scores statewide.			

* The Environmental Effects component was given half the weight of the Exposures component.
** The tract with the highest Pollution Burden score in the state had a value of 81.19.
*** The tract with the highest Population Characteristics score in the state had a value of 96.43.

Source: Office of Environmental Health Hazard Assessment (OEHHA) (2017)

Table 6. Descriptive Summary (mean value of percentiles) for Environmental Scores

Component	SCAG	MTC	SACOG	SANDAG	SJCOG
Ozone	63.98	11.96	59.31	37.63	52.56
PM 2.5 concentration	64.61	40.46	36.16	63.40	78.57
Diesel PM	65.26	61.89	41.60	59.71	54.99
Pesticide use	39.95	39.16	60.14	40.26	82.87
Toxic releases	72.61	55.10	30.05	46.49	61.99
Traffic	68.25	60.44	39.96	63.23	53.59
Drinking water	55.80	31.55	41.87	35.47	71.19
Cleanup sites	55.77	54.19	46.04	52.42	47.69
Groundwater threats	39.77	57.22	53.69	50.59	71.47
Hazardous waste facilities	59.67	55.94	40.50	50.13	59.95
Impaired water bodies	40.85	57.96	54.13	59.08	87.39
Solid waste sites	41.47	37.67	53.34	38.61	51.15
Asthma	51.18	44.96	50.80	34.20	64.80
Cardiovascular disease	55.37	33.18	51.73	27.66	68.57
Low birth weight	58.27	49.12	43.38	44.18	68.24
Educational attainment	54.11	37.85	43.14	40.35	67.57
Housing burden	60.12	45.96	40.81	52.50	41.90
Linguistic isolation	60.76	54.63	39.63	48.26	64.18
Poverty	50.40	29.94	47.53	42.15	57.83
Unemployment	50.48	30.34	55.54	38.98	70.70
CalEnviroScreen Score	61.95	37.74	43.37	38.88	78.24

We explored the sales and lease transaction data of industrial properties in Southern California. For data on the sold properties, organized at the transaction level, we had access to property characteristics including location, transaction time and date, county, market, type, secondary classification, size, price, parking space, transaction value, and other information about the facility. For the leased properties, the data were aggregated for specific time frames and region area, including the total leased deals, the total leased size, average deal price, and other transaction attributes.

Methodology

As mentioned before, in this study, we:

1. Conducted an exploratory evaluation to determine the location and distribution of the establishments under NAICS 493 and other related industries in the study regions;
2. Performed centrographic analysis to calculate yearly barycenters—i.e., the geometric centers weighted by the number of establishments in each zip code. The spatial analyses offer insights about shifts and levels of concentration of the facilities in the study regions;
3. Estimated econometric models to quantify the spatial relationship between W&DCs and other industries, and the factors that explain the concentration of W&DCs in specific areas;
4. Evaluated the relationship between W&DC concentrations and the CS;
5. Evaluated the temporal patterns of industrial real estate transactions by estimating econometric models.

Spatial Aggregate Analyses

Centrographic analyses

These analyses are an extension of previous work conducted for the SCAG region to understand the trends in spatial location of W&DCs in other regions (Jaller and Pineda, 2017). We followed the previously developed methodology to conduct the centrographic analyses. Specifically, we estimated yearly barycenters (geometric centers weighted by the number of establishments in each zip code). We used Equation 1 to estimate the geometric centers for each MPO region.

$$\left(\bar{\boldsymbol{x}}_{\boldsymbol{w}} = \frac{\sum_{i=1}^{n} x_i w_i}{\sum_{i=1}^{n} w_i}, \bar{\boldsymbol{y}}_{\boldsymbol{w}} = \frac{\sum_{i=1}^{n} y_i w_i}{\sum_{i=1}^{n} w_i}\right), \quad (1)$$

where,

$\bar{x}_w$ = latitude coordinate of the weighted geometric center of an MPO region for a specific year,

$\bar{y}_w$ = longitude coordinate of the weighted geometric center of an MPO region for a specific year,

x_i = latitude coordinate of zip code (centroid) i,

y_i = longitude coordinate of zip code (centroid) i,

w_i = number of facilities in zip code i.

Spatial Correlation

One of our objectives was to explore the existence of spatial correlation among W&Ds for each MPO region. To capture the spatial correlation, we estimated the Moran's I statistic by combining the neighboring relationship matrix of all zip codes and number of W&D

establishments in each zip code in an MPO region. In the neighboring relationship matrix, a cell (w_{ij}) was assigned with a value of one if two zip codes bordered each other. The Moran's I was calculated with equation 2:

$$\boldsymbol{I} = \frac{\boldsymbol{N}}{\boldsymbol{S_o}} \frac{\sum_i \sum_j \boldsymbol{w_{ij}}(\boldsymbol{\pi_i} - \overline{\boldsymbol{\pi}})(\boldsymbol{\pi_j} - \overline{\boldsymbol{\pi}})}{\sum_i (\boldsymbol{\pi_i} - \overline{\boldsymbol{\pi}})^2}, \qquad (2)$$

where

I = Moran's I index,

N = total number of zip codes in an MPO region,

w_{ij} = weighed value for two zip codes in a neighboring matrix of an MPO region,

S_o = sum of all the cells in a neighboring matrix of an MPO region,

π_i = number of establishments in zip code i in an MPO region,

$\bar{\pi}$ = mean value of the number of establishments in each zip code in an MPO region.

Econometric Modeling

After the spatial analyses, an exploratory evaluation was conducted to determine the distribution of the W&DCs under NAICS 493. This exploratory evaluation used econometric models to identify the factors influencing the existence and number of W&DCs in an area. All the data compiled (as described in detail in Study Area and Data) were considered in the modeling exercise. Before building the model, an analysis of the numbers of W&DCs in the study areas revealed the existence of over-dispersion and large zero counts. Given these two features, a zero-inflated negative binomial (ZINB) model was selected. A ZINB model is actually a two-step regression, which combines a binary logit model and a negative binomial model. Table 7 summarizes key variables considered in the models. Table 7 shows that, among all the regions studied, the SCAG region has the highest median population at the zip code level. MTC leads with respect to median house value and median household income. SCAG and SJCOG show the largest number of W&DCs facilities per zip code.

Table 7. Data (Median Value per Zip Code) Summary (5 MPOs)

Variable type	Variable Description	SCAG	MTC	SACOG	SANDAG	SJCOG
Demographics	Population (1k)	30.1	24.0	15.6	27.5	21.6
	Median age, years	36.4	40.8	41.1	36.0	35.2
	White population percentage (%)	62.9	63.9	76.4	73.7	65.5
	Median household income (1k dollars)	61.9	84.3	59.3	66.9	57.7
	Median house value (10k dollars)	40.6	61.3	28.6	43.3	23.3
	Adults using public transit (per 1k)*	37.6	83.7	16.5	22.8	12.3
Establishments in NAICS sectors	493 establishments	1.8	1.0	0.9	0.9	2.3
	32 establishments	7.9	5.2	2.8	6.6	5.2
	48 establishments	17.7	10.3	7.1	12.4	17.8
	72 establishments	65.0	67.8	30.5	65.5	35.7
	Neighboring 493 establishments	11.9	5.7	5.7	5.5	13.4
	Neighboring 32 establishments	52.4	29.8	17.9	41.4	29.3
	Neighboring 48 establishments	115.6	57.5	46.3	75.3	99.5
	Neighboring 72 establishments	404.3	376.0	187.6	401.6	196.2
Accessibility	Distance to highway (miles)	1.1	0.9	1.6	1.1	1.0
	Distance to seaport (miles)	41.5	19.3	31.7	22.9	12.1
	Distance to airport (miles)	24.8	22.7	25.8	20.1	37.8
	Distance to intermodal facility (miles)	19.1	20.9	27.3	25.8	8.9

North American Industrial Classification Standards (NAICS): 493, Warehousing and Storage; 32, Manufacturing; 48, Transportation and Warehousing; 72, Accommodation and Food Service. *Commute travel.

Table 13 through Table 17 in Appendix A. Descriptive Statistics for each MPO Region provide descriptive statistics of these variables (at the zip code level) for each of the MPO regions.

Disaggregate Analyses

Considering that we had access to disaggregate information for industrial real estate transactions, the analyses concentrated on:

- Number of properties sold and leased between 1998 and 2018
- Building size and transaction value for the different markets
- Regression analyses for the building size between 1998 and 2018
- Comparison of the average distance between the properties and the downtown for each of the market areas
- Comparison of the average and median distance between the properties and the Ports of Los Angeles and Long Beach
- Analysis of real estate transactions for different distances (buffers) out of the Ports of Los Angeles and Long Beach

Empirical Results

Spatial Aggregate Analyses

Centrographic Analyses

Before implementing the Centrographic analyses, we analyzed the trends in the number of W&DCs in the five MPO regions between 1998 and 2016. Figure 4 shows that the total number of W&DCs in each MPO consistently increased over the years, with the number significantly increasing in 2002 for the SCAG region (though the number could be affected by the changes in the industrial classification systems used). Overall, the total number of W&DCs in the SCAG region is approximately four times that in the MTC region and nearly ten times that in the other three MPO regions. For employment in warehouse-related sectors (NAICS 493), SCAG is still leading (see Figure 5). The maximum employment in NAICS 493 in the SCAG region is approximately six times that in the MTC region. The figure also shows the potential impact of the recession in 2008 on these industries.

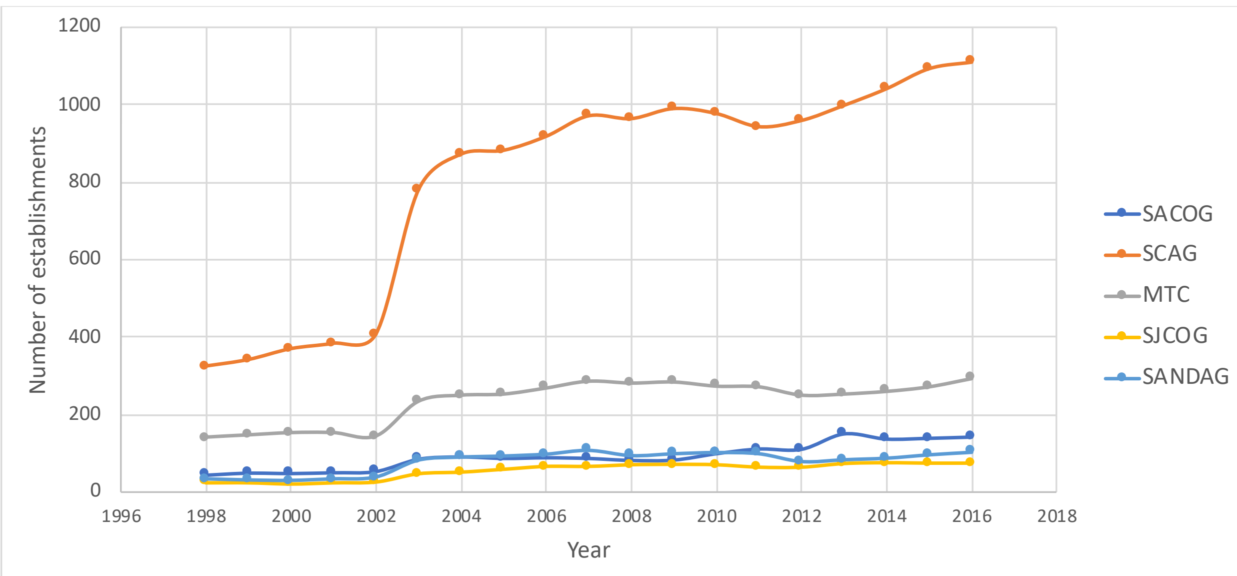

Figure 4. Changes in the Numbers of W&DCs in the five MPO regions

We conducted centrographic analyses of all five MPOs separately and compared the concentrations of W&DCs (NAICS 493) between 1998 and 2016. Appendix B shows the changes in the geographical centers of NAICS 493 establishments for the different MPO regions. To easily compare the differences among these MPO regions, we chose the centers of the downtowns in these MPO regions as reference points; we then compared the changes of distances between the weighted centers to these reference points (Figure 6). In SCAG, for example, while the distance dropped and remained flat after the 2008 recession, it increased over the last couple of years. The results are consistent with previous studies about the presence of logistics sprawl for W&DCs in the SCAG region. However, this phenomenon is not evident in the other four MPO regions. The difference may result from the various sizes and shapes of the regions. The geometric centers of the W&DCs in the MTC are all in the Oakland region, and they distribute as a circle around the city of San Francisco. Other MPO regions may not be as geographically large as SCAG, thus the changes in their weighted centers may not be noticeable.

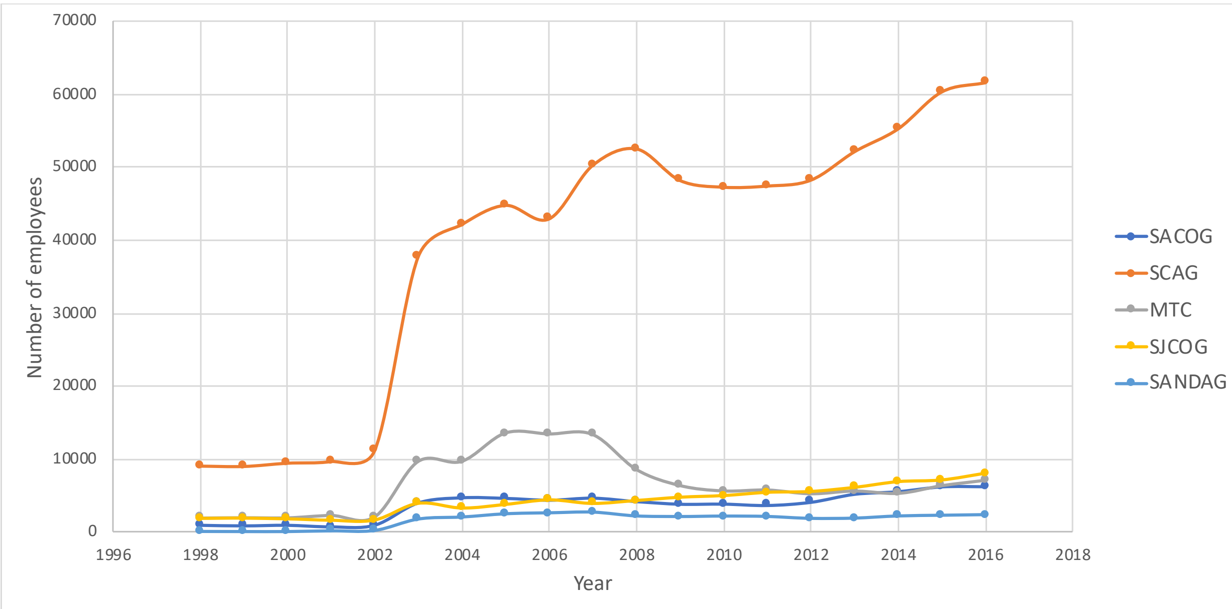

Figure 5. Changes in NAICS 493 employment in the five MPO regions

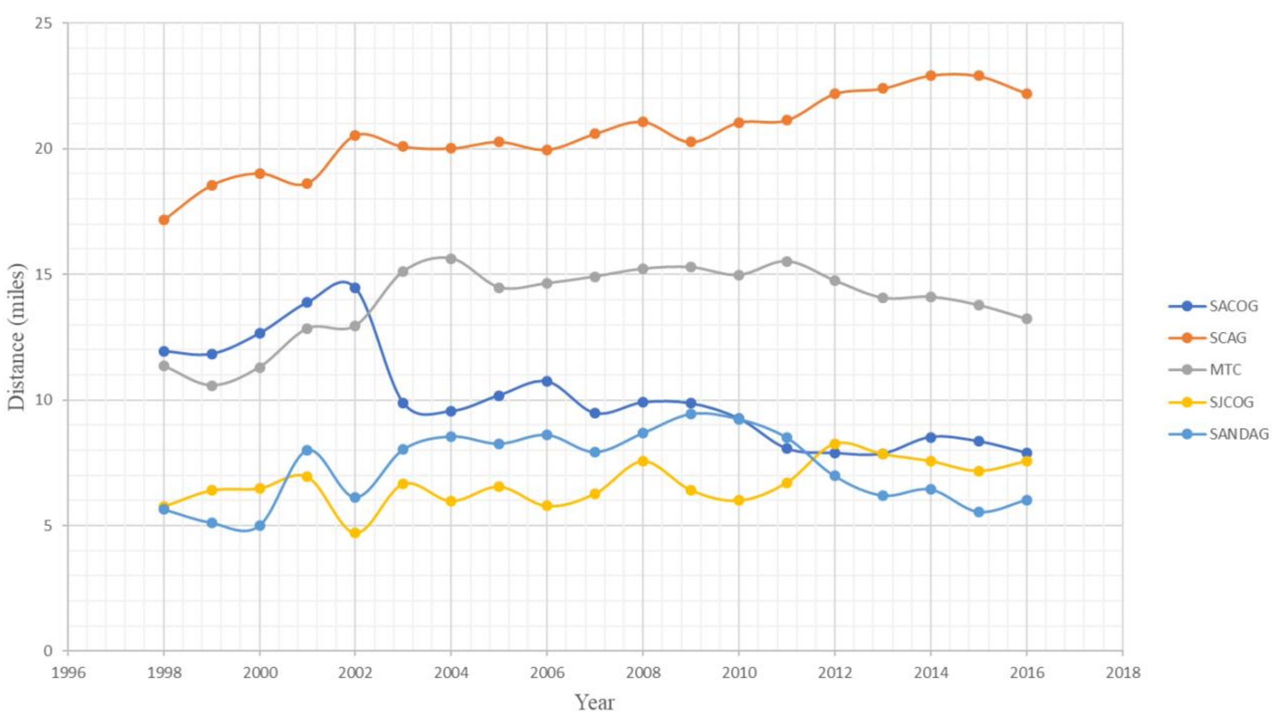

Figure 6. Distance between weighted geometric centers and reference locations

Spatial Correlation

As explained in the Methodology, under Spatial Correlation, the Moran's index was selected to measure the spatial correlation between W&DCs for a zip code and the neighboring zip codes. As illustrated in Figure 7, the presence of spatial correlation in W&DCs became more significant over time in the SJCOG region. Conversely, SANDAG shows a weakened trend in spatial correlation, which means that W&DCs in this region became more dispersed. Other than SJCOG and SANDAG, the changes in Moran's I indexes for MTC, SCAG, and SACOG did not show dramatic shifts.

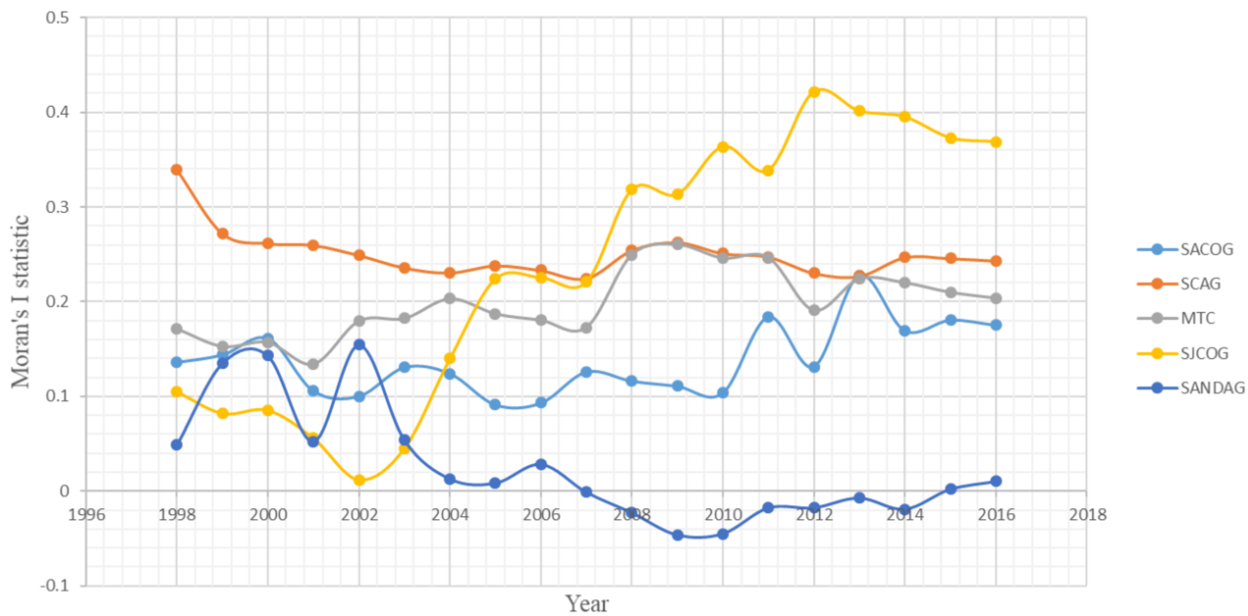

Figure 7. Moran's I statistic change between 1998 and 2016

Econometric Modeling

The first analyses estimated the correlation between the number of establishments in NAICS 493 with the various CS indexes (e.g., ozone, PM2.5, Diesel PM, etc.). Figure 8 through Figure 12 show these correlations, as well as the correlations among the various indexes within each MPO region. With the exception of SANDAG, where there is correlation between W&DCs and traffic, the results do not show a clear patterns of the impacts of W&DCs on the various indexes. Moreover, the results do not show large correlations among the indexes, except for the indexes at the end of the list (Table 4). In some cases, there is correlation between traffic, diesel and PM2.5, which can be as high as 0.84 as in the case of SACOG. The area that shows comparatively stronger correlations among the indexes is SJCOG. The results of this analysis are non-conclusive.

Nevertheless, the number of W&DCs in a zip code area are positively, though with low correlation, related to most of the environmental indexes, e.g., traffic, PM2.5, Diesel PM, cleanup sites (weighted sites), groundwater threats, and hazardous waste facilities/generators.

Consequently, it would be of particular importance to mitigate the impact of these facilities on the communities in such areas, consistent with the discussion from Dessouky et al. (2008).

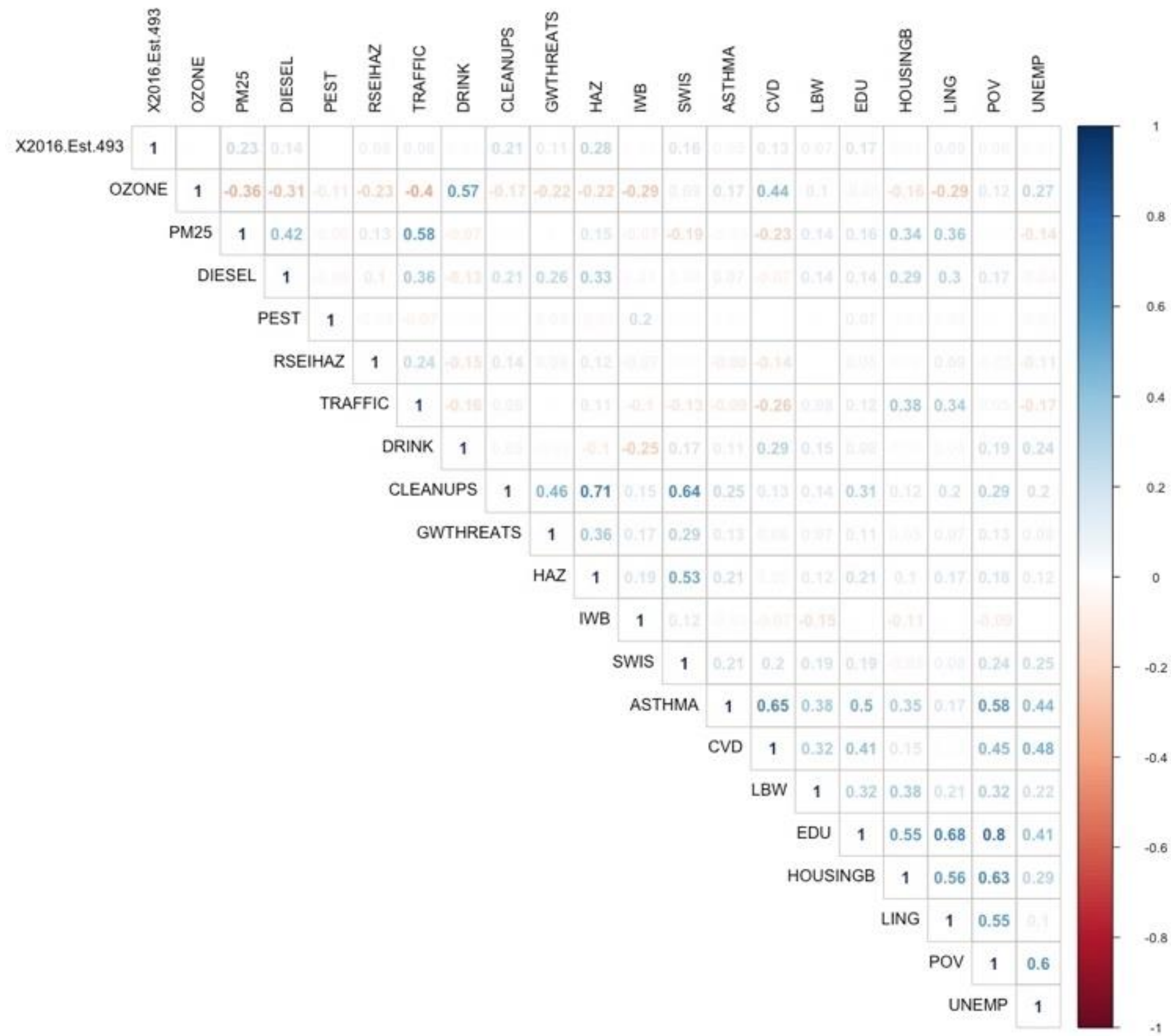

Figure 8. Correlation matrix of the number of W&DCs and all the environmental scores in SCAG

Additionally, we analyzed the relationship between the numbers of establishments under different industry sectors. The results in Appendix C show similar patterns among the various MPO regions. In general, the number of W&DCs (NAICS 493) correlated strongly with the number of establishments in NAICS 49 (as expected because NAICS 493 is contained in NAICS 49), manufacturing, and wholesale trade businesses. Overall, an area with more transportation related companies tends to have more W&DCs.

The next step involved identifying the factors that could explain the number of W&DCs facilities in specific locations. As mentioned, we estimated zero-inflated negative binomial models. Table

8 through Table 12 show the estimated models for the five MPOs. Although there are similarities among the explanatory factors, we found differences between the regions.

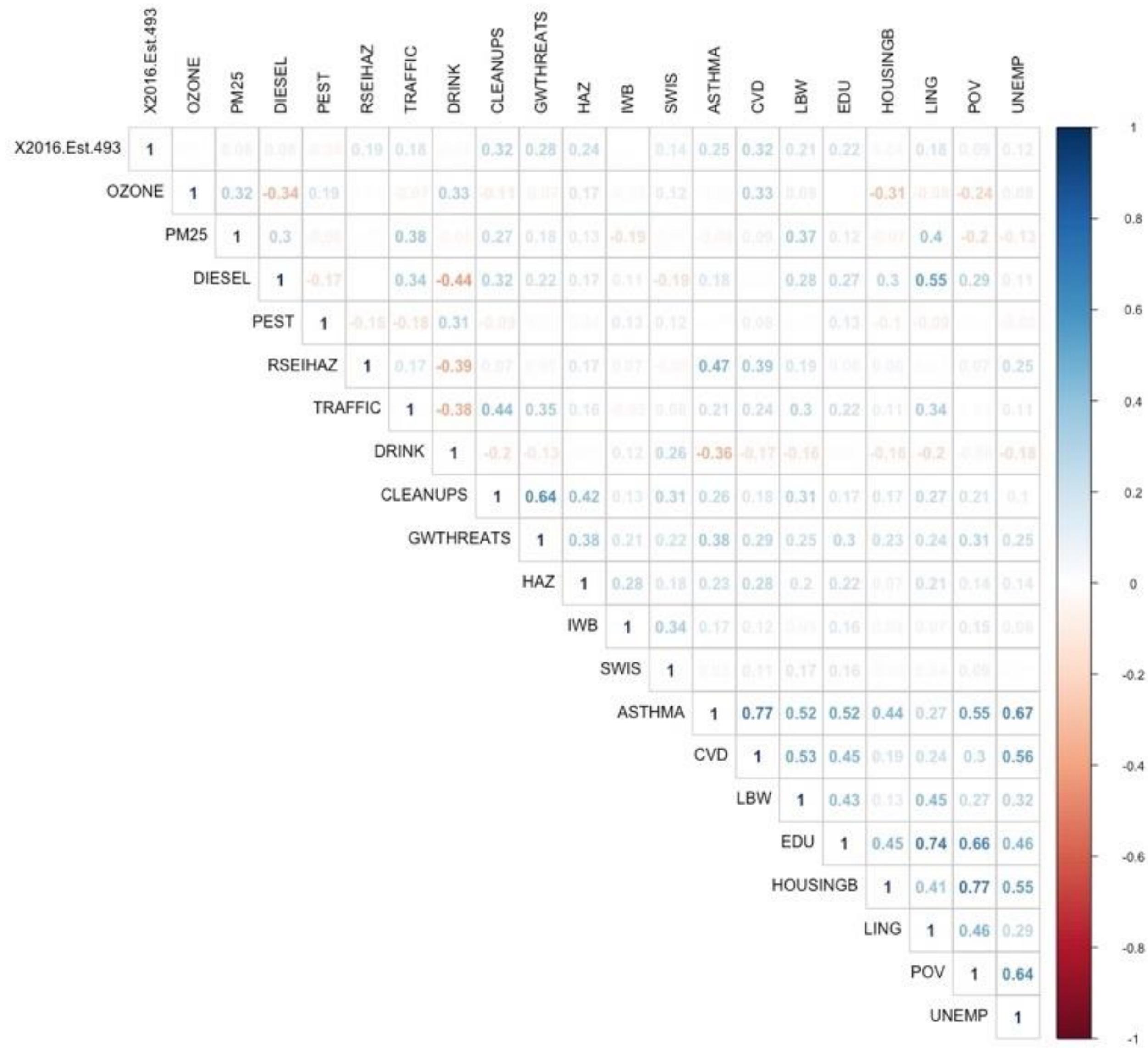

Figure 9. Correlation matrix of the number of W&DCs and all the environmental scores in MTC

Moreover, the sample size (number of zip codes) in each of the regions was different, with smaller samples for SACOG, SANDAG, and SJCOG. For some of the regions, several variables were found to be statistically significant at low confidence levels, though they were left in the model for comparison purposes.

Generally, the number of establishments in manufacturing correlated strongly with both the probability of a zip code having W&DCs and the number of W&DCs. The correlation between W&DCs and the CalEnviroScreen (CS) score was statistically significant in SCAG and MTC, though the results do not show causality. Interestingly, although the CS scores did not correlate with the likelihood of sitting facilities in a specific zip code, they did correlate with the number of W&DCs in a particular zip code. This finding is consistent with the general findings from Dessouky et al. (2008), Yuan (2018a), and Yuan (2018b) that found correlations between W&DCs and DACS. The results here, show correlation between DACS and high CS scores.

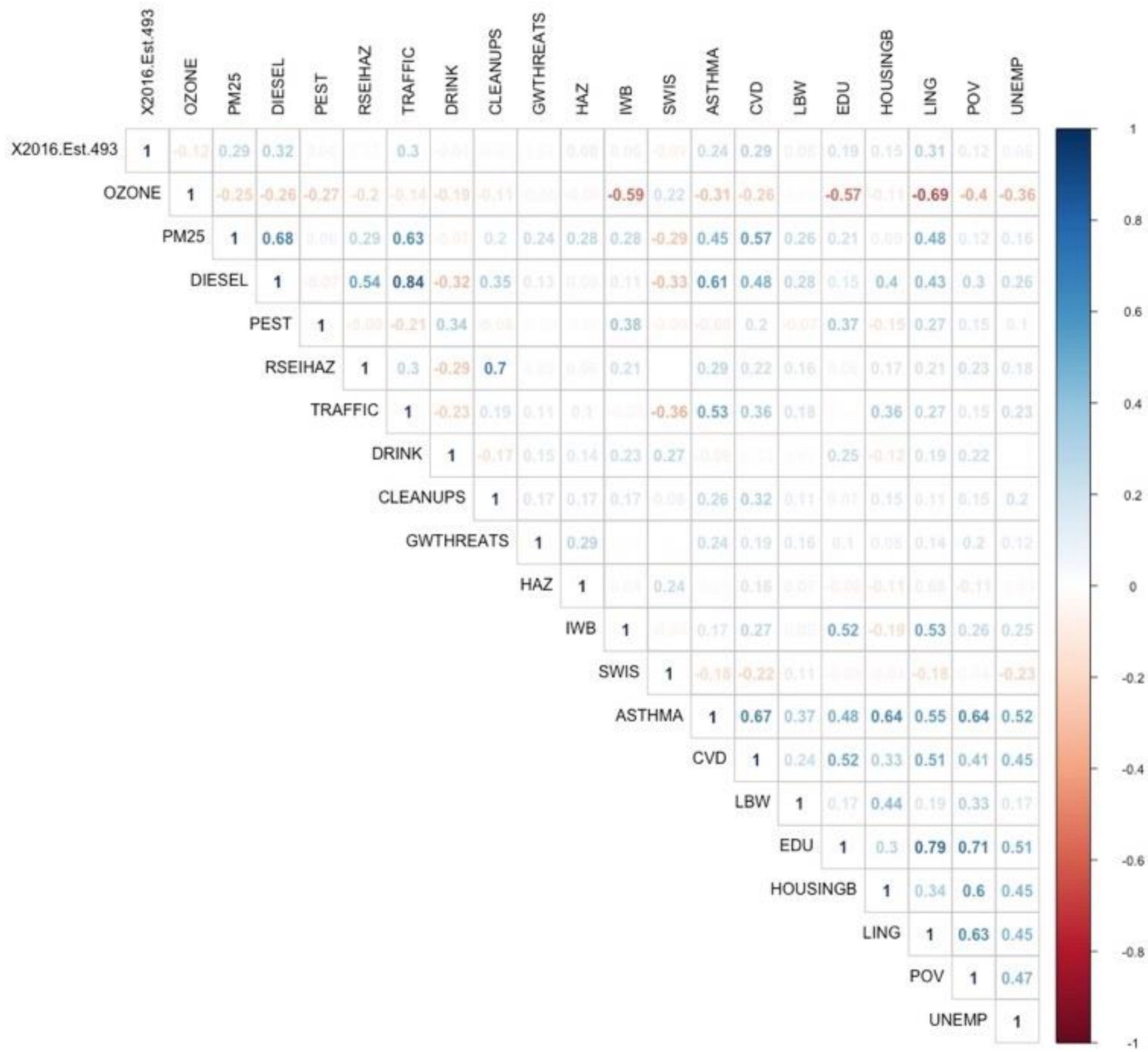

Figure 10. Correlation matrix of the number of W&DCs and all the environmental scores in SACOG

Additionally, the results show that average distances to seaports, intermodal facilities, and airports play an important role in determining whether a zip code has W&DCs in the SCAG, MTC, and SACOG, respectively. This may result from the different shapes and geographic locations of these three MPO regions. SCAG and MTC are on the west coast and close to the Pacific Ocean, while the SACOG is inland. Thus, freight shipping in SACOG may depend on air, rail, and potentially the inland waterways. The results also show that, in general, facilities are located in areas with lower household income and housing values.

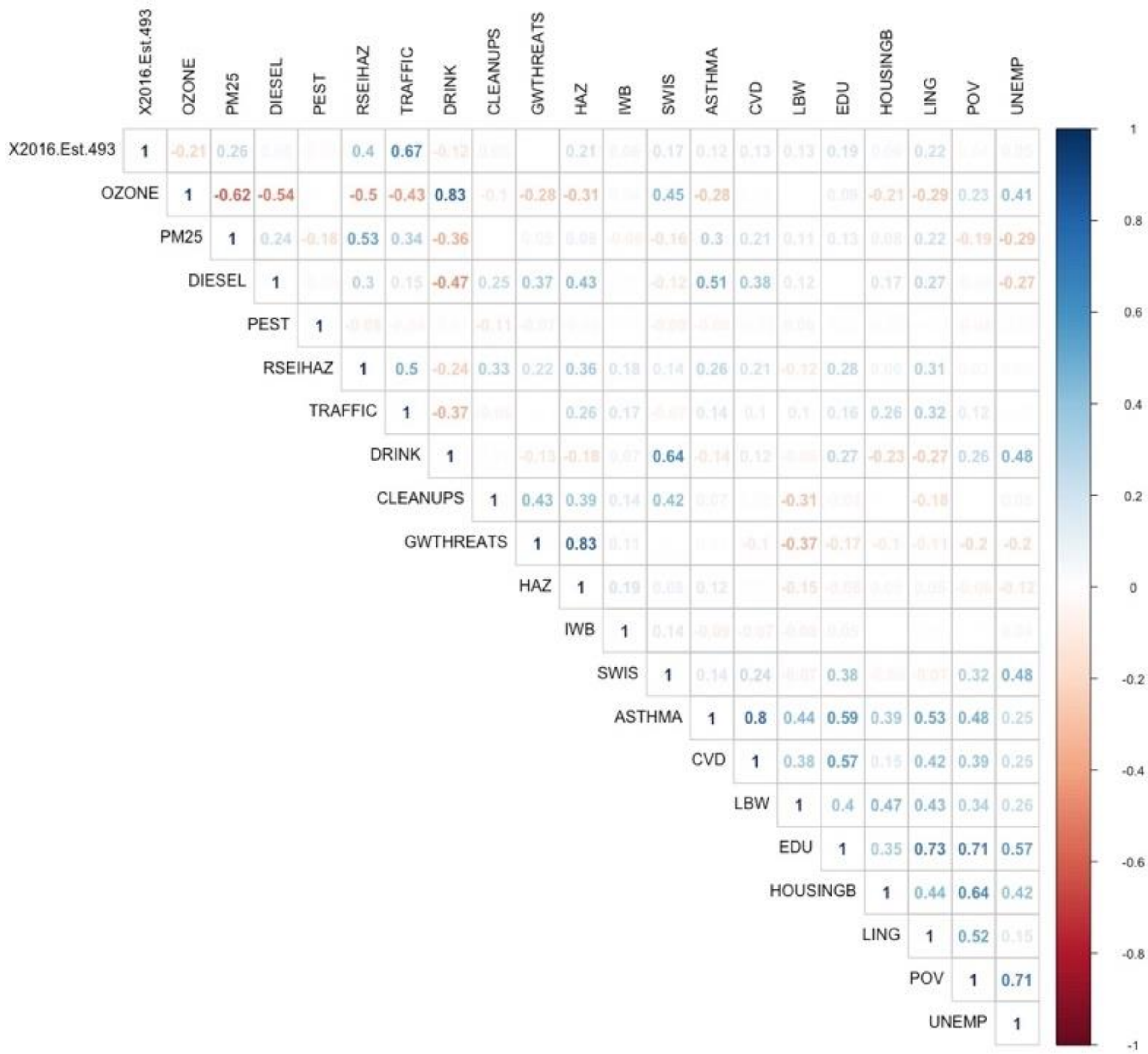

Figure 11. Correlation matrix of the number of W&DCs and all the environmental scores in SANDAG

Table 8. Zero-inflated negative binomial model for SACOG

Model	Variable	Coefficient	Z-Stat	P-value
1. (Inflate model)	Constant	0.12	0.15	0.88
logit model:	Manufacturing (32)	-1.21	-2.30	0.02
identify certain zeros	Average distance to airport	0.06	1.98	0.05
2. Count model:	Constant	-0.28	-0.56	0.57
negative binomial	Median household income ($1,000)	0.00	0.67	0.50
	Manufacturing (32)	0.10	4.30	0.00
	Average distance to airport	-0.01	-0.55	0.58

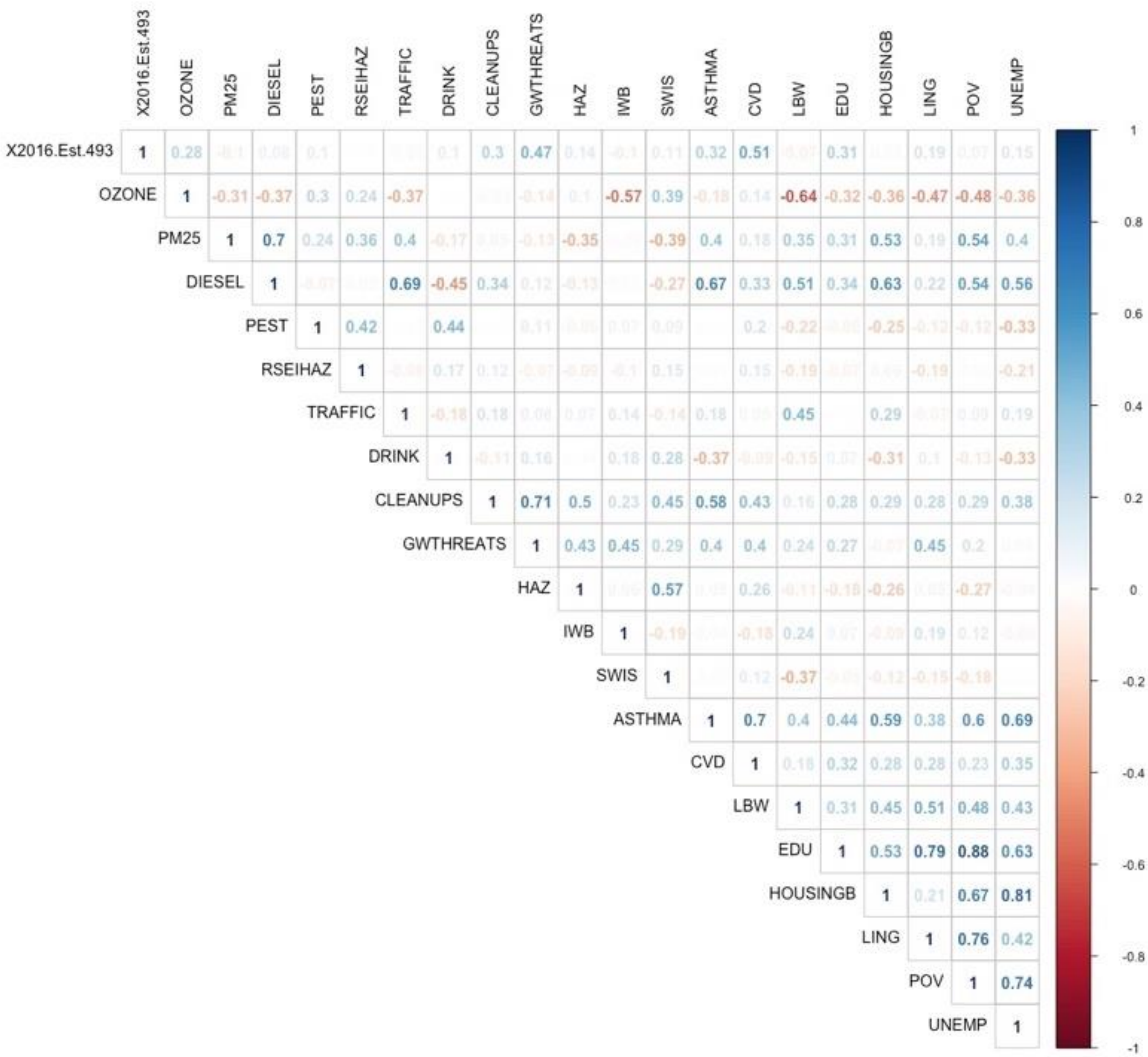

Figure 12. Correlation Matrix of the Number of W&DCs and all the Environmental Scores in SJCOG

Table 9. Zero-inflated negative binomial model for SJCOG

Model	Variable	Coefficient	Z-Stat	P-value
1. (Inflate model) logit model: identify certain zeros	Constant	3.20	2.43	0.02
	Manufacturing (32)	-1.00	-2.31	0.02
2. Count model: negative Binomial	Constant	1.72	0.91	0.36
	White population	-0.01	-0.50	0.62
	Manufacturing (32)	0.06	1.21	0.23

Table 10. Zero-inflated negative binomial model for SANDAG

Model	Variable	Coefficient	Z-Stat	P-value
1. (Inflate model) logit model: identify certain zeros	Constant	15.96	2.04	0.04
	Median house value	-0.40	-1.95	0.05
	Public transit users per 1000s	-0.12	-2.12	0.03
2. Count model: negative binomial	Constant	-0.19	-0.26	0.79
	Median household income ($1000)	-0.01	-1.57	0.12
	Manufacturing (32)	0.09	4.32	0.00

Table 11. Zero-inflated negative binomial model for SCAG

Model	Variable	Coefficient	Z-Stat	P-value
1. (Inflate model) logit model: identify certain zeros	Constant	33.94	0.42	0.67
	Median household income ($1,000)	-2.29	-0.34	0.74
	Neighboring establishments (48)	-17.78	-0.30	0.76
	Average distance to intermodal facilities	-2.21	-0.29	0.77
	California environmental score	14.15	0.30	0.77
2. Count model: negative binomial	Constant	-1.22	-3.06	0.00
	White population	-0.01	-1.21	0.23
	Manufacturing (32)	0.03	5.78	0.00
	Retail trade (45)	0.01	3.59	0.00
	Neighboring W&DC establishments (493)	0.02	6.02	0.00
	Average distance to highway	-0.15	-2.28	0.02
	California environmental score	0.02	3.90	0.00

Table 12. Zero-inflated negative binomial model for MTC

Model	Variable	Coefficient	Z-Stat	P-value
1. (Inflate model) logit model:	Constant	1.63	4.79	0.00
identify certain zeros	Manufacturing (32)	-0.39	-3.52	0.00
2. Count model: negative binomial	Constant	-0.40	-0.53	0.59
	Median house value	0.00	-0.49	0.62
	Transportation (48)	0.02	3.95	0.00
	Neighboring W&DC establishments (493)	0.05	4.62	0.00
	California environmental score	0.01	0.98	0.33

Disaggregate Analyses

For the disaggregate analyses, we used the Costar Group Inc. data between 1998 and 2018 for specific markets in Southern California and property types. The analyses included properties sold and leased during the study period.

Number, Size and Price of Properties Sold

Market Analyses

The total number of industrial properties increased with the economic development in the past 30 years. This section investigates the number of real estate transactions, the price, the size of the properties, and the location and distance of the properties from the Port of Los Angeles and central of the real estate market over the 1989-2018 period.

Southern California Market

Between 1989 and 2018 the Costar database contained a total of 49,697 industrial property transactions in Southern California. These included 30,997 warehouses, 12,762 manufacturing properties, 2,700 service properties, 1,684 distribution, 650 showrooms, 335 food processing properties, 224 truck terminals, 205 refrigeration facilities, 24 telecom/hotel, and 116 with no information (see Figure 13).

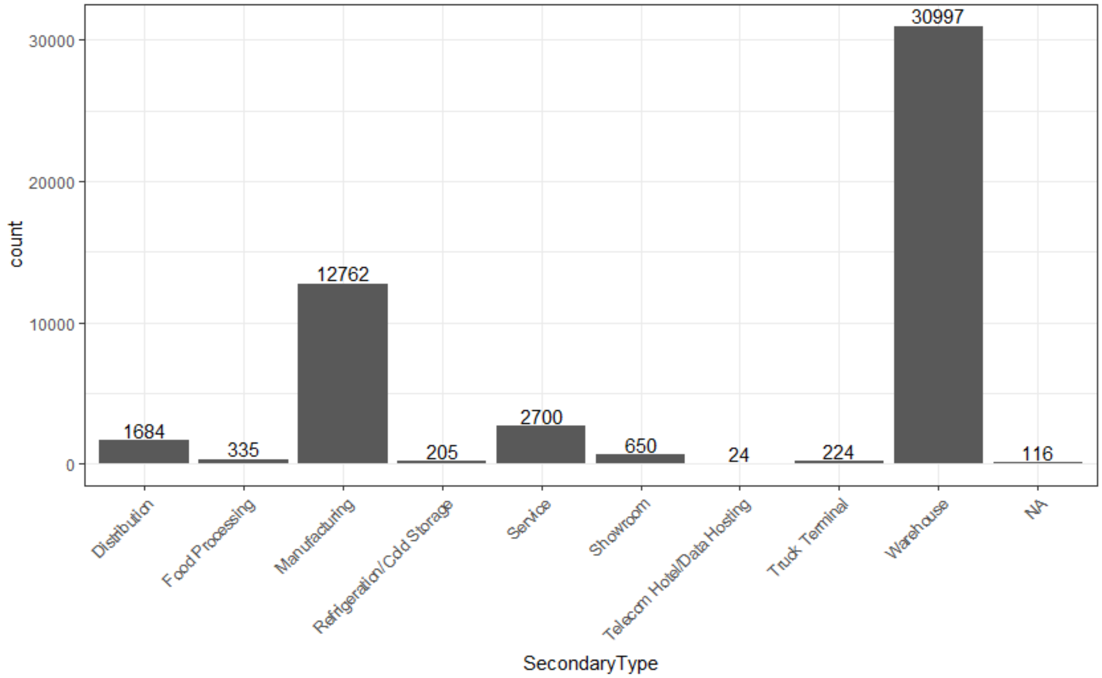

Figure 13. Number of properties sold between 1998 and 2018 (NA indicates "no information available")

The distribution of property sales among the four markets were: 19,186 (38.6%) in the Los Angeles market; 13,537 (27.2%) in the Orange market; 10,052 (20.2%) in the San Diego market; and 6,922 (13.9%) units in the Inland Empire market. Figure 14 shows the number of properties sold per market and the distribution of facility types. Overall, warehouse and manufacturing are the two largest secondary types of all the industrial property transactions.

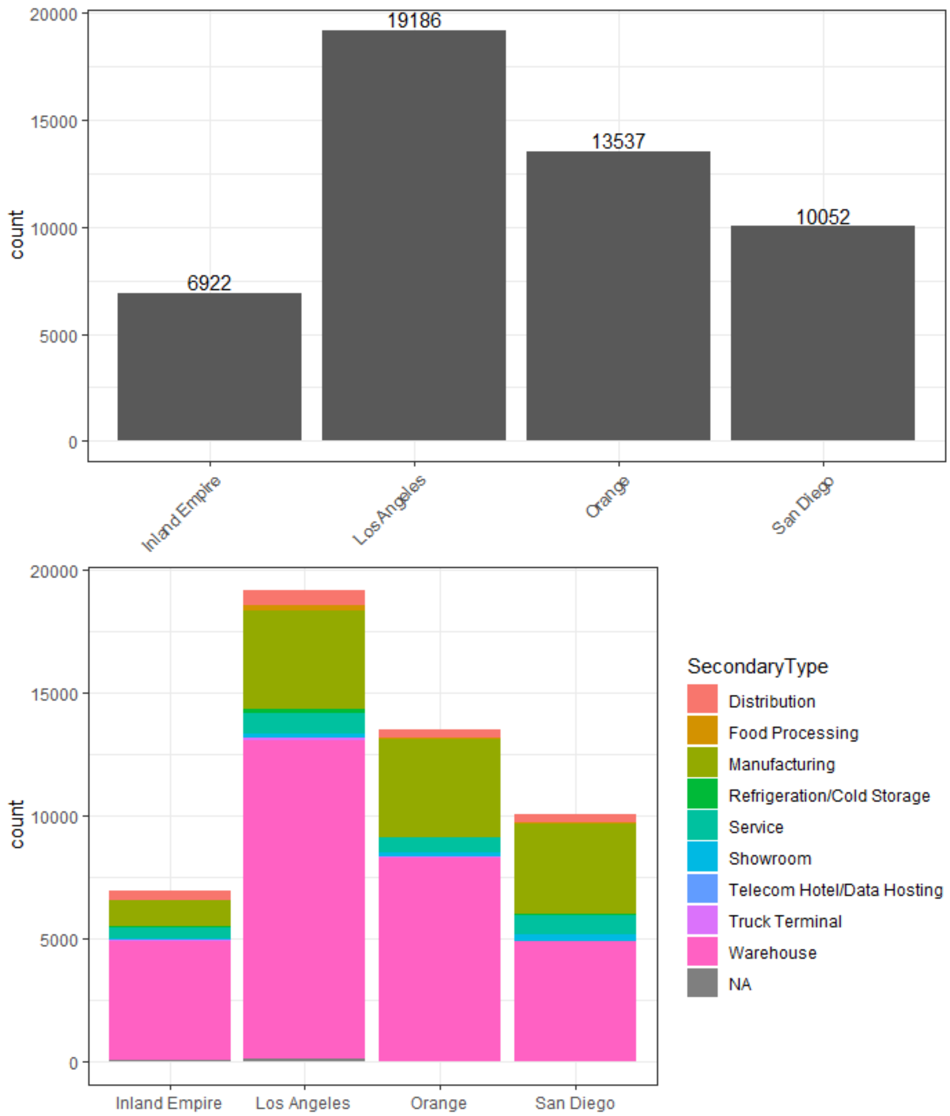

Figure 14. Number of properties sold per market (top) and distribution of facility types (bottom)

Figure 15 shows the temporal trends of the distribution of transactions per market and type. The Los Angeles market shows increased activities. The total number of properties in the Orange and San Diego markets did not increase much and show a decrease in the last three years. Warehouses were more dominant in the Inland Empire and Los Angeles markets, while manufacturing related transactions were more prevalent in San Diego.

Overall, the transactions have consistently increased, from 89 in 1989 to 3,042 in 2018, with drops around 2000 and 2008 (see Figure 16). It is not clear to us how comprehensive the database is in the 1990s.

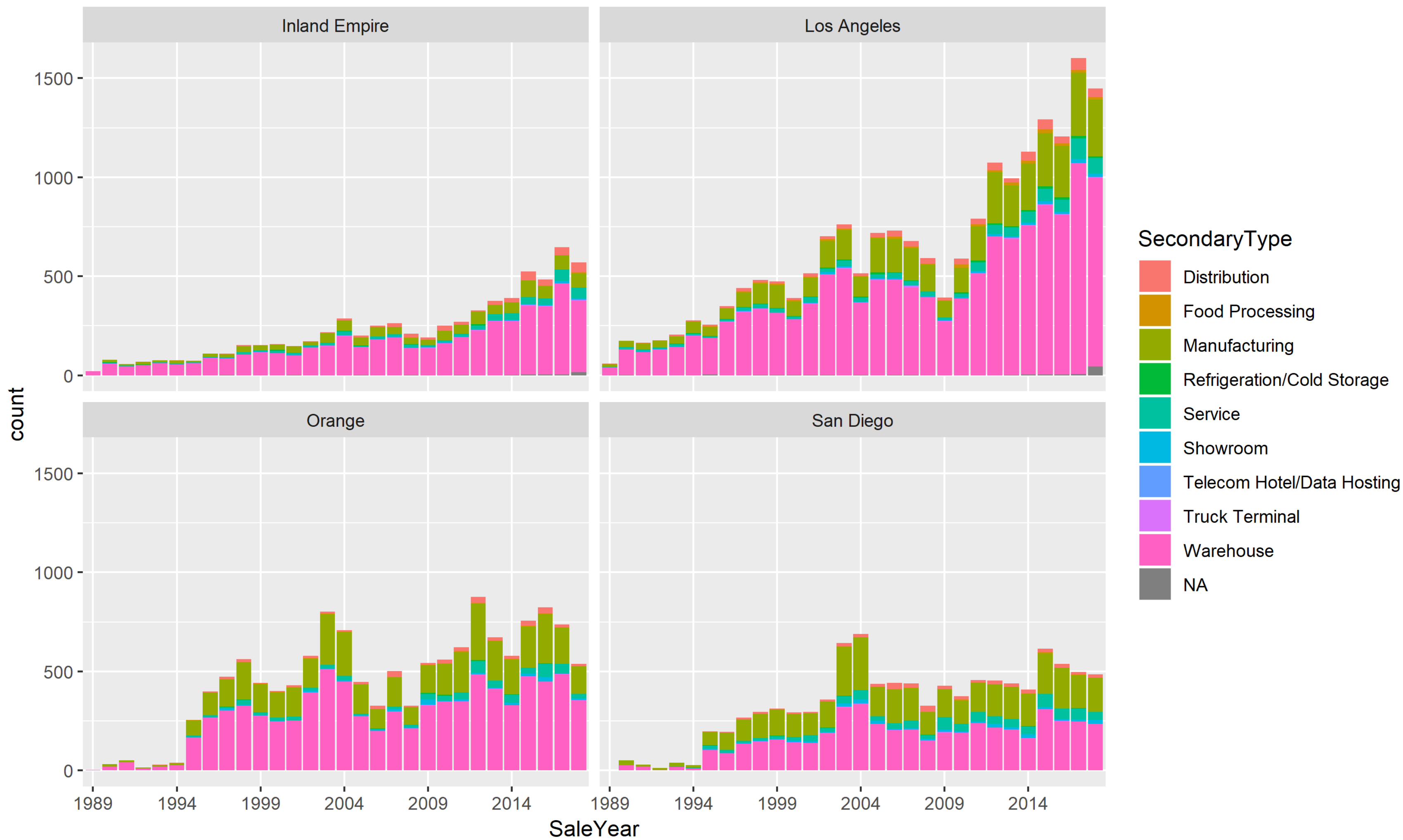

Figure 15. Secondary types of properties in the four markets (NA is type not available)

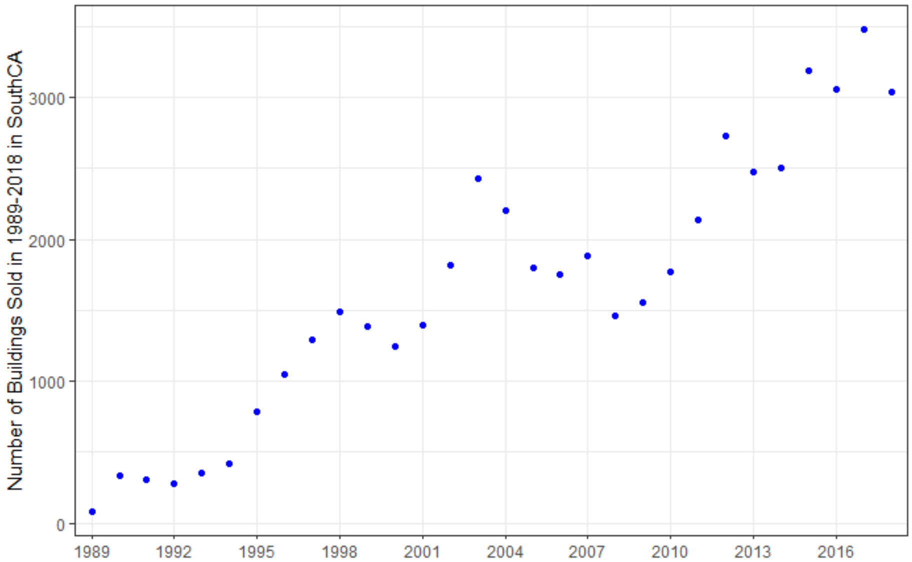

Figure 16. Number of units sold in Southern California in 1989-2018

Moreover, Figure 17 and Figure 18 show the average and median price per square foot for the transactions. Overall, there is an increasing trend. The yearly average price shows three significant peaks in 2001, 2015, and 2018. Several extremely expensive properties could affect the mean price, therefore, the median may provide a better indication of the trends. The median transaction price increased from around $50/sf in the 1990s to around $130/sf in 2007. There was a drop in 2008 with the economic crisis. After then, the median price increased steadily from $81.7/sf in 2009 to $195.8/sf in 2018.

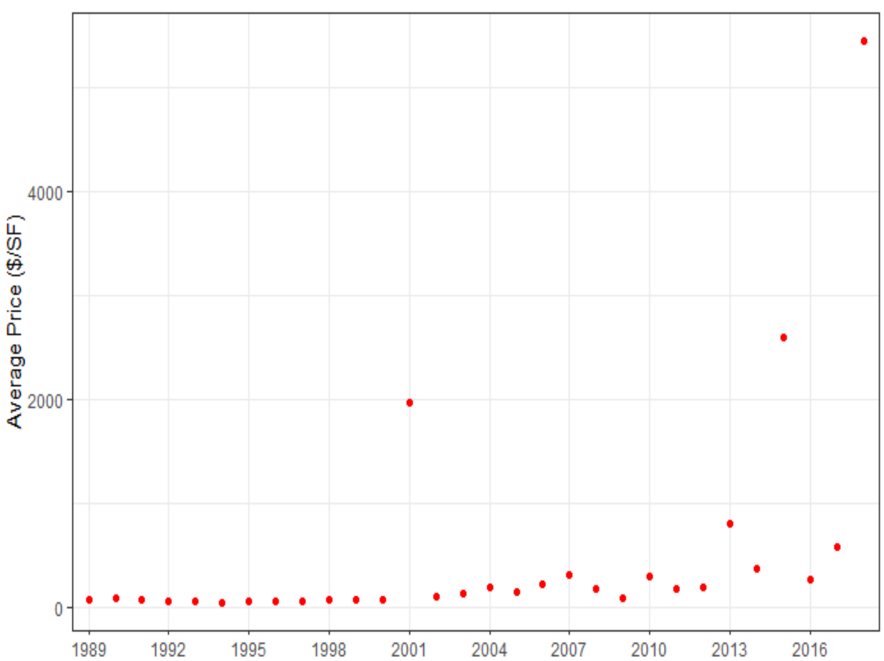

Figure 17. Average price of industrial properties sold in Southern California in 1989-2018

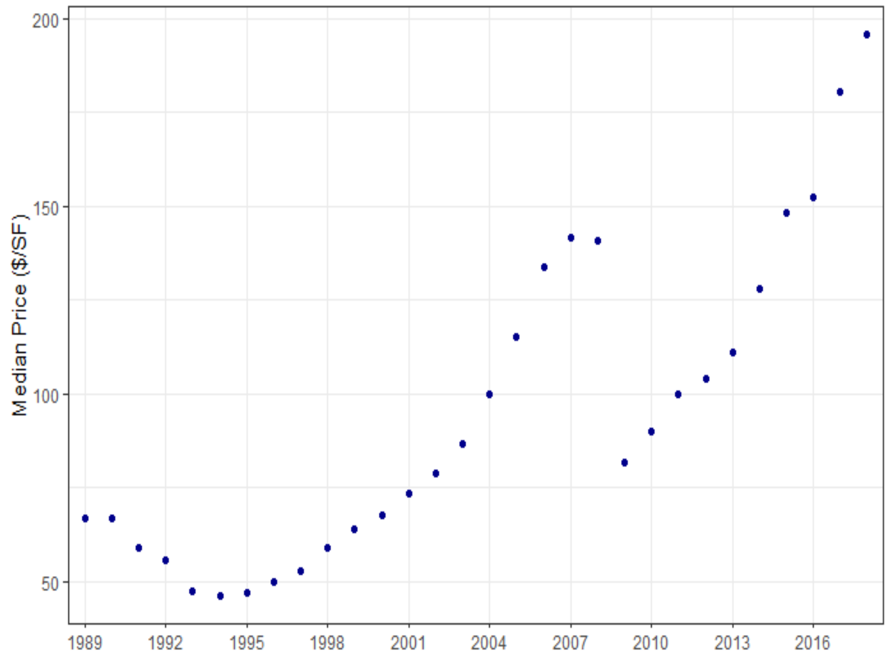

Figure 18. Median price of industrial properties sold in Southern California in 1989-2018

The average building size of the sold properties fluctuated between 25,000 square feet and 35,000 square feet between 1993 and 2018 (Figure 19). The median size of the properties shows a clear decreasing trend over time, especially after 2008 (Figure 20). In the last three years (2016-2018), half of the properties sold are smaller than 12,000 square feet.

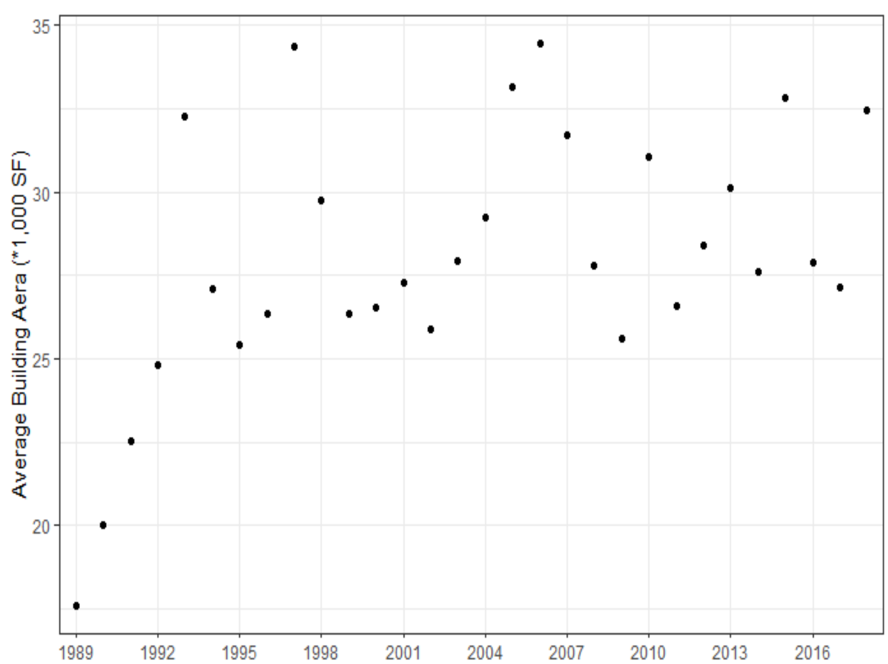

Figure 19. Average size of industrial properties sold in Southern California in 1989-2018

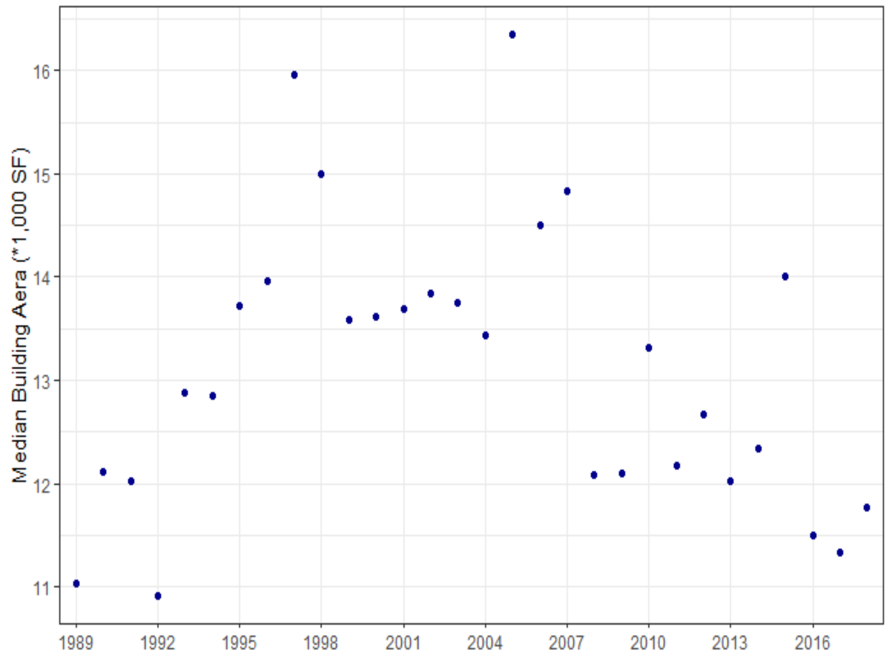

Figure 20. Median size of industrial properties sold in Southern California in 1989-2018

Los Angeles Market

As the hub of international goods distribution, Los Angeles had an increase in industrial properties sold from 60 in 1989 to 1,448 in 2018 (Figure 21).

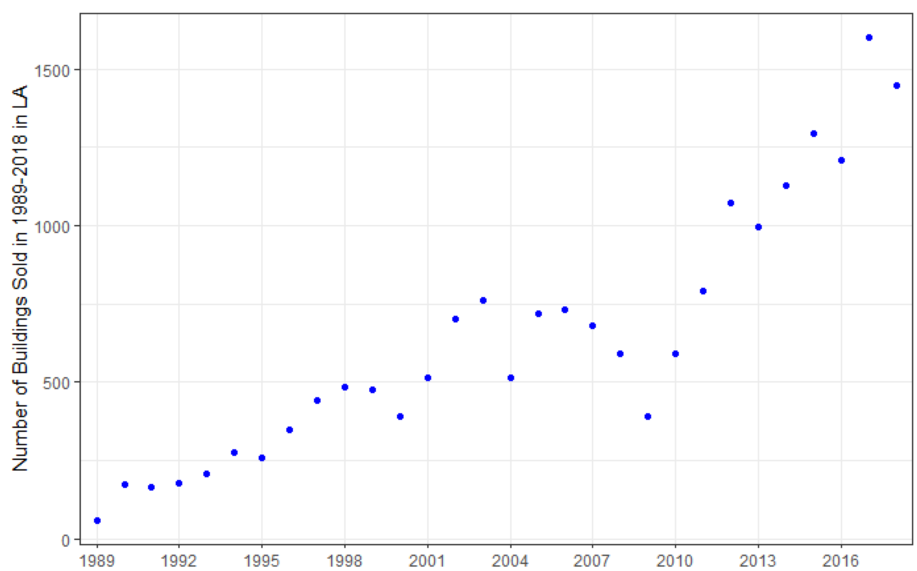

Figure 21. Number of units sold in Los Angeles between 1989 and 2018

Similar to the overal trend, the yearly average deal price was affected by some extreme values in 2001, 2015, and 2018, with an overall trend of prices increasing over the years (Figure 22). As shown in Figure 23, the median sale price increased from $67.9/sf in 1989 to $161.4/sf in 2008, dropped to around $113/sf during 2009-2013, and increased again from $146.5/sf in 2014 to $219.4/sf in 2018. The average building size of the industrial properties in Los Angeles (Figure 24) decreased slightly from 37,964 sf in 1993 to 23,627 sf in 2018. The median building size of the properties (Figure 25) decreased more sharply, from 16,246 sf in 1997 to 10,000 sf in 2018.

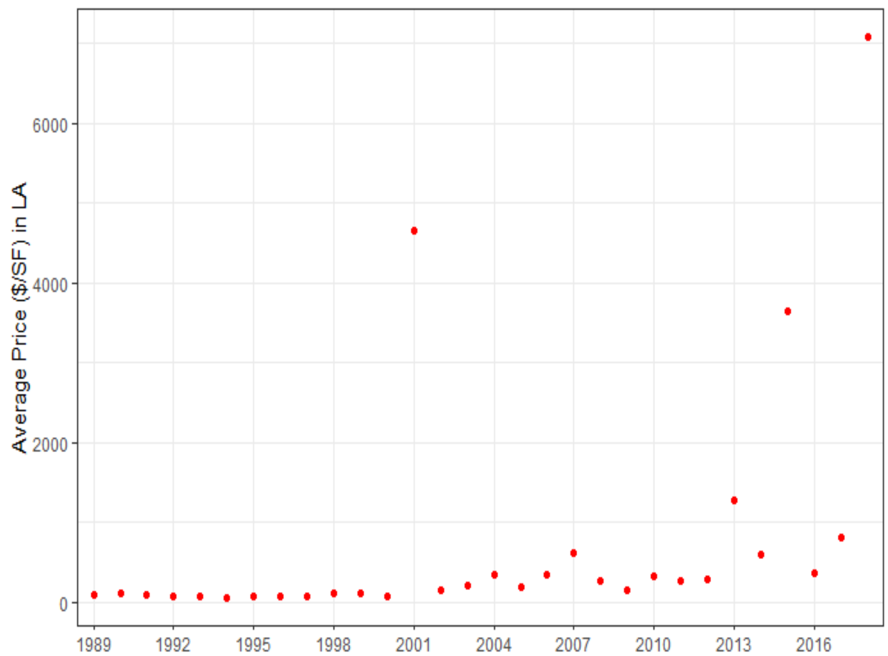

Figure 22. Average price of industrial properties sold in Los Angeles in 1989-2018

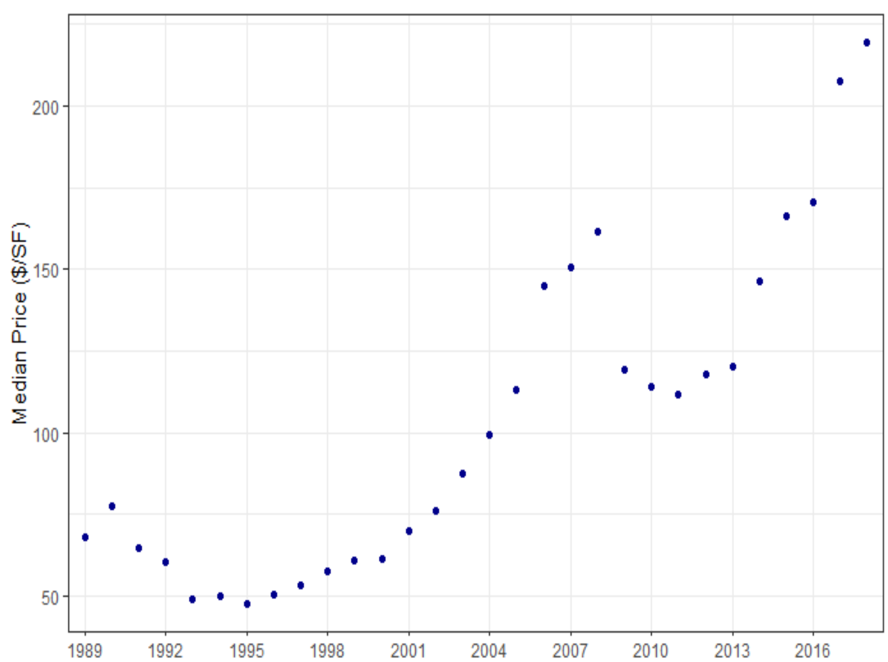

Figure 23. Median price of industrial properties sold in Los Angeles in 1989-2018

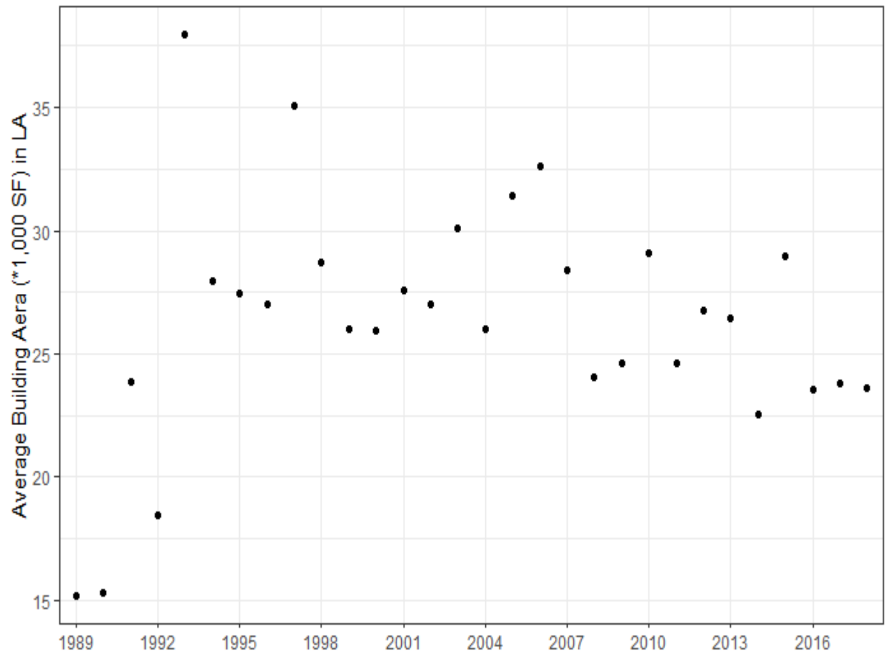

Figure 24. Average size of industrial properties sold in Los Angeles in 1989-2018

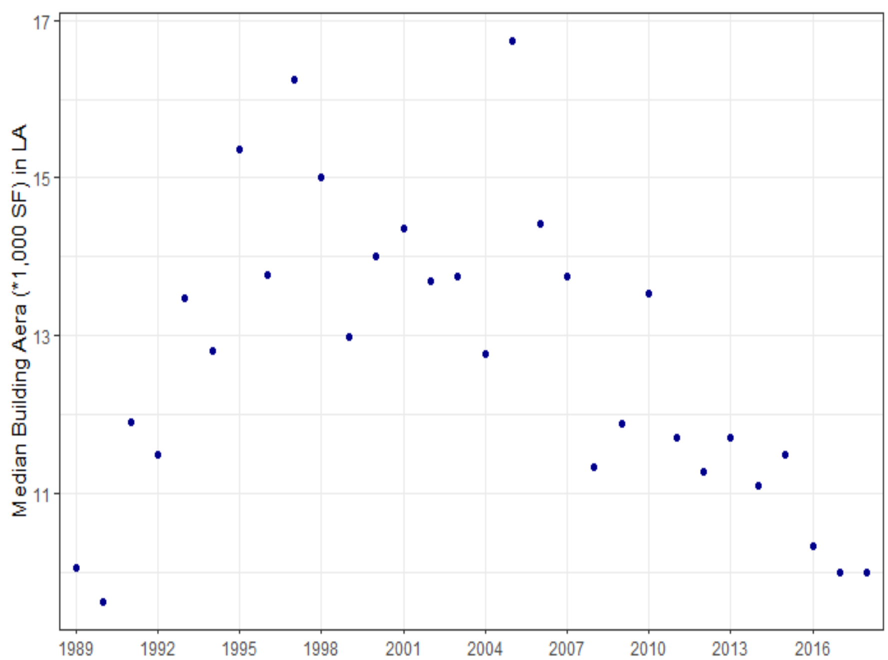

Figure 25. Median size of industrial properties sold in Los Angeles in 1989-2018

Inland Empire Market

The number of properties sold in the Inland Empire increased steadily from 20 in 1989 to 647 in 2017 and 570 in 2018 (Figure 26). Similar to the previous cases, the average transaction price could have been affected by outlier properties (see Figure 27). However, the median price

(Figure 28) increased from $46.7/sf in 1989 to $139.0/sf 2007, remained at around $75/sf from 2009 to 2014, and rose from $82.4/sf in 2013 to $153.5/sf in 2018.

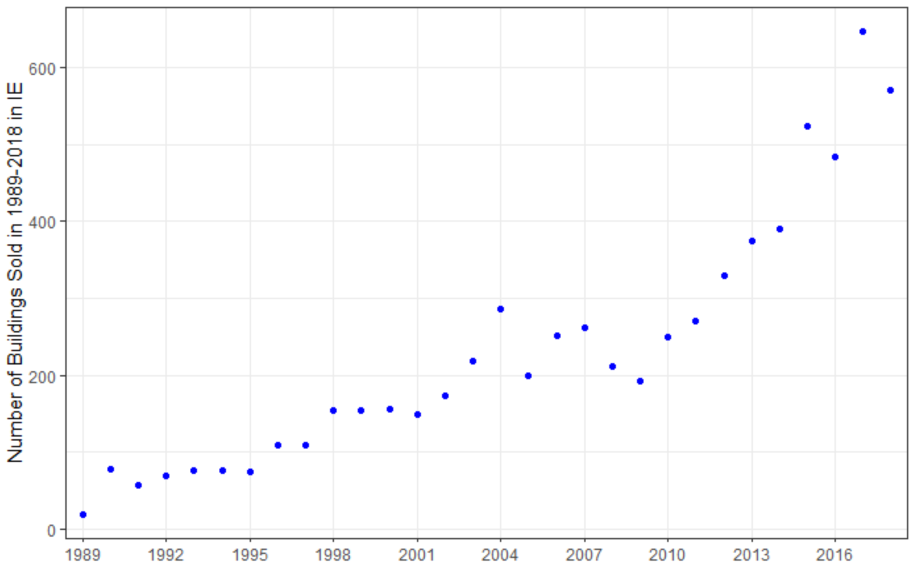

Figure 26. Number of industrial properties sold in Inland Empire in 1989-2018

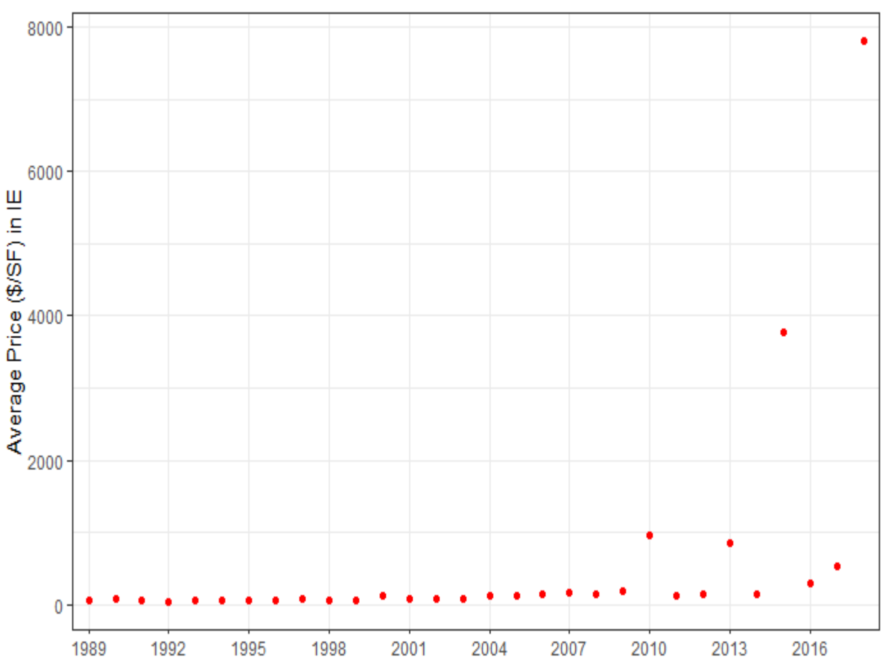

Figure 27. Average price of industrial properties sold in Inland Empire in 1989-2018

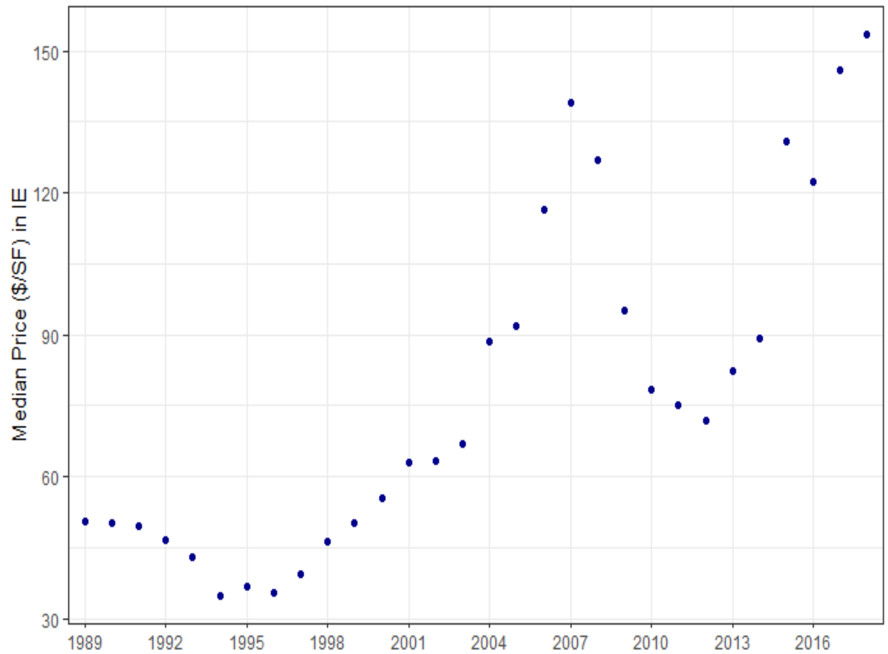

Figure 28. Median price of industrial properties sold in Inland Empire in 1989-2018

The average size of the industrial buildings in the Inland Empire show a slightly increasing trend (Figure 29). However, the trend of the median size shows smaller properties in the last decades, with the median size of the buildings decreasing from 19,067 sf in 2003 to 11,636 sf in 2017 and 12,965 sf in 2018 (Figure 30).

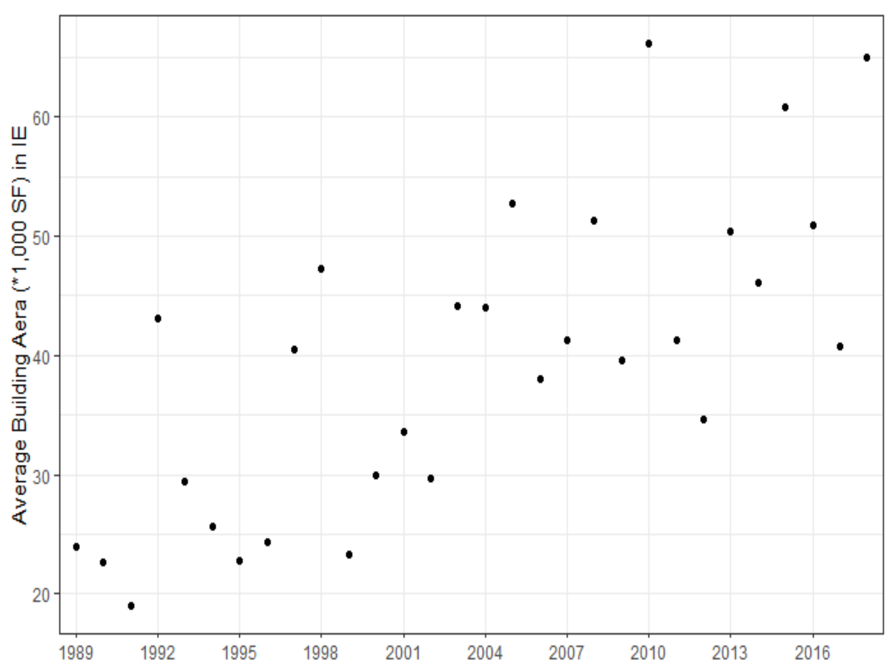

Figure 29. Average size of industrial properties sold in Inland Empire in 1989-2018

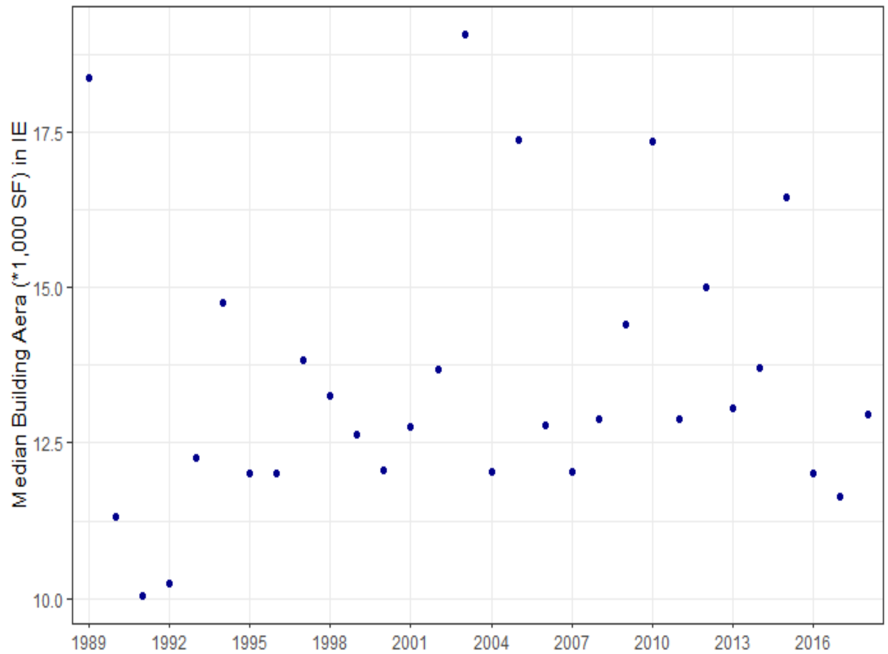

Figure 30. Median size of industrial properties sold in Inland Empire in 1989-2018

Orange Market

The number of industrial properties sold in the Orange market had a large increase in 1995; it increased from dozens in the early 1990s to 255 in 1995; after that, the number of building units sold steadily and slightly increased to 824 in 2016. This number then dropped slightly in the past two years, to 737 in 2017 and 539 in 2018 (Figure 31).

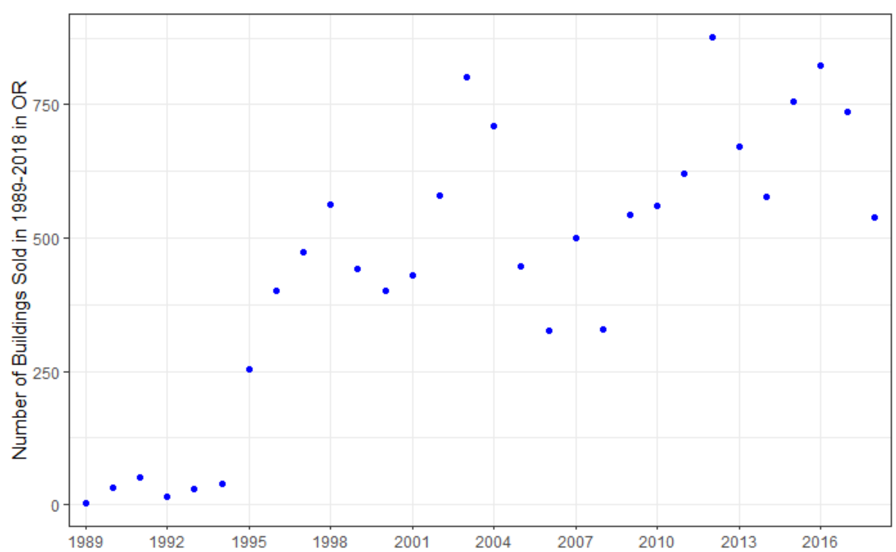

Figure 31. Number of industrial properties sold in Orange County in 1989-2018

The average and median prices in Orange County showed trends that were consistent with that of the number of properties sold (Figure 32 and Figure 33). They had steady growth with a drop in 2008. The mean and median prices were \$210.9/sf and \$218.1/sf in 2018.

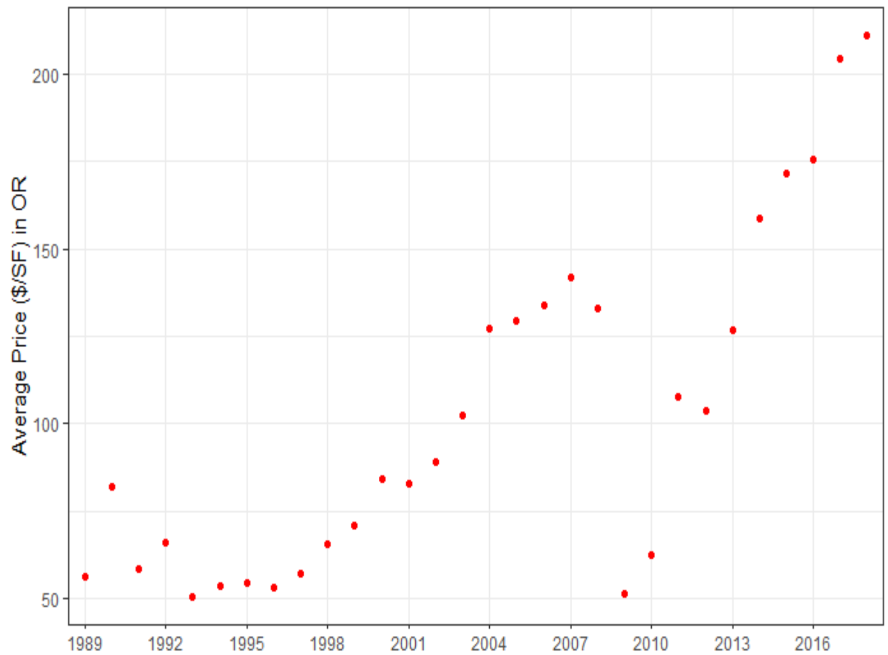

Figure 32. Average price of industrial properties sold in Orange County in 1989-2018

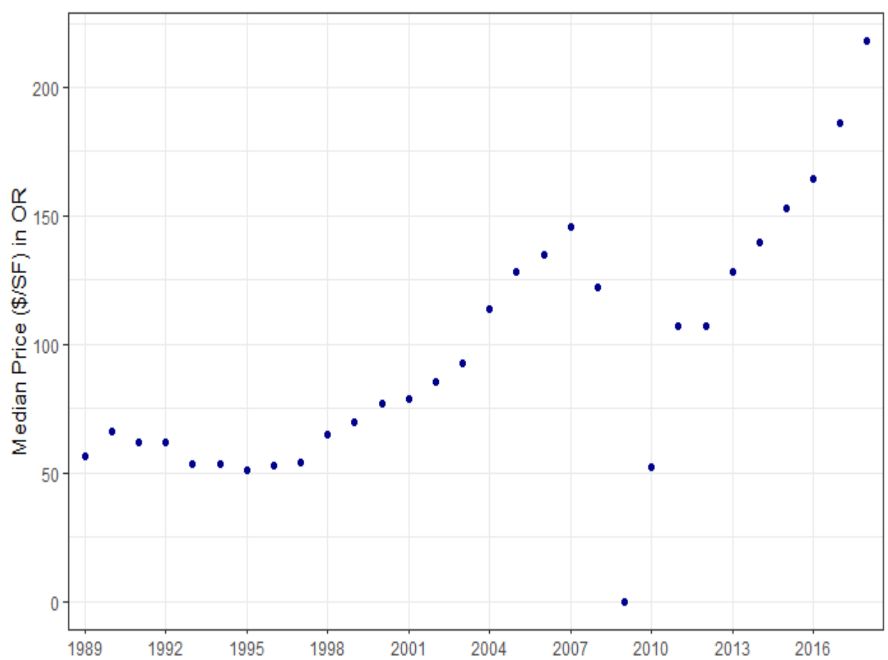

Figure 33. Median price of industrial properties sold in Orange County in 1989-2018

The mean and median of the property sizes fluctuated less during the 30 years between 1989 and 2018 (Figure 34 and Figure 35). However, the mean size was around 27,000 sf, while the median size was around 13,500 sf.

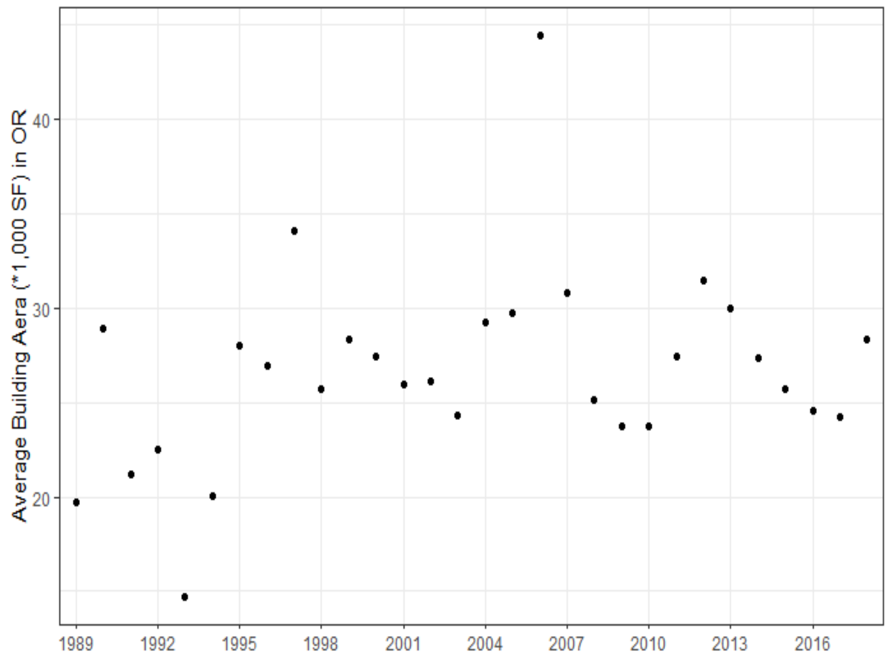

Figure 34. Average size of industrial properties sold in Orange County in 1989-2018

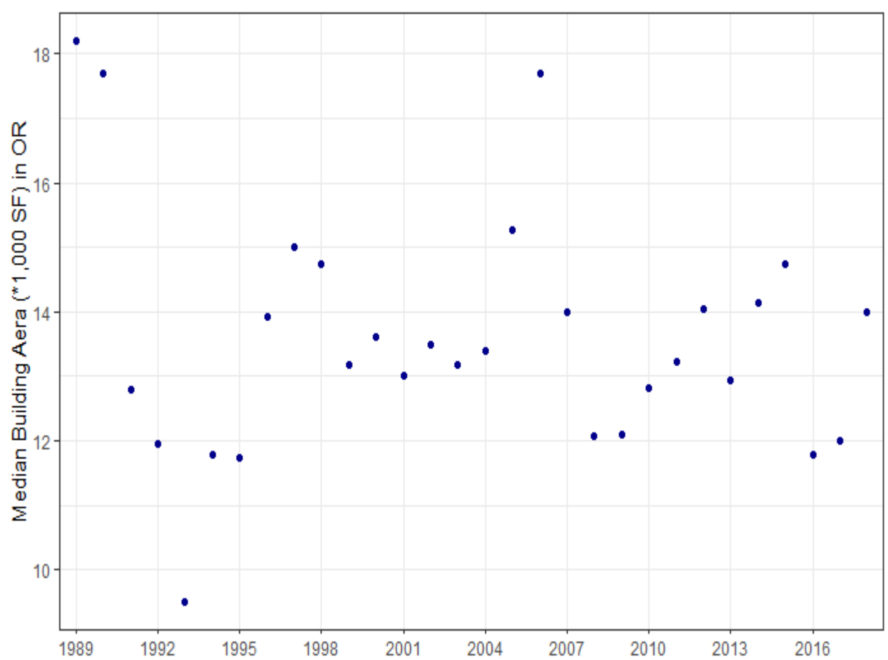

Figure 35. Median size of industrial properties sold in Orange County in 1989-2018

San Diego Market

Similar to the number of industrial properties sold in the Orange market, the number sold in the San Diego market increased from dozens to nearly 200 between 1989 and 1994, then jumped to 197 in 1995, and increased steadily to 616 in 2015. However, the number decreased in the past three years to 485 in 2018 (Figure 36).

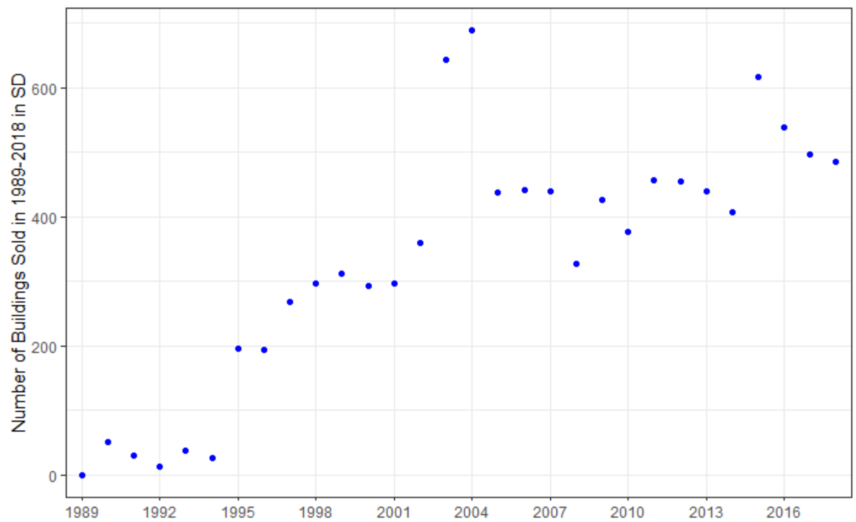

Figure 36. Number of the industrial properties sold in San Diego in 1989-2018

The mean and median price of the properties sold in San Diego showed trends consistent with that of the number of properties sold, with a rise from 1989 to 2007, a decrease in 2008, and an increase again from 2009 to 2018 (Figure 37 and Figure 38).

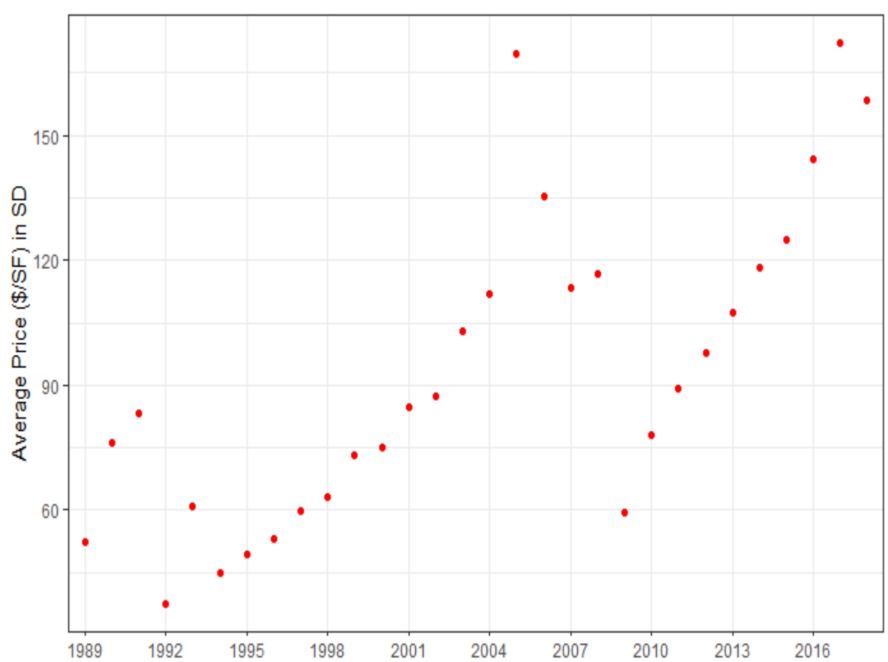

Figure 37. Average price of industrial properties sold in San Diego in 1989-2018

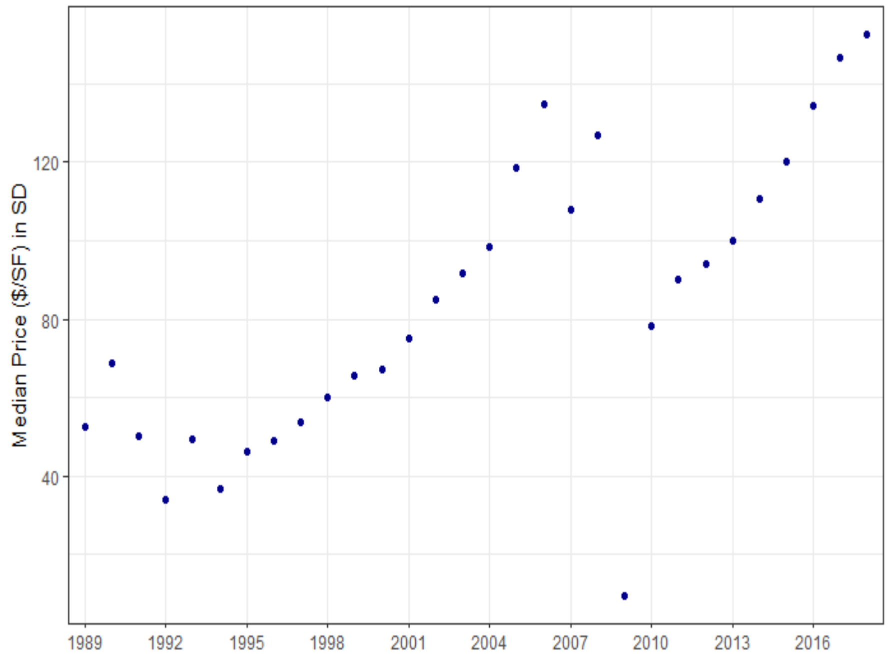

Figure 38. Median price of industrial properties sold in San Diego in 1989-2018

The average building size in San Diego fluctuated around 25,000 sf in 1989 to 2018. The median building size showed a slightly decreasing trend over the years, with the largest median size of 26,041 sf in 1989 and 19,138 sf in 1993; the median sizes in 2017 and 2018 were 14,933 sf and 14,290 sf, respectively (see Figure 39 and Figure 40).

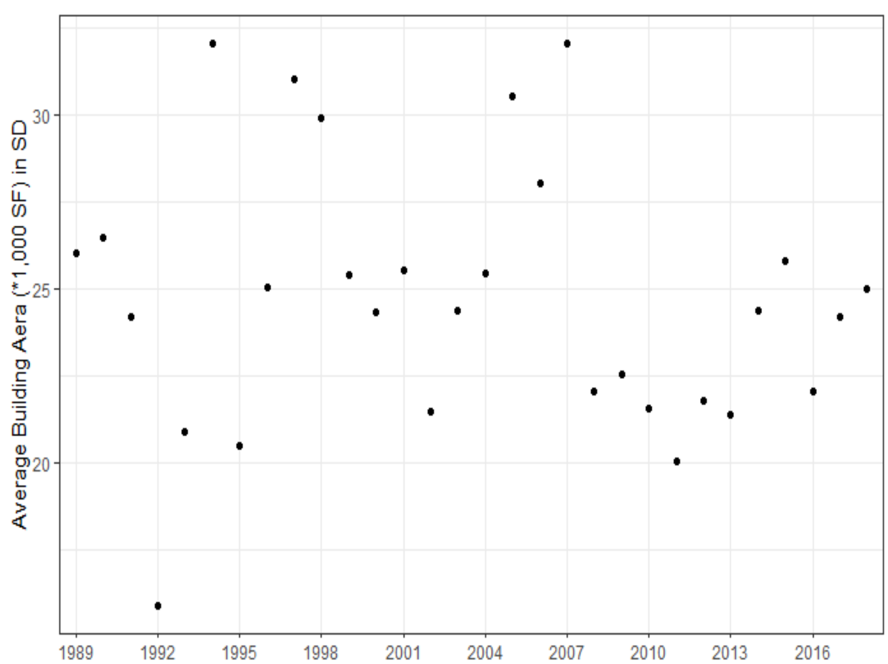

Figure 39. Average size of industrial properties sold in San Diego in 1989-2018

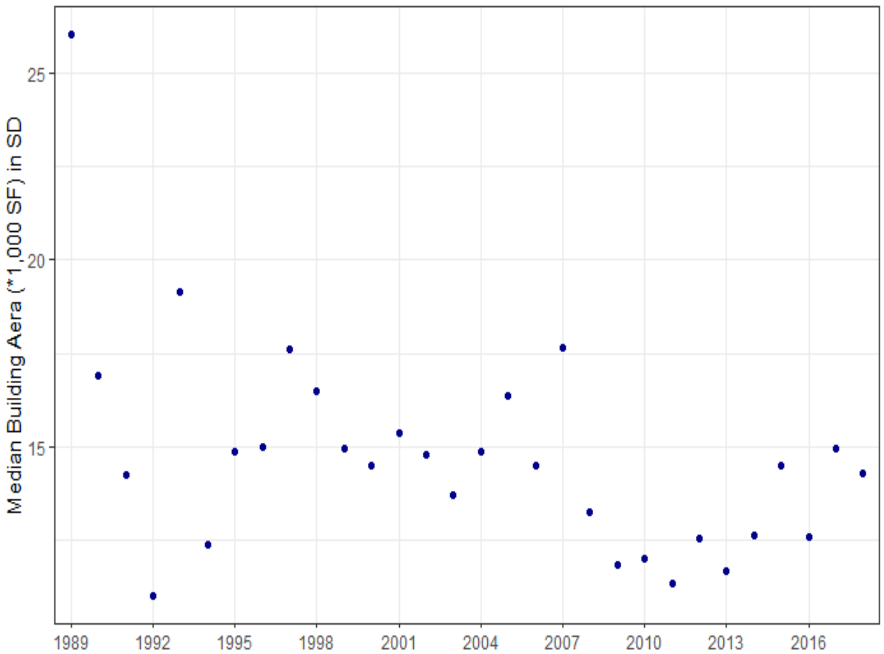

Figure 40. Median size of industrial properties sold in San Diego in 1989-2018

Changes in the Size of Properties Sold

The previous graphs show that, overall, the properties sold in the various markets have decreased in size from 2000 to 2008, and in some cases decreased even more after 2008. We estimated a linear regression to get a general idea of the magnitude of this trend. Specifically, we concentrated on the period between 2000 and 2018.

For the properties in Los Angeles, the mean size of the properties sold between 2000 and 2018 showed a downward trend from 26 k sf in 2000 to 23.6 k sf in 2018. The fitted linear function has a slope of -0.244, which means that the mean size of the properties sold decreased 0.244 k sf every year (see Figure 41). The median size also shows a downward trend, with a median size of 14 k sf in 2000 decreasing to 10 k sf in 2018. The slope of the fitted line of the median size is -0.259—in other words, a decrease by 0.259 k sf every year (Figure 42).

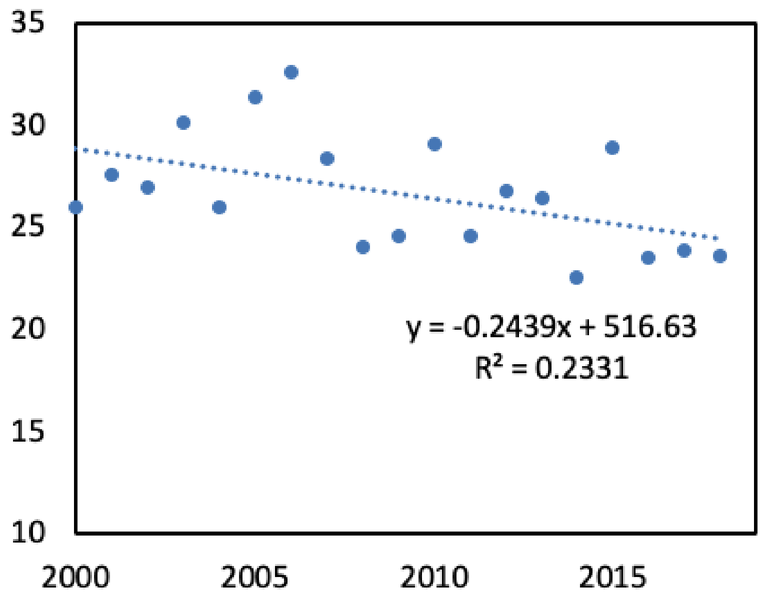

Figure 41. Los Angeles mean property sizes (2000-2018)

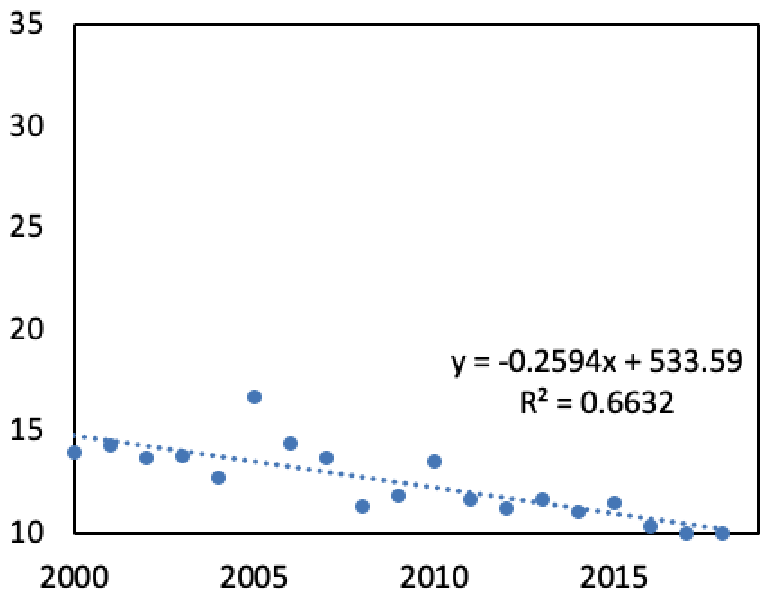

Figure 42. Los Angeles median property sizes (2000-2018)

In the Inland Empire, the mean size of properties sold from 2000 to 2018 increased from 29.9 k sf in 2000 to 64.9 k sf in 2018. The large increase in average size may be due to the fact that there were a number of high cube mega warehouse developments in the area in recent years. The fitted line has a slope of 1.100—i.e., an increase of 1.100 k sf every year (Figure 43). On the contrary, the median size (Figure 44) shows a downward trend, at 12.1 k sf in 2000 to 12.9 k sf in 2018. The slope of the fitted line of the median size is -0.043, or a decrease of 0.043 k sf every year.

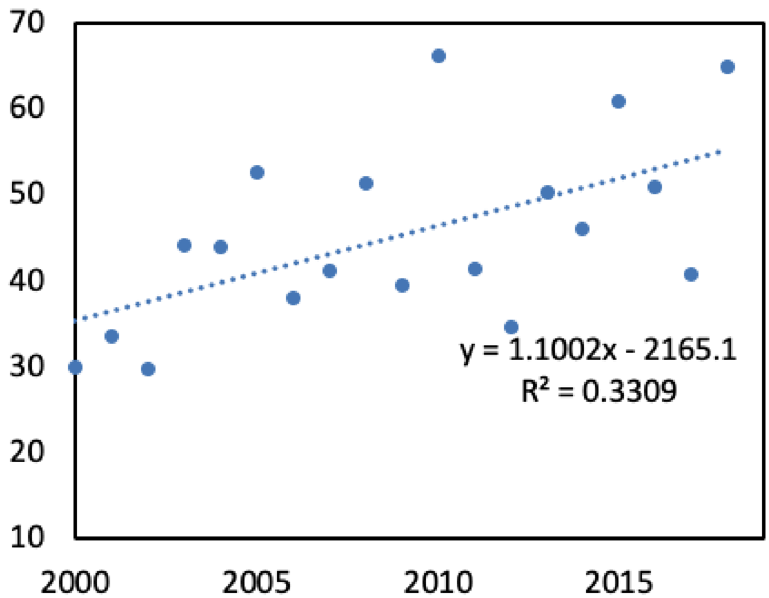

Figure 43. Inland Empire mean property sizes (2000-2018)

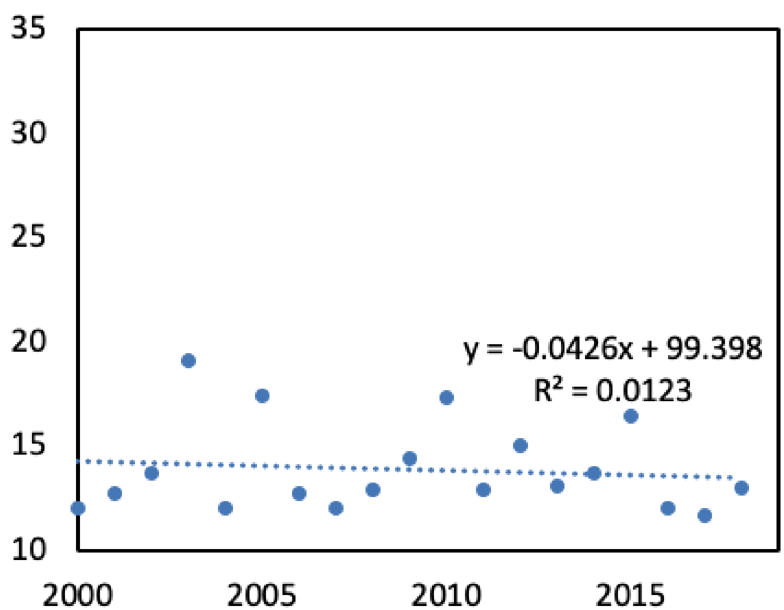

Figure 44. Inland Empire median property sizes (2000-2018)

In Orange County, the mean size (Figure 45) of properties sold between 2000 and 2018 showed a downward trend from 27.4 k sf in 2000 to 24.2 k sf in 2017 and 28.4 k sf in 2018. The fitted line has a slope of -0.111, indicating a decrease of 0.111 k sf every year. Of note, the property size in Orange County may have not followed a linear trend (explained by the low R2), showing a drop after 2008, increasing for the few years until 2012, and then decreasing again. The median size (Figure 46) also shows a downward trend (with less variability than the average size, though the linear fit is poor), with median size of 13.6 k sf in 2000 decreasing to 12.0 k sf in

2017. The slope of the fitted line of the median size is -0.043, indicating a decrease of 0.043 k sf every year.

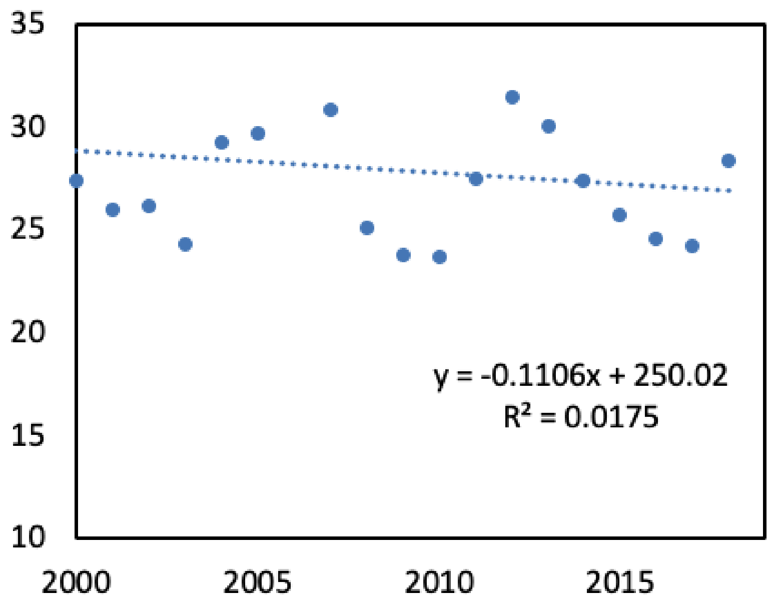

Figure 45. Orange County mean property sizes (2000-2018)

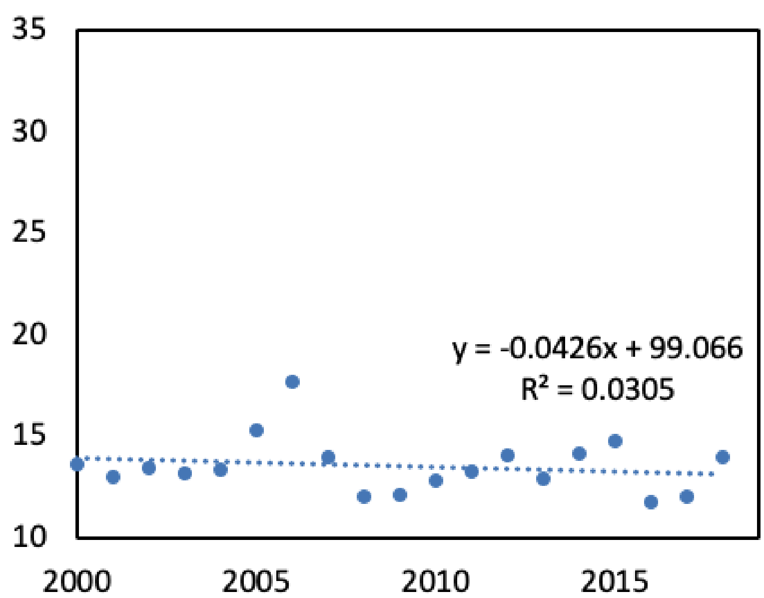

Figure 46. Orange County median property sizes (2000-2018)

Finally, properties sold in the San Diego market also showed a downward trend from 25.5 k sf in 2001 to 24.2 k sf in 2017. The fitted line has a slope of -0.135, indicating a decrease of 0.135 k sf every year (Figure 47). The median size also showed a downward trend (Figure 48) with median size of 14.5 k sf in 2000 to 14.3 k sf in 2018. The slope of the fitted line of the median size is -0.115, indicating a decrease of 0.115 k sf every year.

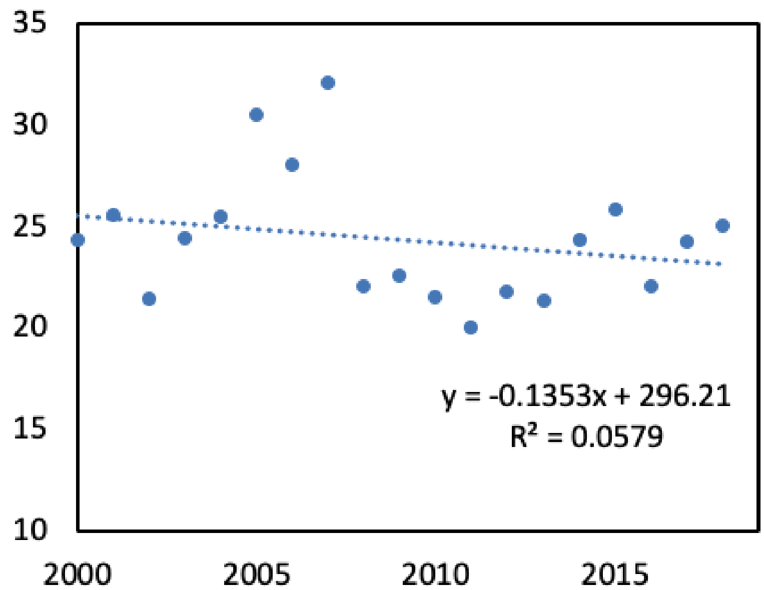

Figure 47. San Diego mean property sizes (2000-2018)

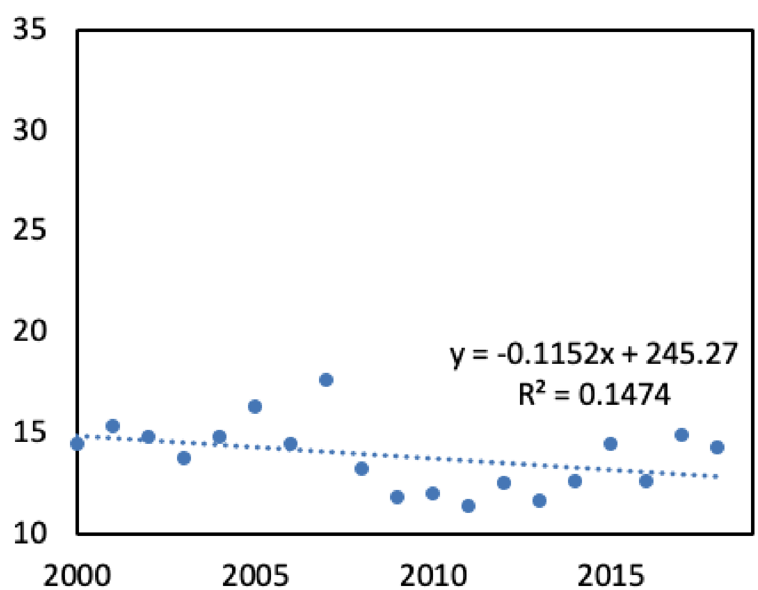

Figure 48. San Diego median property sizes (2000-2018)

Relative Distance to Downtown Area

Los Angeles Market

The location of central Los Angeles was set at longitude and latitude of -118.2437, 34.0522. We then estimated the Euclidean distance from the properties sold to downtown Los Angeles. The yearly mean distance for the sold properties between 1989 and 2018 shows a downward trend

(Figure 49). A linear fit with the yearly average distance has a slope of -55.21, indicating that industrial properties were getting 55 meters closer to central Los Angeles every year. The yearly median distance between 1989 and 2018 also show a downward trend, with the slope less steep (Figure 50). A linear fit with the yearly median distance had a slope of -16.19, indicating that the median distance of industrial properties were 16 meters closer to central Los Angeles every year.

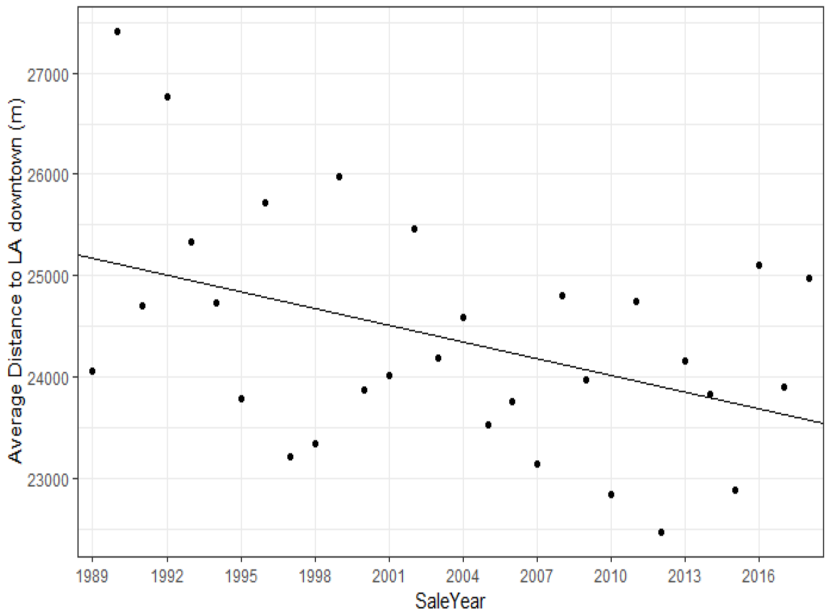

Figure 49. Mean distance (meters) of industrial properties in Los Angeles to Central Los Angeles. d=−55.21 t+25231.8

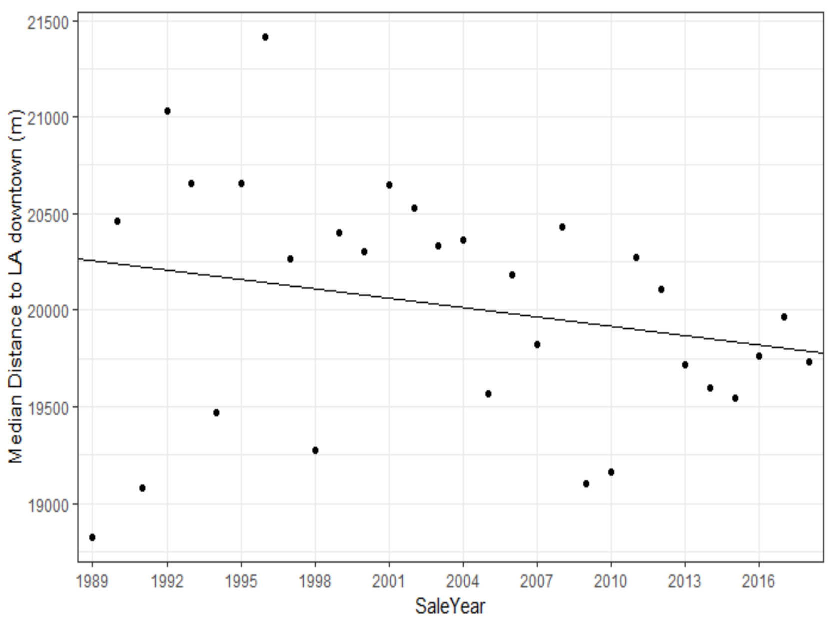

Figure 50. Median distance (meters) of industrial properties in Los Angeles to Central Los Angeles. d=−16.19 t+20273.8

Figure 51 and Figure 52 show the location of the geographic center of the properties sold. The dots display the yearly center of the industrial properties and the triangles represent the center weighted by size of the industrial properties. Two trends can be observed in the geographical change over time: the geographical centers are overall moving closer to the Los Angeles downtown area; and larger properties locate farther from LA downtown area which result in a weighted center farther away from the downtown area.

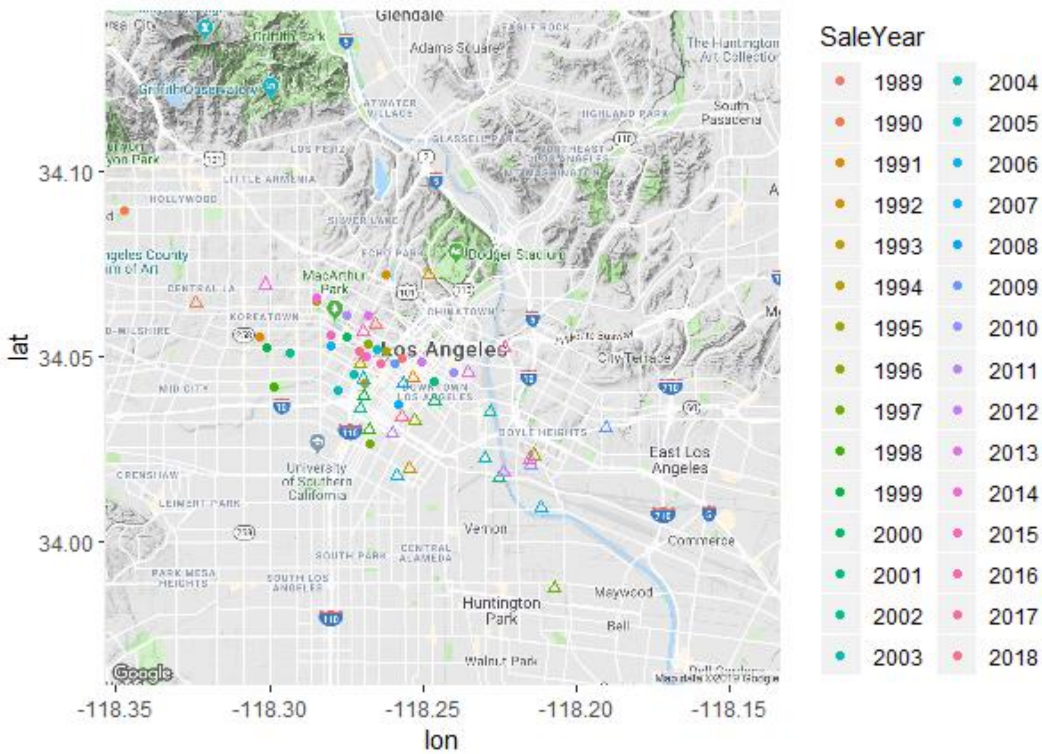

Figure 51. Geographic centers of industrial properties sold in Los Angeles by year. Dots represent geographical centers and triangles represent geographical centers weighted by center size.

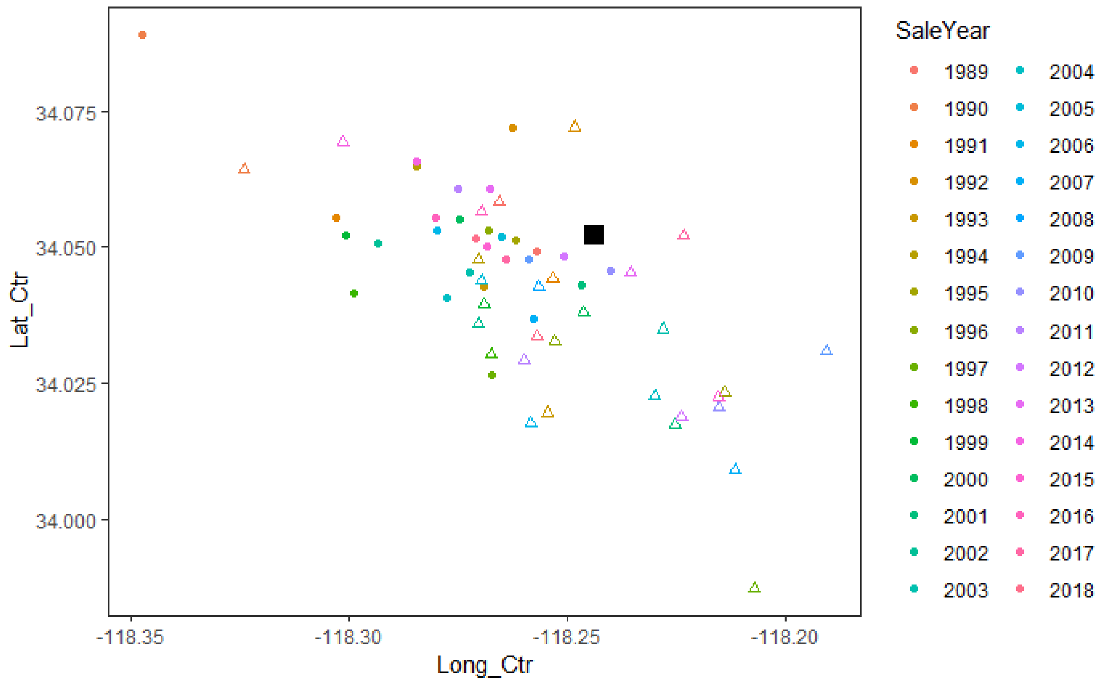

Figure 52. Relative location of geographic centers of industrial properties sold in Los Angeles to downtown Los Angeles (represented by the black square). Dots represent geographical centers and triangles represent geographical centers weighted by center size.

Inland Empire Market

The location of central Inland Empire (IE) was set at longitude and latitude to -118.2437, 34.0522. We estimated the distance to downtown IE of the properties sold in the IE market. The mean distance of industrial properties to central IE is decreasing (Figure 53). The fitted linear function has a slope of -207, which means that properties are moving 207 meters closer to central IE every year. The median distance (Figure 54) of industrial properties to central IE also decreased from 1989 to 2018. The slope of the linear model was -184, slightly smaller in magnitude than that of the mean distance fit and indicating that sold industrial properties are moving 184 meters closer to central IE every year.

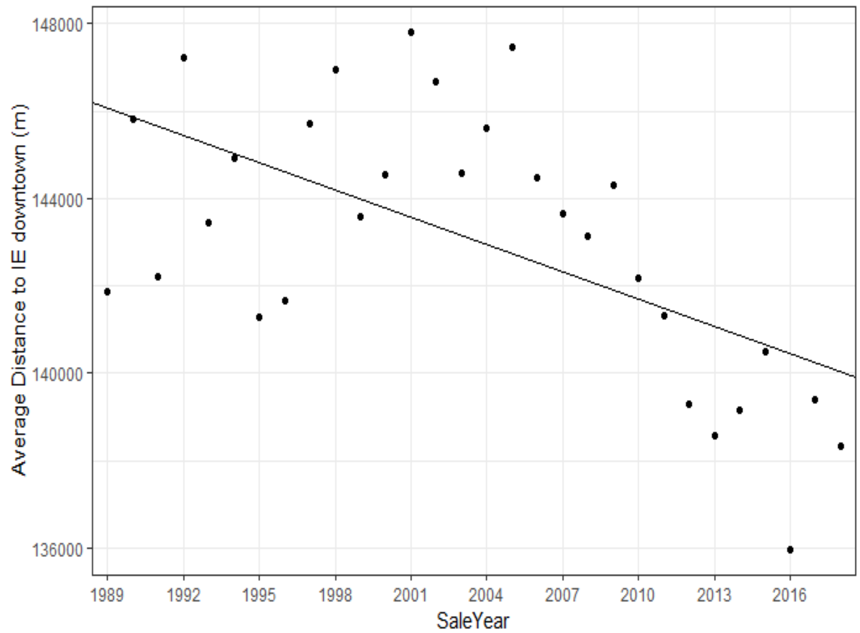

Figure 53. Mean distance (meters) of industrial properties in the Inland Empire (IE) to central IE. $\mathrm{d} = \boldsymbol{-207.65\ t + 146273.25}$

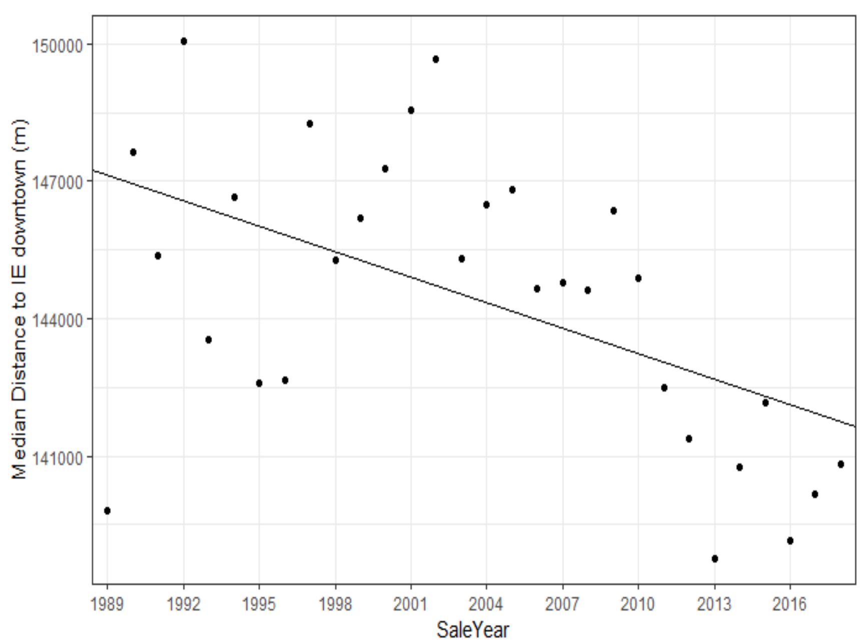

Figure 54. Median distance (meters) of industrial properties in the IE to central IE. $\mathrm{d} = \boldsymbol{-184.68\ t + 147302.0}$

Orange Market

The location of central Orange County was set to longitude and latitude of -117.8311, 33.7175.

The mean distance of industrial properties to central Orange County also got shorter during this time period (Figure 55). A slope of -62.58 means the properties sold were moving 62.58 meters closer to central Orange County every year.

The median distance also decreased with a slope of -31.09, indicating a movement of 31.09 meters closer to central Orange County every year (Figure 56).

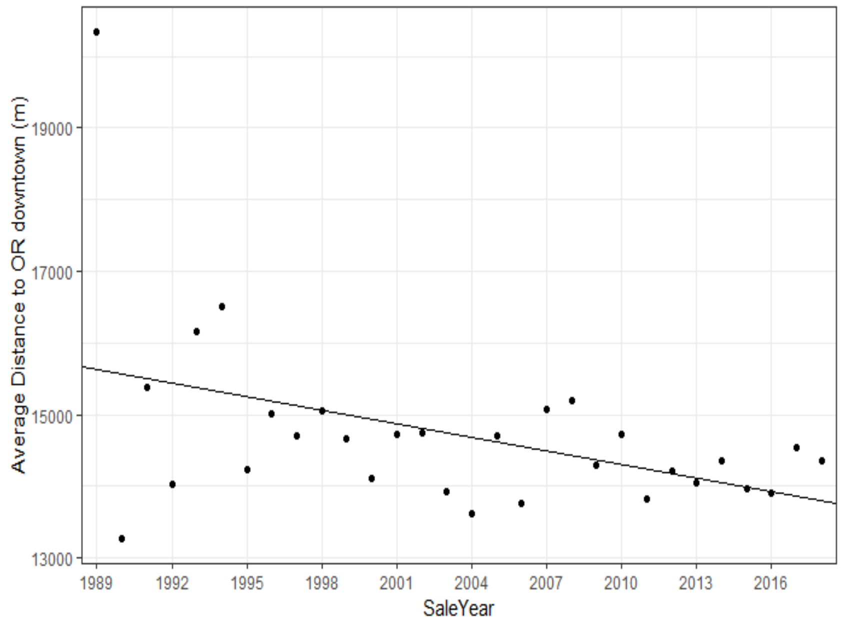

Figure 55. Mean distance (meters) of industrial properties in Orange County market to central Orange County. $d = -62.58\, t + 15684.94$

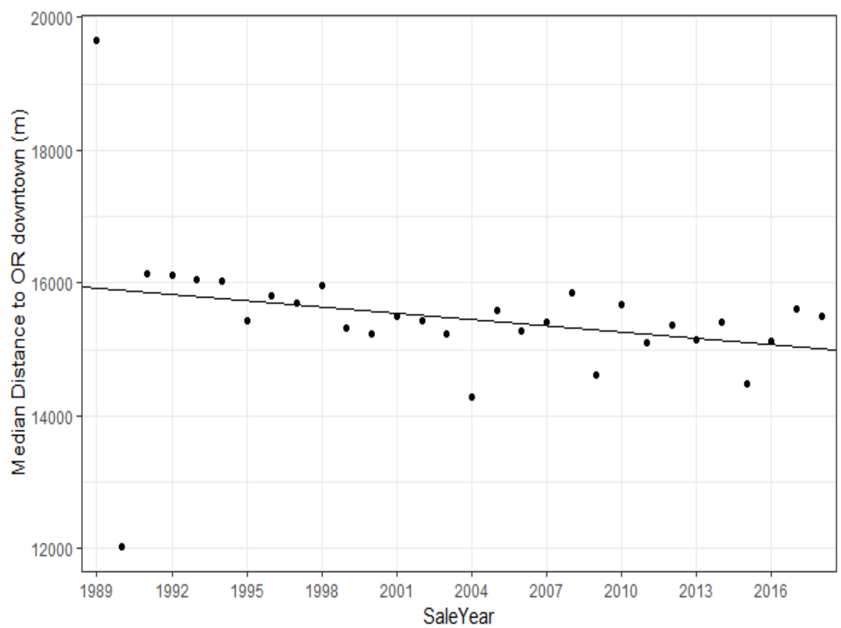

Figure 56. Median distance (meters) of industrial properties in Orange County market to central Orange County. $d = -31.09t + 15949.49$

San Diego Market

The location of central San Diego was set to longitude and latitude of 117.1611, 32.7157. The mean distance of San Diego industrial properties is getting farther away from central San Diego. A slope of 103 indicates that, on average, the properties sold are getting 103 meters farther away from the central San Diego area (Figure 57).

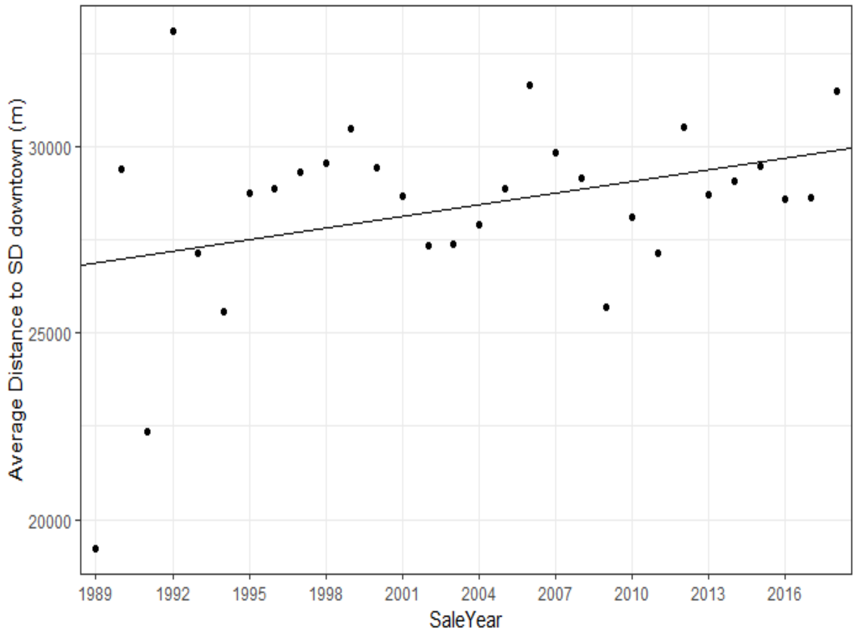

Figure 57. Mean Distance (meters) of Industrial Properties in SD to central SD. $d = \mathbf{103.23}\ \boldsymbol{t} + \mathbf{26774.38}$

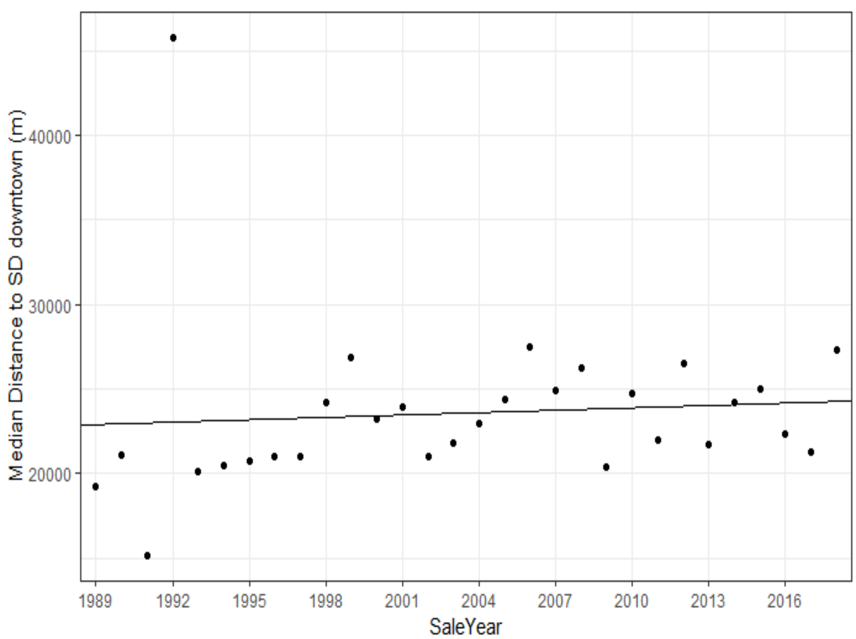

Figure 58. Median Distance (meters) of Industrial Properties in SD to central SD. $d = \mathbf{45.42}\ \boldsymbol{t} + \mathbf{22868.88}$

The median distance (Figure 58) of industrial properties is smaller than the mean distance, which implies that there are more properties closer to rather than further from central San Diego. The slope of the linear fit of the median distance is 45.42, which means the properties sold are getting 45.42 meters further away from center San Diego.

Relative Distance to the San Pedro Bay Ports

As in the previous analyses, we estimated the relative distance of the sold properties to the San Pedro Bay Ports. Specifically, the team used the Port of Los Angeles (POLA), and set the reference point to longitude and latitude of -118.2922, 33.7360.

The mean distance of industrial properties to POLA are in Figure 59. The overall trend is that the mean distance increased from 1989 to 2008 and then deceased from 2009 to 2018. The slope of the linear fit is 274.99, indicating that sold properties moved 275 meters farther away from POLA every year. Noteworthy, as mentioned before, although the distance has increased from 1989 to 2008, it then decreased (not captured by the linear model).

The median distance of industrial properties to POLA are shown in Figure 60. The overall trend is that the median distance fluctuated from 1989 to 2018. The linear fit has a slope of -10.88, indicating that the median distance of sold properties from POLA decreased by 10.88 meters every year.

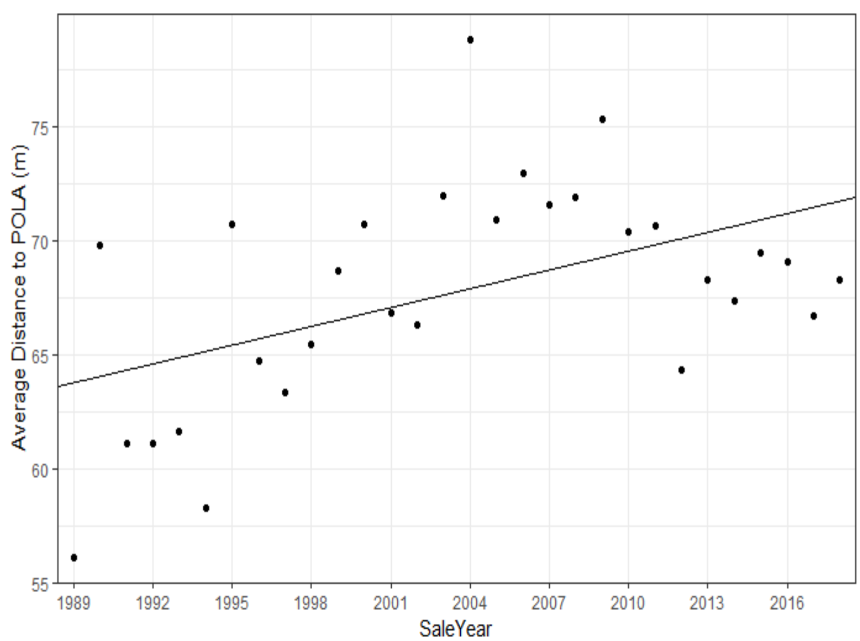

Figure 59. Mean distance (meters) of industrial properties sold in Southern California from the Port of Los Angeles (POLA). $d = \mathbf{274.99}\ \boldsymbol{t} + \mathbf{63498.3}$

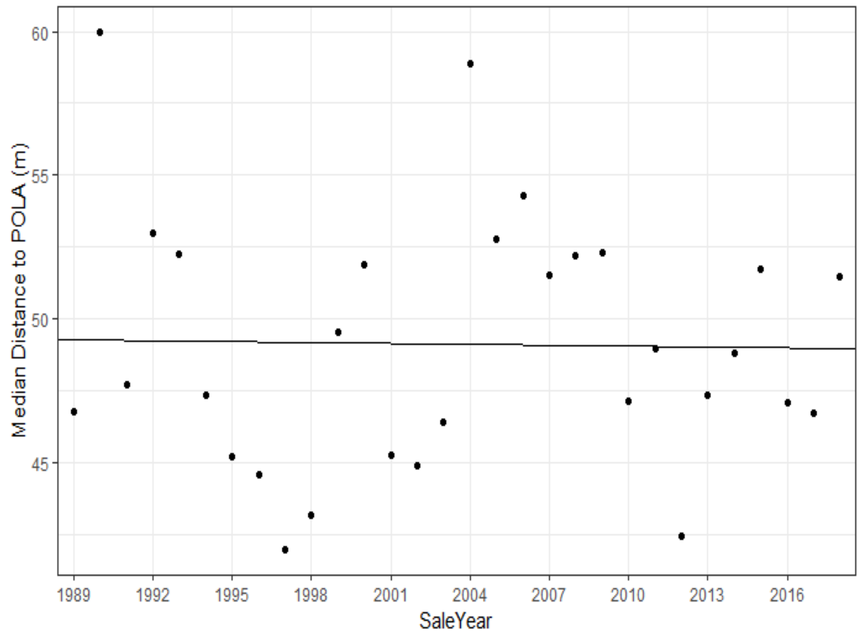

Figure 60. Median distance (meters) of industrial properties sold in Southern California from the Port of Los Angeles (POLA). $d = \mathbf{-10.88}\boldsymbol{t} + \mathbf{49284.8}$

Properties Sold in Different Distance Buffers from the Port of LA

We created several distance buffers from POLA to conduct more detailed analyses. The buffers were: 0-20 km, 20-50 km, 50-100 km, and more than 100 km. Figure 61 and Figure 62 show the number of transactions and the percentage for each buffer, respectively. Among the different buffers from POLA, the buffer from 20 to 50 km from POLA had the highest number of sold properties, and these have increased fast in past years. The overall distribution of sold properties among these buffers was consistent throughout the study period.

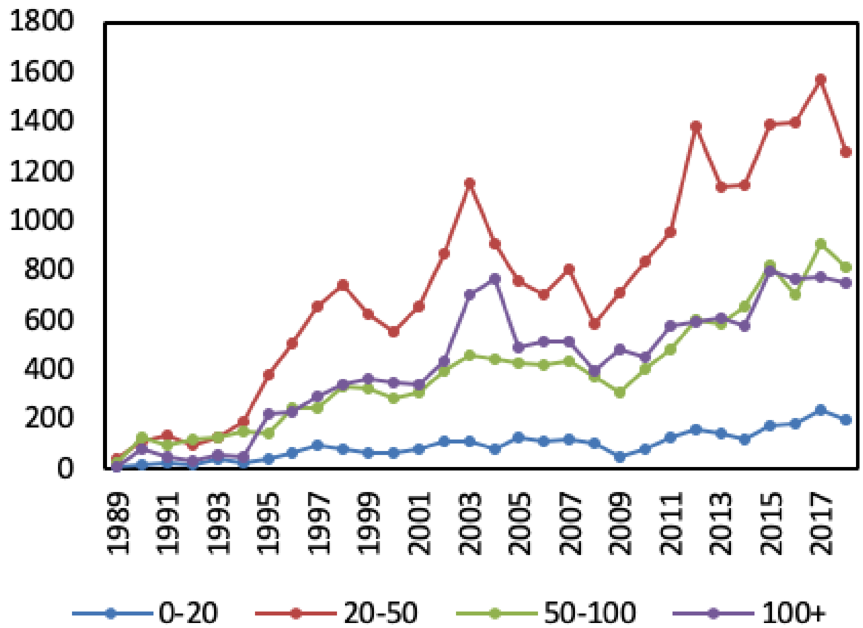

Figure 61. Number of properties sold in different distance (miles) buffers

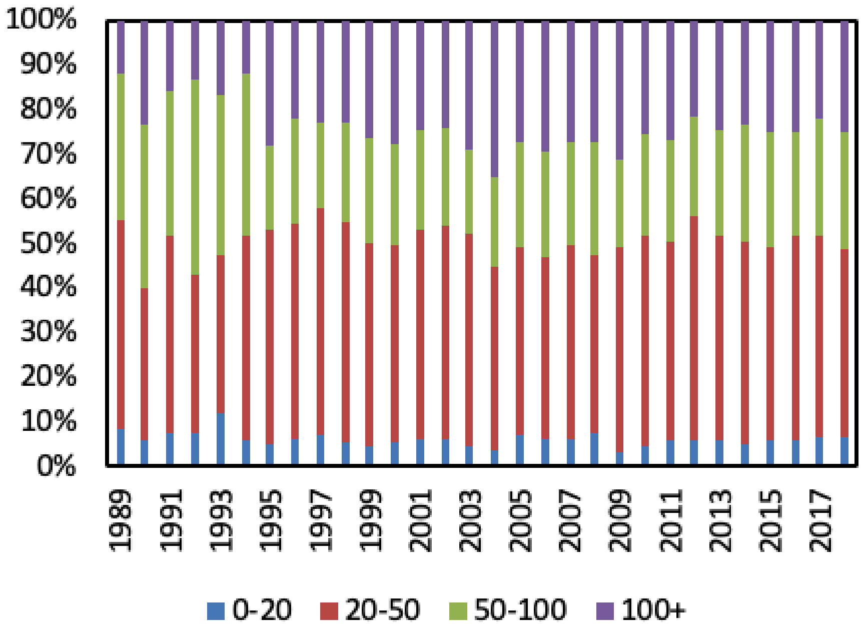

Figure 62. Percentage of properties sold each year in the different distance (miles) buffers

Figure 63 and Figure 64 show the mean and median size of the properties sold in the distance buffers. The mean size fluctuated around 30k square feet during the last decade, while the median sizes of the properties slightly decreased over this period. In the last decade, the properties sold in the 0-20 km buffer experienced a larger size reduction than those in other buffers.

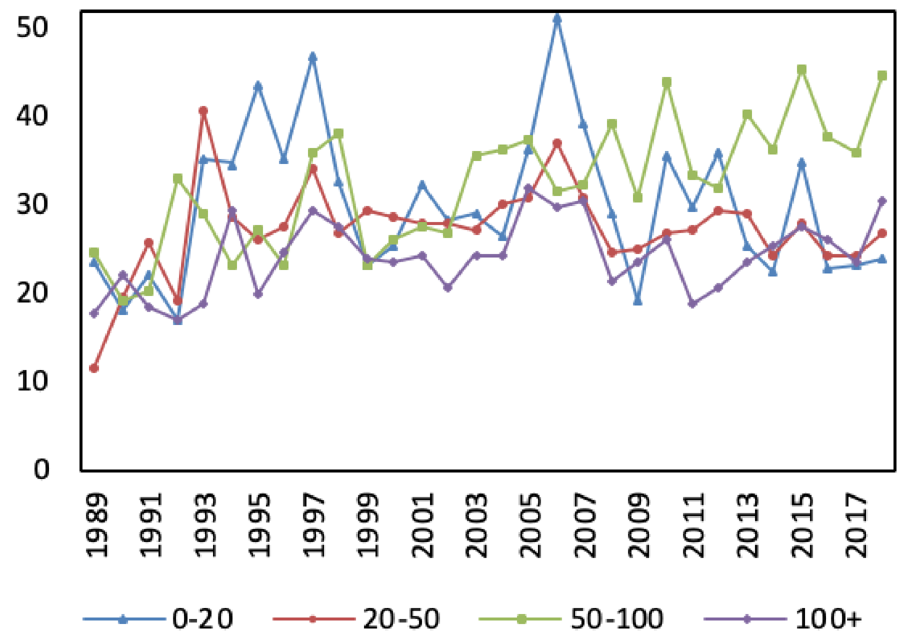

Figure 63. Average size of the industrial properties sold in Southern California in 1989-2018 in the different distance (miles) buffers

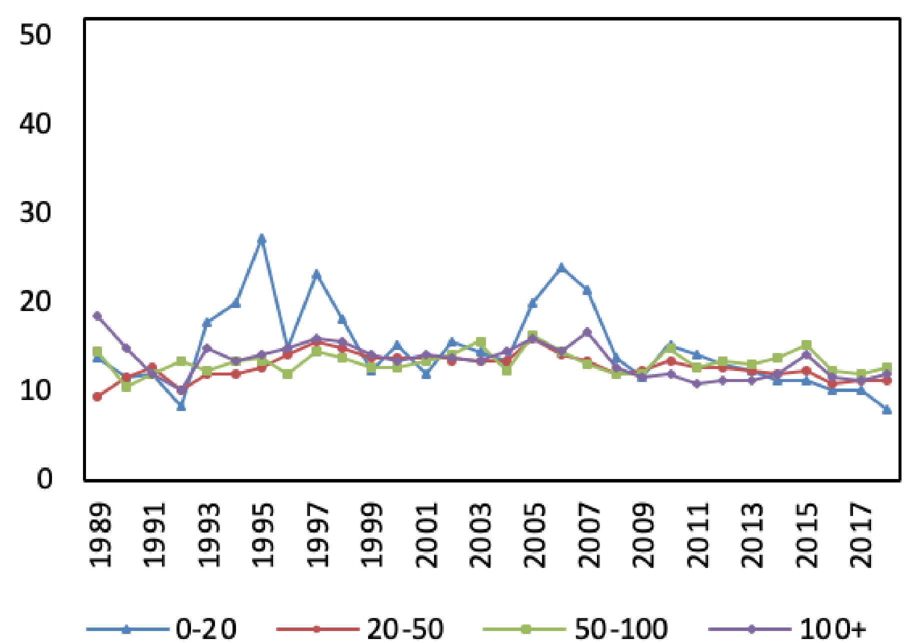

Figure 64. Median size of the industrial properties sold in Southern California in 1989-2018 in the different distance (miles) buffers

Leased Properties

The Costar Group Inc. database contains disaggregate information about every leased transaction, however these data can be downloaded only in summary form, unlike the data on sold properties. Therefore, we gathered only summary data for these transactions. We focused on the period between 2000 and 2018 for the four industrial real estate markets.

During this period, there were 123,885 lease transactions of industrial properties in Southern California (in the Costar Group Database). In 2018, for example, 20.7% of the leases were in the Inland Empire market, 40.0% in the Los Angeles market, 21.8% in the Orange market, and 17.6% in San Diego market in 2018 (as shown in Figure 65).

From the size perspective, 1.8 billion sf of industrial properties were leased in Southern California between 2000 and 2018. Among them, 45.5% were in the Inland Empire, 27.6% in Los Angeles, 15.0% in Orange County, and 11.9% in San Diego in 2018 (Figure 66). Figure 67 shows the number of industrial properties leased in the four markets in this period. Between 2000 and 2018, the number of leases recorded peaked in 2013 and slightly decreased between 2013 and 2018. Among the four markets, about 40% of the properties were leased in Los Angeles, and 20% were in each of the other three markets. On average, there were 2,607 leases per year in Los Angeles, 1,349 in the Inland Empire, 1,418 in Orange County, and 1,146 in San Diego.

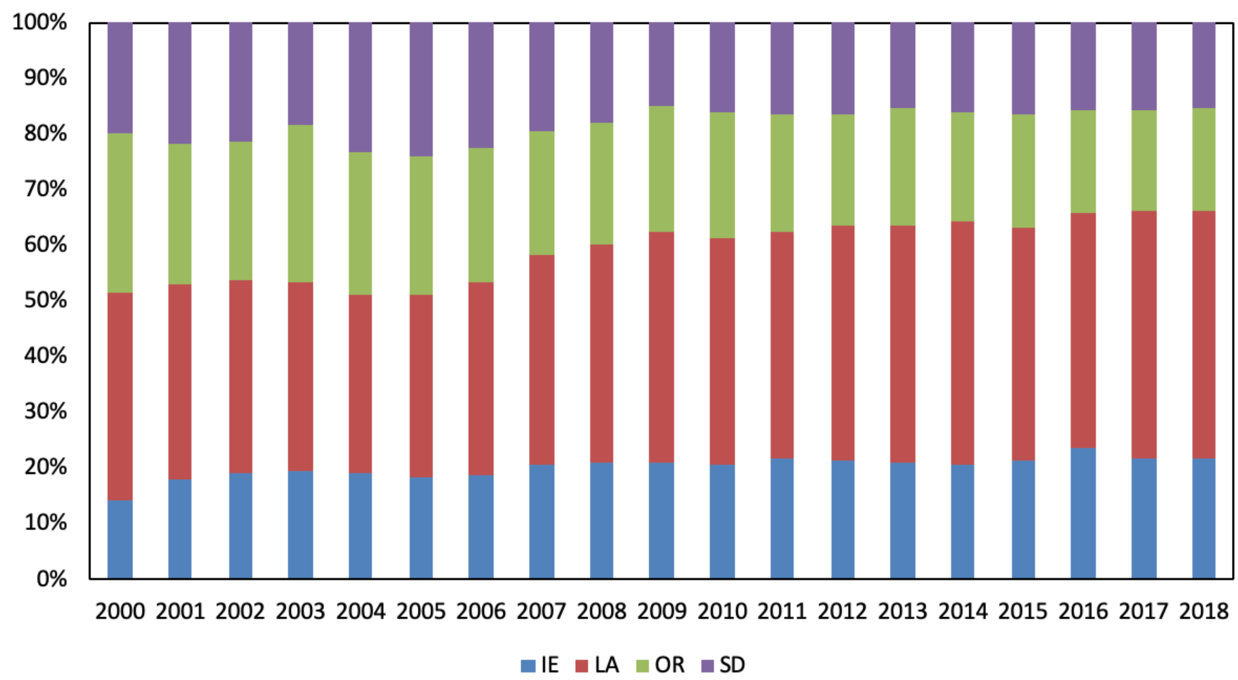

Figure 65. Percentage of industrial properties leased in each market (IE, Inland Empire; LA, Los Angeles; OR, Orange County; SD, San Diego)

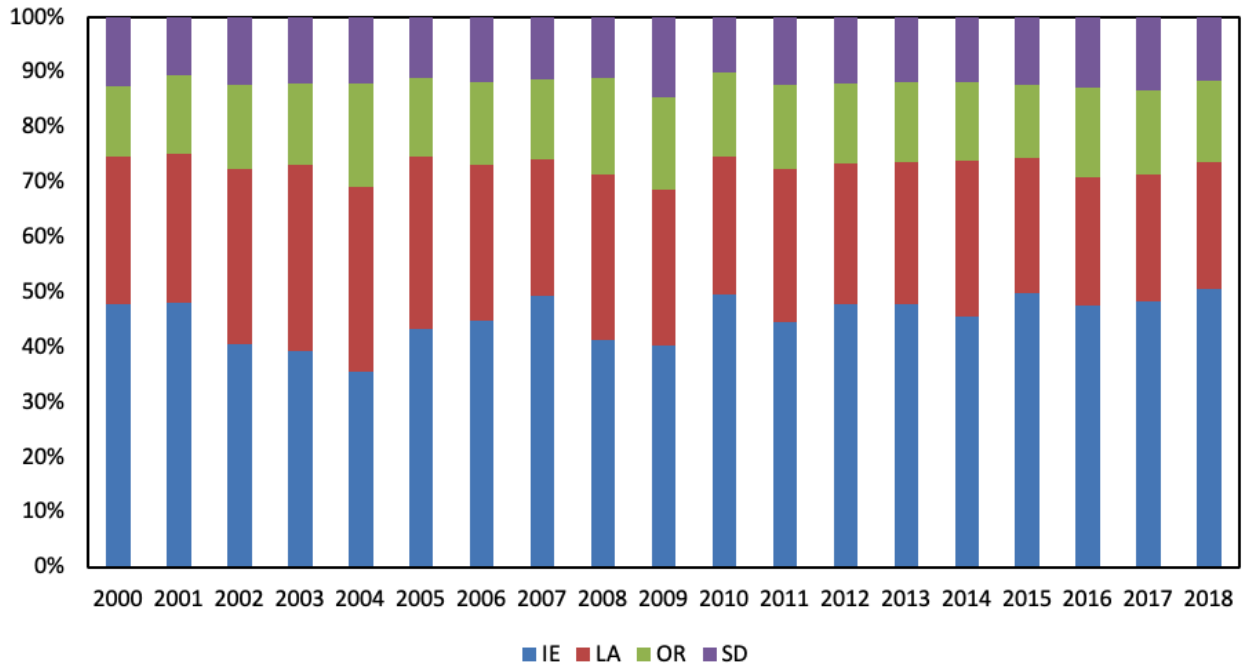

Figure 66. Size of leased properties (IE, Inland Empire; LA, Los Angeles; OR, Orange County; SD, San Diego)

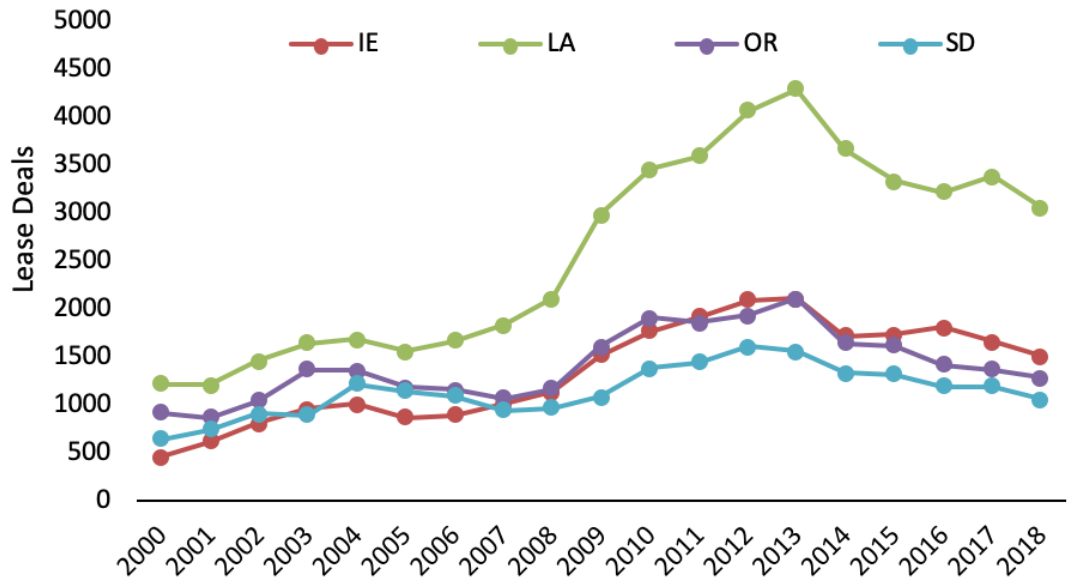

Figure 67. Number of leased properties (IE, Inland Empire; LA, Los Angeles; OR, Orange County; SD, San Diego)

Figure 68 shows the changes in the average size of the leased properties. In the Inland Empire, the average size is the largest, ranging between 18k-38k sf. In Los Angeles, the size is smaller than those in the Inland Empire, but larger than those in Orange County and San Diego. Between 2000 and 2018, the average size has been decreasing in the Los Angeles market. The units leased in the Orange County market and those in San Diego are similar in size, and the trend over the years was stable.

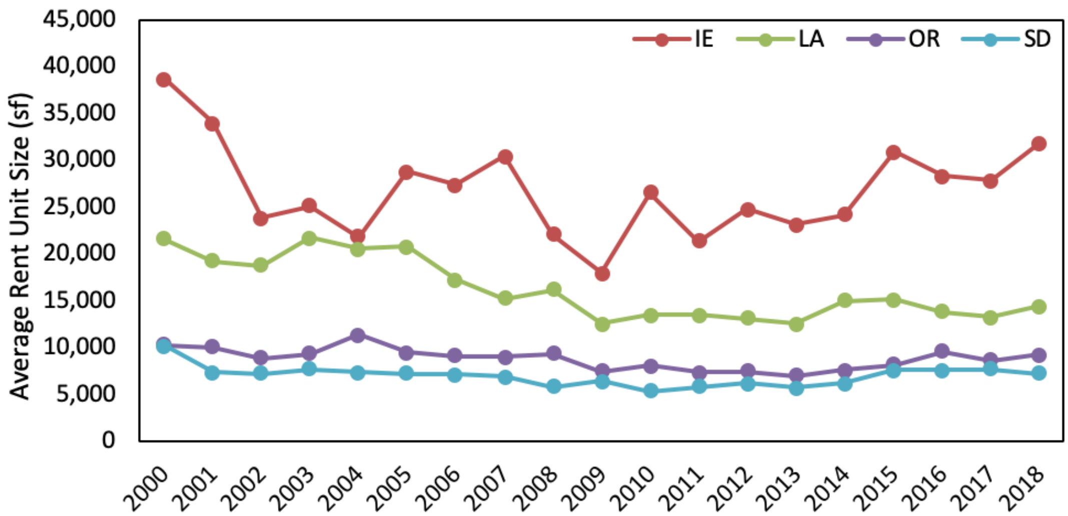

Figure 68. Average industrial property size leased in Southern California between 2000-2018 (IE, Inland Empire; LA, Los Angeles; OR, Orange County; SD, San Diego)

The team also analyzed the changes in leased prices (see Figure 69). The average lease price in the four markets converged after 2005. While the overall average price was higher in San Diego and lower in the Inland Empire, the rental price in Los Angeles and the Orange County were close to one another, lying in between those of San Diego and the Inland Empire. The average prices over the years were $4.9/sf in the Inland Empire, $8.0/sf in Los Angeles, $7.9/sf in Orange County, and $10.3/sf in San Diego.

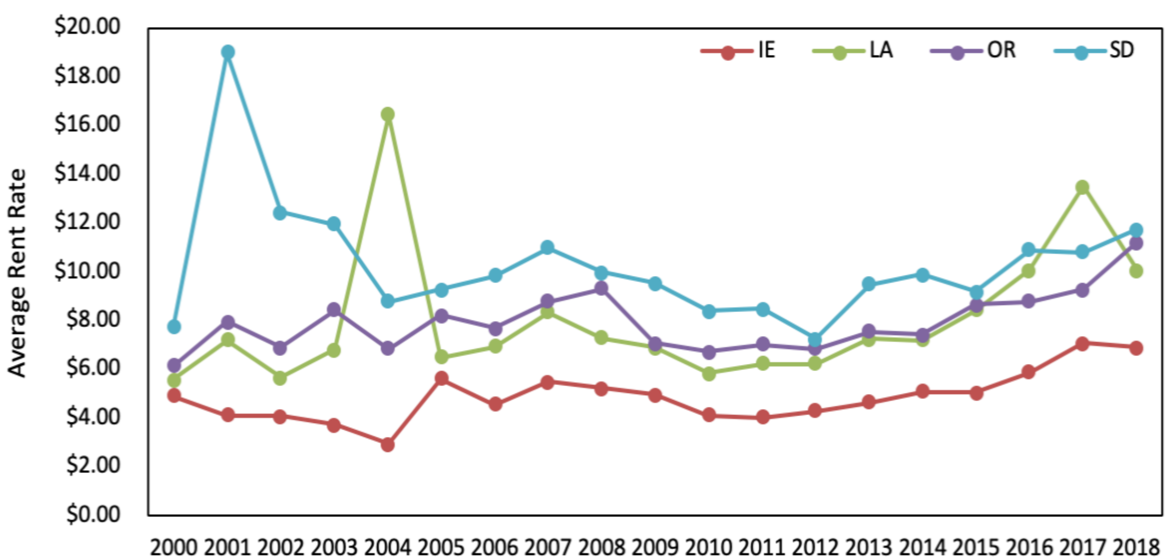

Figure 69. Average lease price (IE, Inland Empire; LA, Los Angeles; OR, Orange County; SD, San Diego)

Properties Size

We estimated linear models for the average size of leased properties, in an analysis similar to that used on properties sold. Overall, the data show a decrease in the size of leased properties in Southern California (Figure 70). Moreover, each of the markets shows a different reduction rate in the average sizes. In the Inland Empire, where the average property size is the largest, a linear fit showed a decrease in average size of -134.36 sf per year Figure 71. However, the linear fit does not reflect the annual variability during the last 19 years (2000-2018), with a rapid decrease between 2000 and 2008, followed by an increase during the last decade.

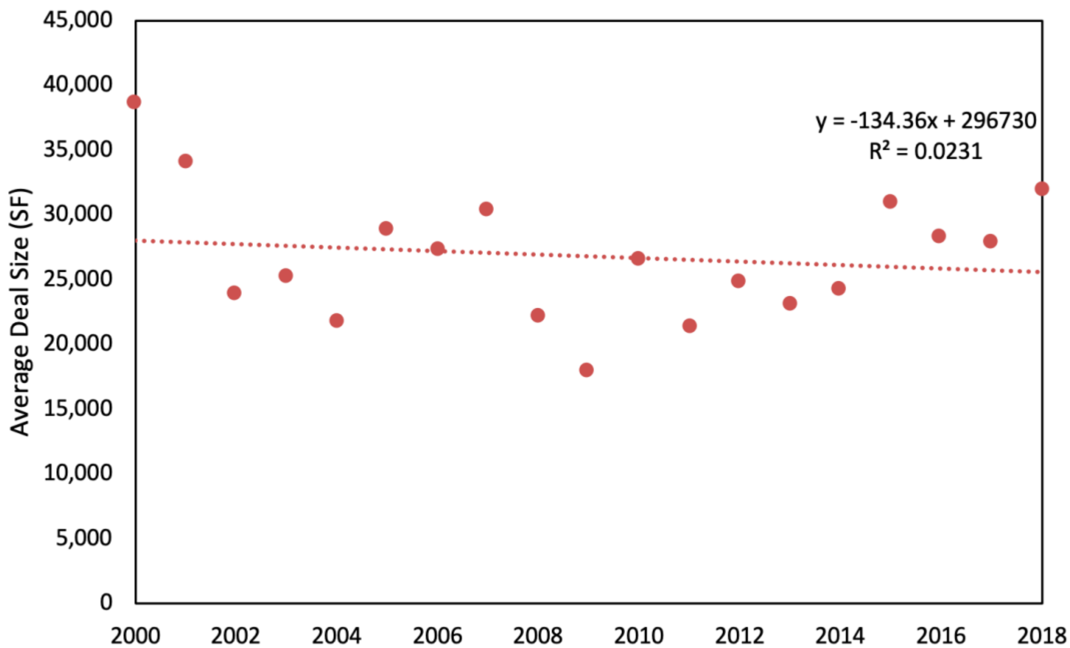

Figure 70. Average size of leased properties in the Inland Empire (2000-2018)

In the Los Angeles market, the average size of leased property showed the steepest decent, with a reduction of almost 466.05 sf per year. From an average of more than 20,000 sf in 2000 to less than 15,000 in 2018 (Figure 71).

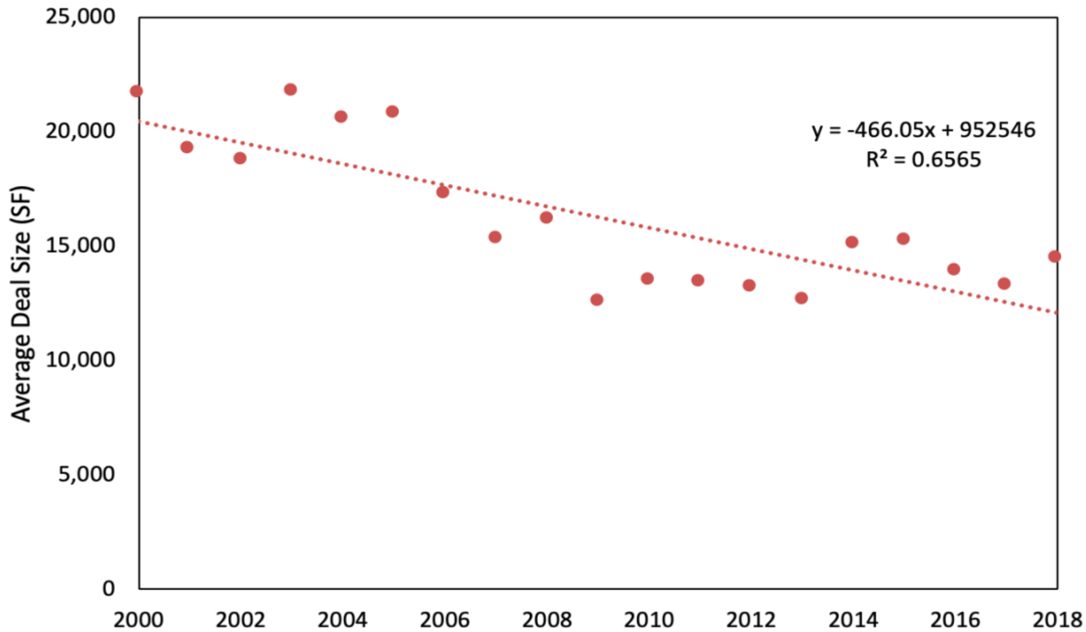

Figure 71. Average size of leased properties in Los Angeles (2000-2018)

The size of leased properties in Orange County has decreased just slightly over this period, at a rate of 108.24 sf per year (Figure 72).

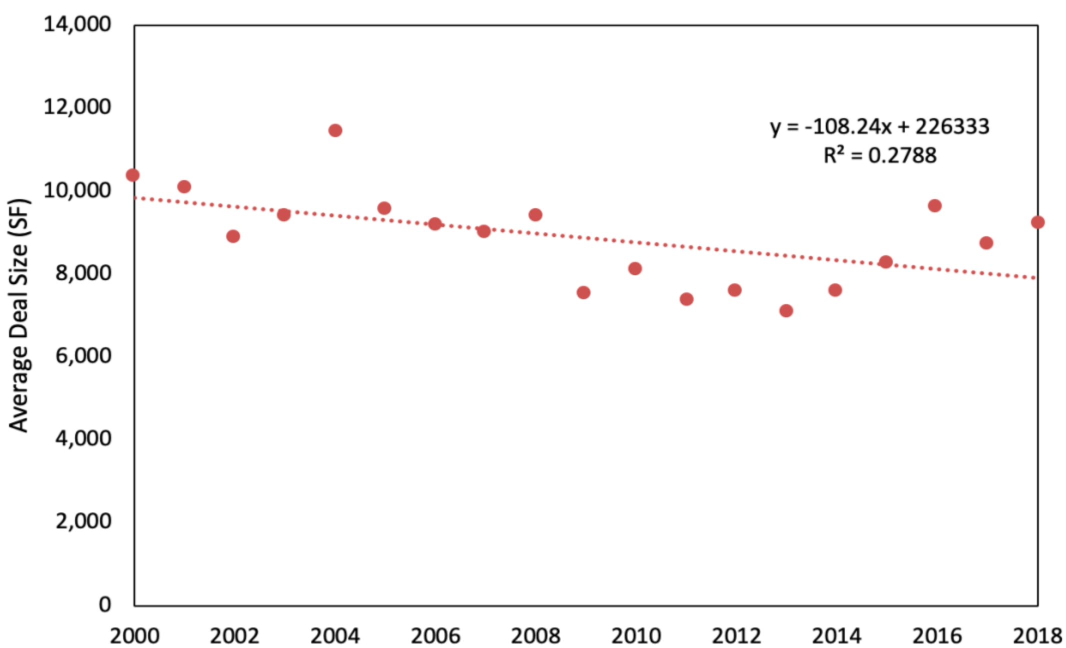

Figure 72. Average size of leased properties in Orange County (2000-2018)

Similar to the market in Orange County, the market in San Diego shows a decrease in the average size of leased properties, with a decrement of 70 sf per year (Figure 73).

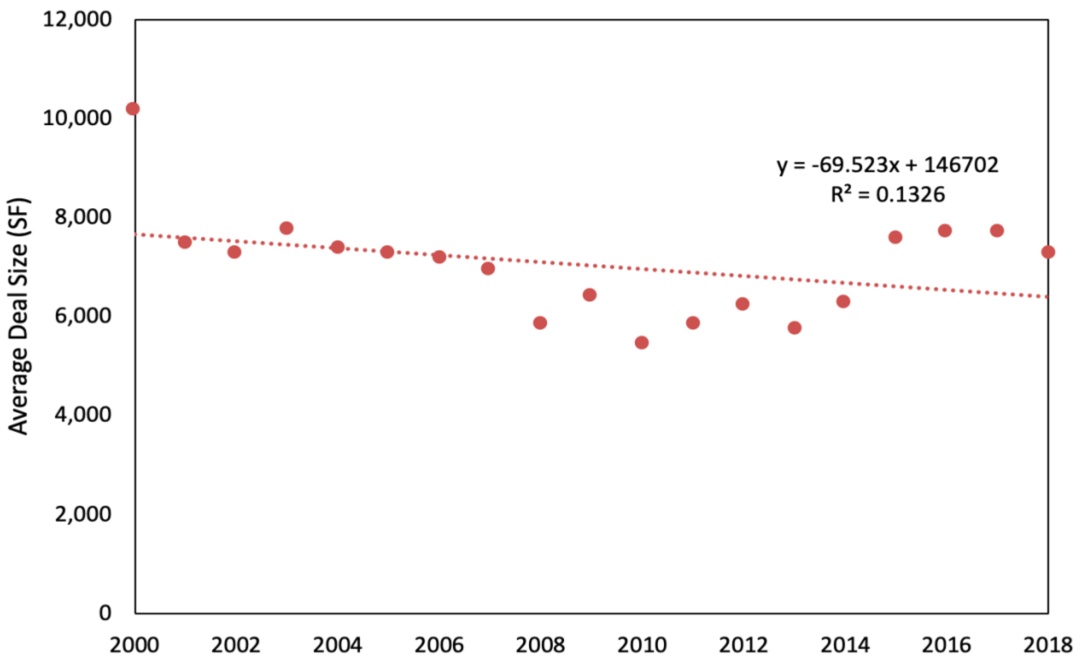

Figure 73. Average size of leased properties in San Diego (2000-2018)

Properties Leased in Different Distance Buffers from the Port of LA

Using the Port of Los Angeles (POLA) as the reference point, the team also studied the characteristics of the leased industrial properties in buffer distances from the port in 2018. The data show that the largest number of leased properties (65%) were located within 40 miles of the port (with the highest number, almost 1,600 properties, between 10 and 20 miles). The properties within 40 miles, represented 61% of the leased square footage (see Figure 74 and Figure 75).

In 2018, the average area of the leased properties ranged from 5k sf in the 110-120 miles buffer to 40k sf in the 50-60 miles buffer (around the Inland Empire). The average lease price peaked 70-80 miles from the port at $22/sf, which could possibly be skewed by the high price of a few properties leased at this distance. The average lease in all the other buffers ranged from $4.57/sf to $12.49/sf. The lowest prices were the ones with the largest average size, located 40 to 60 miles from POLA, which are mainly in the Inland Empire. In addition, the largest number of transactions were within 40 miles of POLA, but these tended to be smaller properties compared to the industrial and warehouse concentrations in the Inland Empire (which, on the contrary, show larger sizes but a smaller number of transactions).

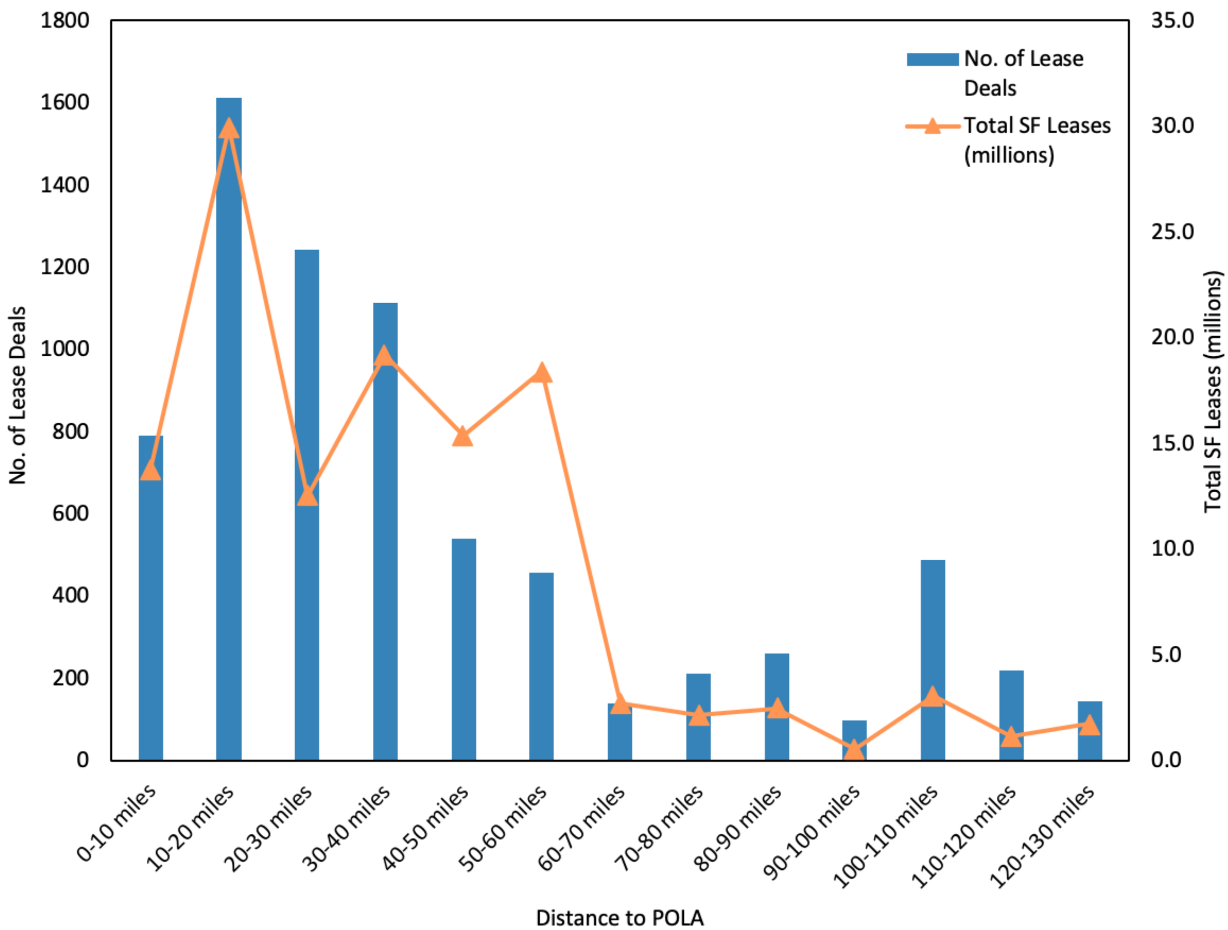

Figure 74. Number of leases and total area leased in different buffers from the Port of Los Angeles (POLA) in 2018 (SF, square footage)

We also analyzed the lease transactions between 2008 and 2018 (for different distance buffers), which included the period just after the recession (see Figure 76 and Figure 77). The data show that the number of leases started to increase between 2008 and 2012, with a continuous decline after that. From the percentage perspective (Figure 78), the distribution of leased properties among the different distance buffers remained relatively constant over this time, with the most transactions between 20-50 km and 50-100 km from POLA. For the buffer closest to the Port (0-20 km), the sold transactions (Figure 61) showed more variability than the leases (Figure 76).

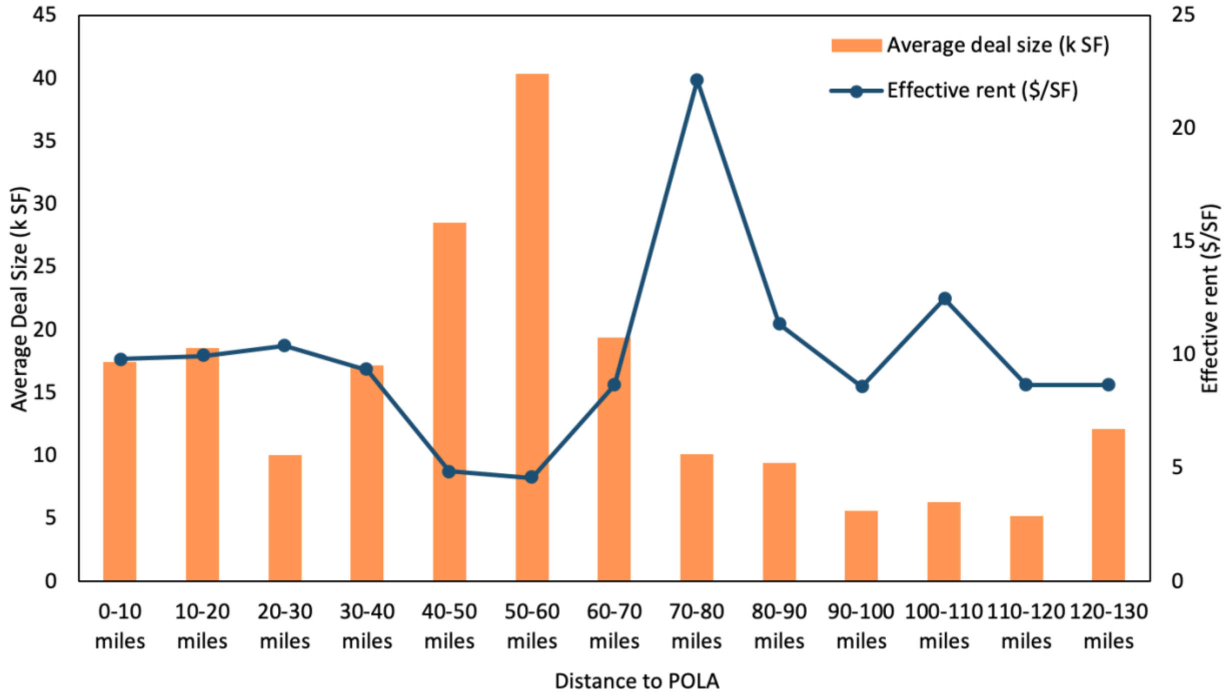

Figure 75. Average size and rental rates of leased properties in different distance buffers from the Port of Los Angeles (POLA) in 2018 (SF, square feet)

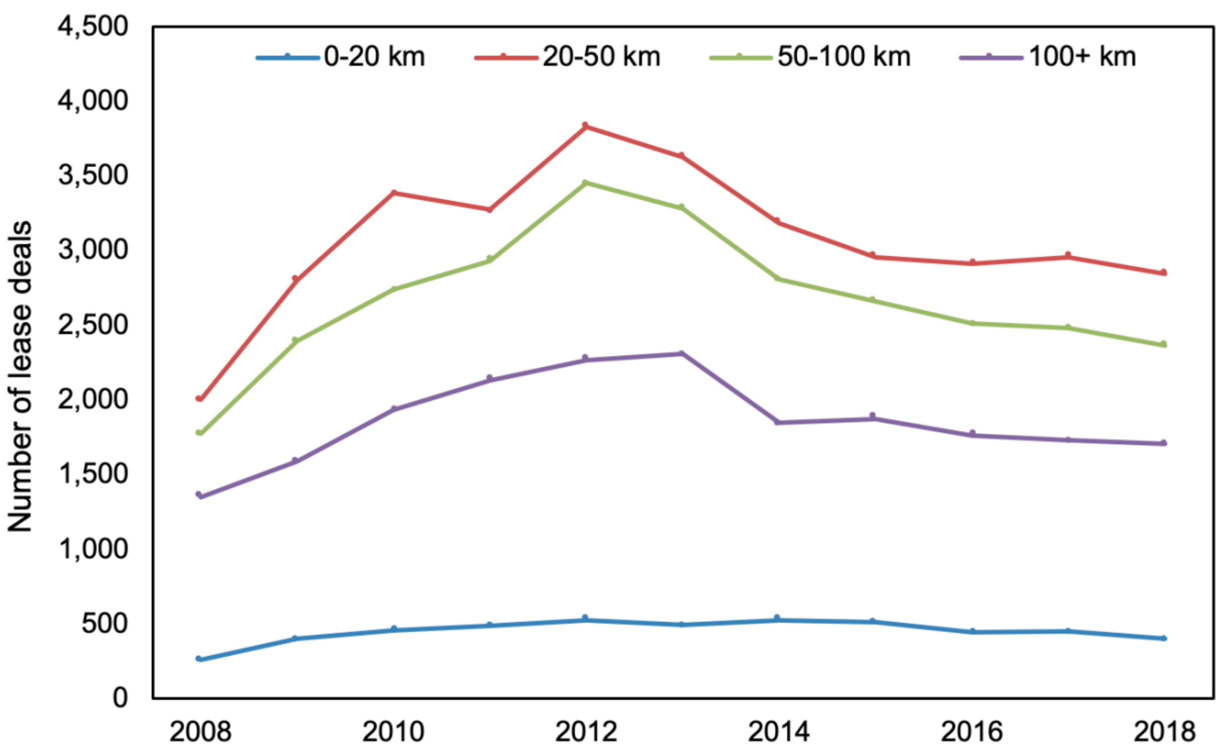

Figure 76. Number of leases in different distance buffers distant from the Port of Los Angeles

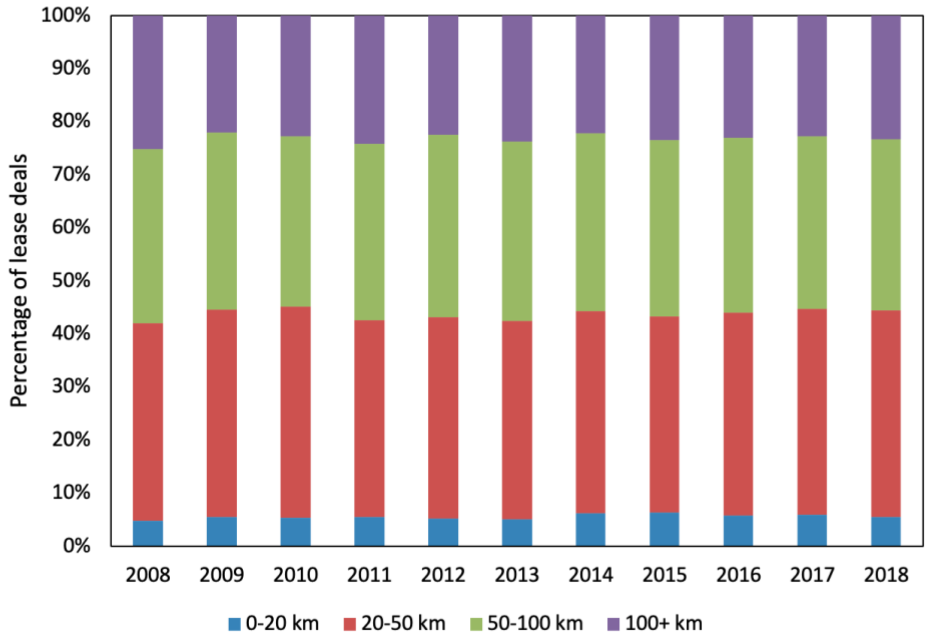

Figure 77. Percentage of leases in different buffers distant from the Port of Los Angeles

Figure 78 shows the average size of the properties in the four buffers. In the last decade, the properties leased had yearly average sizes ranging between 5k and 25k square feet, which are smaller than the mean sizes of properties sold during the same period. Overall, there is a slight opposite trend between sold and leased properties in terms of the size and the concentrations at the different distance buffers.

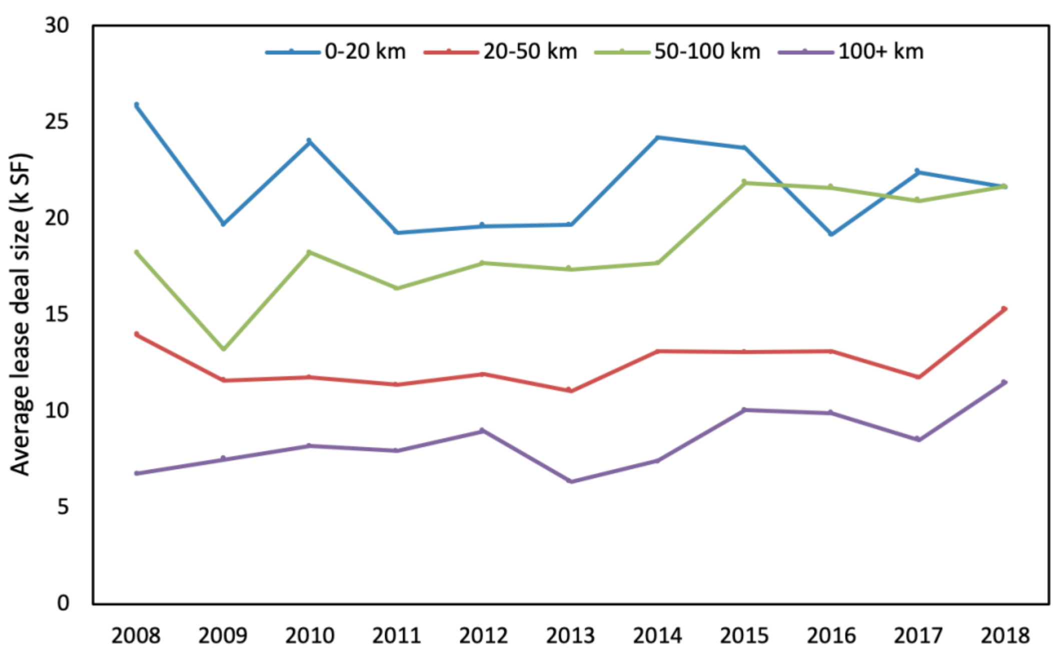

Figure 78. Average size of leased properties in different buffers distant from the Port of Los Angeles

W&DCs & Disadvantaged Communities

As already discussed, in California, the Office of Environmental Health Hazard Assessment (OEHHA) through CalEnviroScreen 3.0 (Office of Environmental Health Hazard Assessment (OEHHA), 2017) identifies and designates Disadvantage Communities (DACs) pursuant to Senate Bill 535. The CalEnviroScreen considers traffic, diesel PM, and other factors, which are highly related to freight traffic. For illustration purposes, Figure 79 highlights the regional PM2.5 primary and secondary source contributions (Ying et al., 2009), while Figure 80 shows the locations of DACs, truck networks, and high truck volumes in California. Moreover, researchers have found that areas with many W&DCs tend to have air pollution problems (Dessouky et al., 2008), which are the main focus of this work and raise social and environmental justice issues.

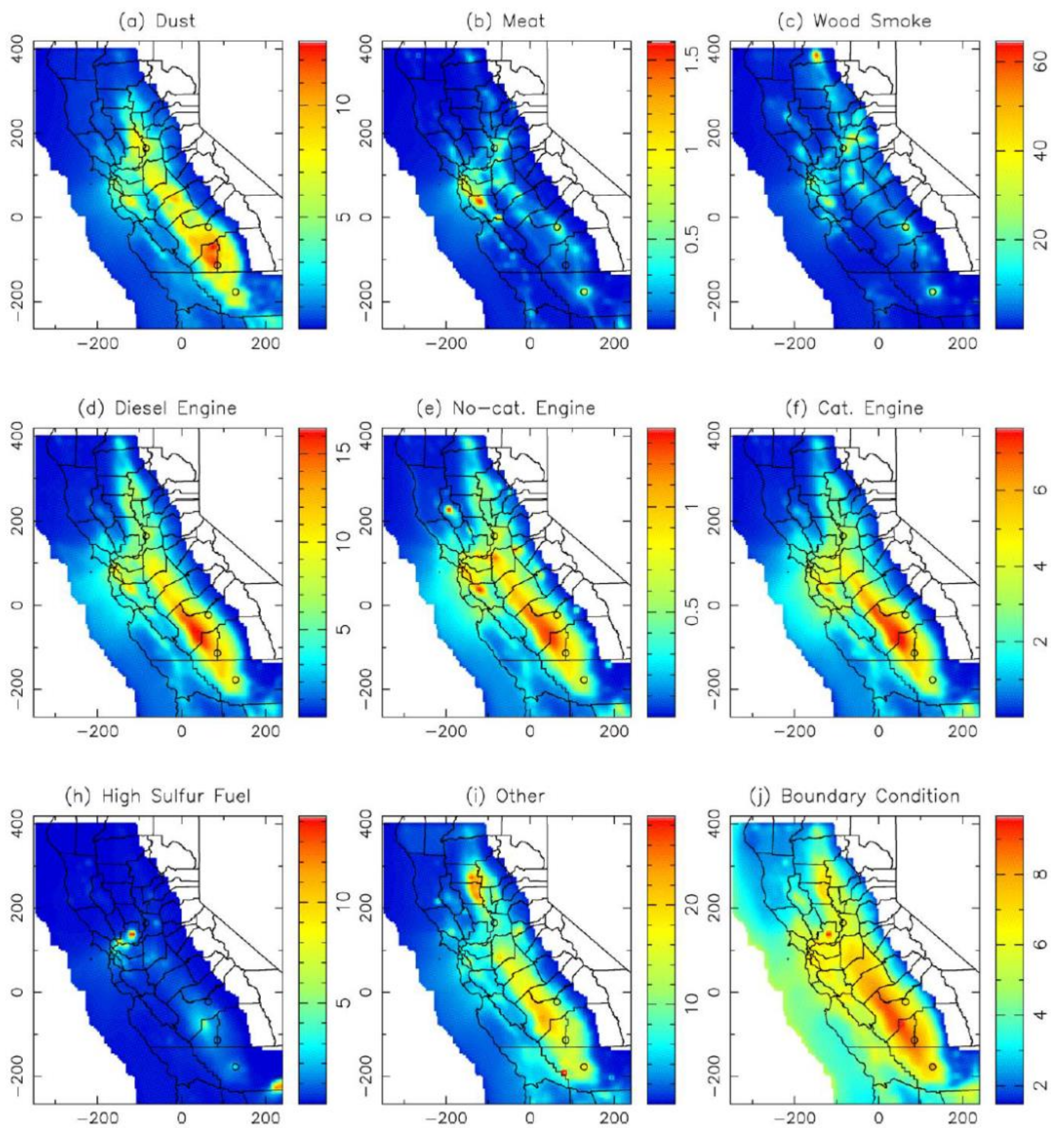

Figure 79. Regional PM 2.5 contributions (Ying et al.)

In that regard, Yuan (2018a) and Yuan (2018b) conducted in-depth analyses regarding environmental justice related to the location of W&DCs. In general, disadvantaged populations have limited choices for their living environment because of their disadvantages in the housing market (Yuan, 2018b). Thus, disadvantaged populations tend to live in areas with low house prices and land values, which are also the areas more attractive for W&DC locations (if they provide land availability, transport access, and skilled labor). The results of our current research corroborate those findings, however not all factors had the same statistical significance in the four MPO regions evaluated. Nevertheless, it is a consistent trend.

Additionally, Yuan (2018b) found that the process of warehouses locating in minority neighborhoods is independent of the process of minorities moving into areas with many warehouses. The author applied a simultaneous equation model to the location choices for both warehouse firms and minority populations. The results showed that neighborhoods with more minority populations attract new warehouses, though minorities are not moving into warehouse-dense areas. Yuan (2018a) also showed the relationship between warehouse distribution and neighborhoods with different demographic and socio-economic characteristics. The results showed that there is a disproportionate concentration of facilities in low- and medium-income areas.

The findings from this research complement those of Yuan (2018a) and show relationships between freight activity in general—and W&DCs in particular—and environmental justice and the potential impacts on disadvantaged communities.

This is both a regional and local issue, therefore different levels of authority must develop strategies to mitigate such impacts through changes in the regulatory environment of land use, air quality, and equity. These findings are of particular importance for the Community Air Protection Program (AB 617), as they show the dynamic landscape of the W&DC market and the potential factors explaining the location of these facilities.

The second part of this project, which focused on the Southern California market, shows an even more important aspect of freight activity and W&DC location that requires thoughtful policy strategies. Overall, businesses are buying or renting smaller spaces (in larger transaction numbers) closer to the core of the study region (e.g., Los Angeles). While this study is not able to fully show that this phenomenon is primarily because of e-commerce, informal communications and ongoing research in the area shows that locating W&DCs closer to consumers is a need for companies offering faster delivery times. More importantly, whether or not the trend of having more, smaller W&DCs closer to urban centers is a result of e-commerce, this trend will generate an increased number of trips from trucks and other vehicles, resulting in more traffic, emissions, and safety issues for those communities where these facilities are. Additionally, it is not clear, if planning efforts and other mobility and accessibility analyses are considering these dynamics.

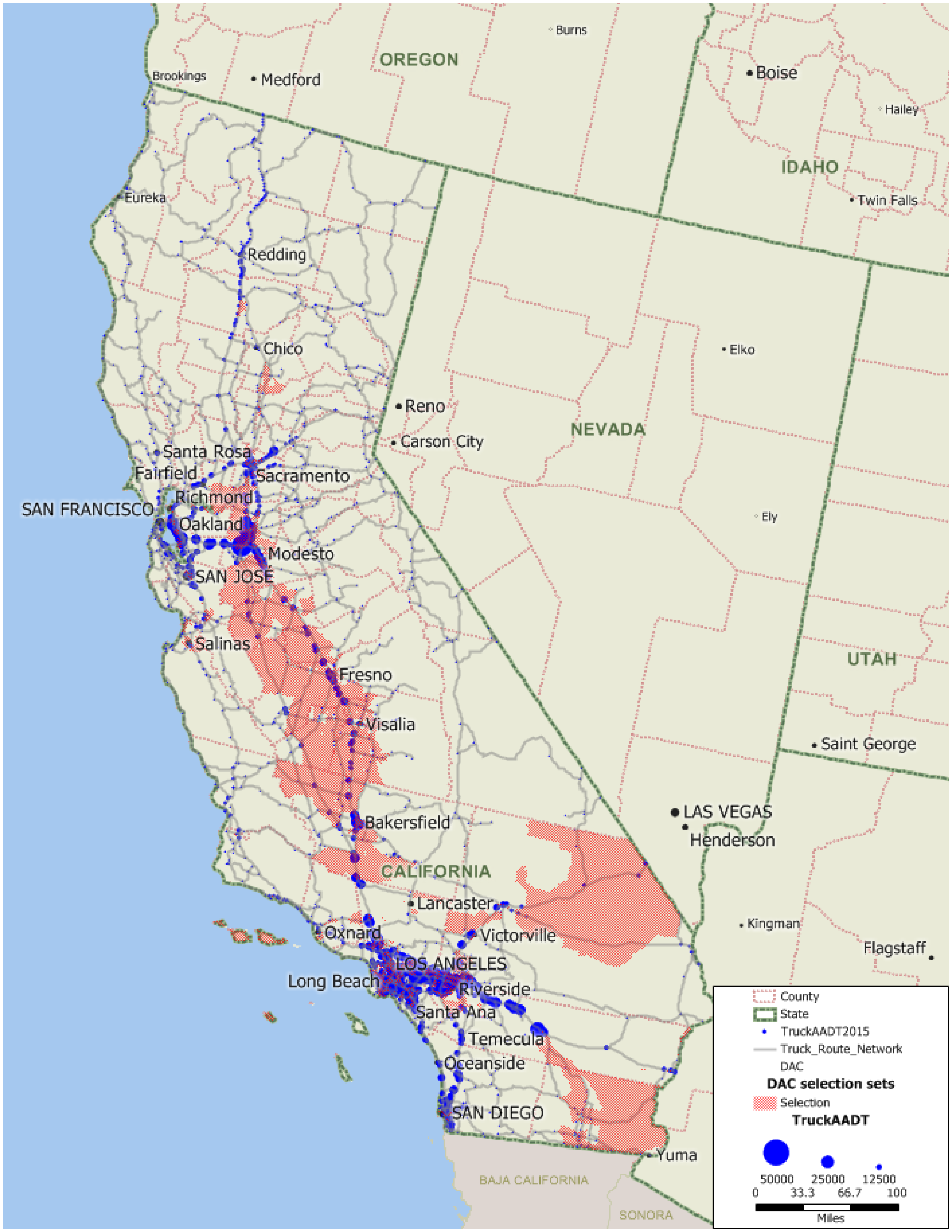

Figure 80. Location of disadvantaged communities (DACs), truck networks, heavy truck volumes

Conclusions

This research shows an obvious increase over the last decade of W&DCs number and employment in four MPO regions in California. This trend is most significant in SCAG. The spatial analysis shows that the geometric centers of establishments under NAICS 493 are moving closer to downtown areas, especially in MTC and SCAG.

More importantly, the results provide insights about the potential effect of e-commerce on the distribution of W&DCs locations. This trend of meeting delivery demand has been noted by Jaller, Pineda, and Phong (2017). As we can expect, more and more W&DCs will move towards central areas in cities, where there is an expected higher demand.

The study found spatial correlation between W&DCs and other industry establishments (e.g., manufacturing, warehousing, food services), especially in the SJCOG.

Besides analyzing the spatial distribution features of W&DCs in California, the study evaluated the correlation between the number of W&DCs and all the environmental scores provided by the OEHHA. The results show a positive but small correlation between the number of W&DCs in a zip code area and the environmental indexes, e.g., cleanup sites (weighted sites), groundwater threats, hazardous waste facilities/generators. This trend shows that W&DCs are likely to be sited in areas with serious pollution concern for all MPOs, though it is not clear whether W&DCs are the main cause of such pollution. These areas with higher environmental scores are more likely to be disadvantaged areas, also defined by the OEHHA. The correlation between an area having W&DCs and higher environmental indexes was most significant in SCAG, where there are many areas with higher environmental scores or with serious environmental pollution. However, MTC, SACOG, and SANDAG are regions with much fewer areas with serious environmental problems, which is reflected in Table 6 showing a summary of environmental scores. Thus, the environmental score does not significantly correlate with distribution of W&DCs in MTC, SACOG, and SANDAG. For SJCOG, there are only 32 zip codes, and the correlations with the environmental scores were not statistically significant.

Overall, the study provides the following conclusions:

- Some of the factors explaining the location of W&DCs are characteristic of areas identified as disadvantaged communities;
- There are evident changes in the distribution of W&DCs in the last decade that may further intensify their negative effects (e.g., congestion in and around facilities, environmental emissions);
- If the amount of cargo is considered constant (though demand is increasing, especially for e-commerce), the use of more and smaller facilities will result in more freight traffic. It is not clear from this study the type of vehicles used. However, there has been an increase in smaller commercial vehicles and lower load factors, in many urban areas. Recalling Table 1, e-retailing leads to higher frequencies of smaller shipments and

therefore may explain many of the finding of this study regarding the location, distribution, and size of W&DCs;

- More facilities, as explained in the previous bullet point, will result in more traffic, because such an increase is an indication of deconsolidation. While newer and cleaner vehicle technologies will be able to mitigate some of the impacts; increased traffic will have a negative effect on congestion, energy consumption, accessibility, especially at the curb level;
- As discussed elsewhere (Holguín-Veras et al., 2011), there is a difference between freight generation and freight trip generation, and the divisibility of cargo and freight trips. Consequently, these freight facilities will also generate more traffic in the communities where they locate;
- The number of W&DCs positively correlated with indexes of environmental impact, although not for all criteria pollutants; and,
- The dynamic landscape must be considered and further explored in planning efforts. Regional and local authorities must evaluate land use, building, and air quality strategies to mitigate such impacts.

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Appendix A. Descriptive Statistics for each MPO Region

Table 13. Summary for Variables in SCAG (per Zip Code)

Variable type	Variable Description	Mean	SD	Min.	Max.
Demographics	Population (1k)	30.1	23.0	0.0	106.0
	Median age	36.4	9.4	0.0	75.0
	White population percentage (%)	62.9	N/A	0.0	100.0
	Median household income (1k dollars)	61.9	28.1	0.0	171.4
	Median house value (10k dollars)	40.6	24.7	0.0	100.0
	Adults using public transit (per 1k)*	37.6	N/A	0.0	450.3
Establishments in NAICS sectors	493 establishments	1.8	5.6	0.0	94.0
	32 establishments	7.9	13.1	0.0	127.0
	48 establishments	17.7	25.4	0.0	267.0
	72 establishments	65.0	54.8	0.0	290.0
	Neighboring 493 establishments	11.9	19.9	0.0	188.0
	Neighboring 32 establishments	52.4	49.2	0.0	281.0
	Neighboring 48 establishments	115.6	108.7	0.0	654.0
	Neighboring 72 establishments	404.3	242.2	0.0	1298.0
Accessibility	Distance to highway (miles)	1.1	3.4	0.0	63.3
	Distance to seaport (miles)	41.5	35.3	0.7	202.8
	Distance to airport (miles)	24.8	31.4	0.9	195.1
	Distance to intermodal (miles)	19.1	27.1	0.1	178.9

Note: N/A (not available) is shown for zip codes with no records. * Commute travel.

Table 14. Summary for Variables in MTC (per Zip Code)

Variable type	Variable Description	Mean	SD	Min.	Max.
Demographics	Population (1k)	24.0	20.0	0.0	86.0
	Median age	40.8	7.8	0.0	66.3
	White population percentage (%)	63.9	N/A	7.5	100.0
	Median household income (1k dollars)	84.3	32.1	0.0	250.0
	Median house value (10k dollars)	61.3	24.8	0.0	100.0
	Adults using public transit (per 1k)*	83.7	N/A	0.0	434.4
Establishments in NAICS sectors	493 establishments	1.0	2.4	0.0	17.0
	32 establishments	5.2	8.1	0.0	51.0
	48 establishments	10.3	18.5	0.0	209.0
	72 establishments	67.8	70.0	0.0	410.0
	Neighboring 493 establishments	5.7	7.3	0.0	43.0
	Neighboring 32 establishments	29.8	23.1	0.0	122.0
	Neighboring 48 establishments	57.5	55.0	0.0	371.0
	Neighboring 72 establishments	376.0	276.8	0.0	1825.0
Accessibility	Distance to highway (miles)	0.9	1.4	0.0	12.6
	Distance to seaport (miles)	19.3	16.9	0.5	89.1
	Distance to airport (miles)	22.7	20.4	0.5	102.7
	Distance to intermodal (miles)	20.9	16.4	0.1	84.4

Note: N/A (not available) is shown for zip codes with no records. * Commute travel.

Table 15. Summary for Variables in SACOG (per Zip Code)

Variable type	Variable Description	Mean	SD	Min.	Max.
Demographics	Population (1k)	15.6	18.4	0.0	74.0
	Median age	41.1	8.6	0.0	59.5
	White population percentage (%)	76.4	N/A	29.8	98.9
	Median household income (1k dollars)	59.3	18.8	0.0	124.0
	Median house value (10k dollars)	28.6	11.7	0.0	73.6
	Adults using public transit (per 1k)*	16.5	N/A	0.0	78.6
Establishments in NAICS sectors	493 establishments	0.9	1.8	0.0	13.0
	32 establishments	2.8	4.4	0.0	24.0
	48 establishments	7.1	10.6	0.0	69.0
	72 establishments	30.5	44.0	0.0	223.0
	Neighboring 493 establishments	5.7	6.0	0.0	26.0
	Neighboring 32 establishments	17.9	15.9	0.0	68.0
	Neighboring 48 establishments	46.3	41.5	0.0	193.0
	Neighboring 72 establishments	187.6	161.4	2.0	684.0
Accessibility	Distance to highway (miles)	1.6	2.0	0.0	11.8
	Distance to seaport (miles)	31.7	20.8	1.8	82.8
	Distance to airport (miles)	25.8	18.3	0.5	75.4
	Distance to intermodal (miles)	27.3	20.5	0.3	80.9

Note: N/A (not available) is shown for zip codes with no records. * Commute travel.

Table 16. Summary for Variables in SANDAG (per Zip Code)

Variable type	Variable Description	Mean	SD	Min.	Max.
Demographics	Population (1k)	27.5	22.8	0.0	87.2
	Median age	36.0	8.9	0.0	56.4
	White population percentage (%)	73.7	N/A	29.5	93.7
	Median household income (1k dollars)	66.9	33.0	0.0	250.0
	Median house value (10k dollars)	43.3	23.7	0.0	100.0
	Adults using public transit (per 1k)*	22.8	N/A	0.0	117.6
Establishments in NAICS sectors	493 establishments	0.9	3.4	0.0	32.0
	32 establishments	6.6	11.8	0.0	91.0
	48 establishments	12.4	26.4	0.0	261.0
	72 establishments	65.5	77.0	0.0	553.0
	Neighboring 493 establishments	5.5	8.1	0.0	40.0
	Neighboring 32 establishments	41.4	40.1	0.0	241.0
	Neighboring 48 establishments	75.3	65.6	0.0	315.0
	Neighboring 72 establishments	401.6	288.8	2.0	1676.0
Accessibility	Distance to highway (miles)	1.1	1.5	0.0	10.9
	Distance to seaport (miles)	22.9	15.7	2.4	67.4
	Distance to airport (miles)	20.1	15.0	0.7	67.1
	Distance to intermodal (miles)	25.8	14.1	0.5	63.5

Note: N/A (not available) is shown for zip codes with no records. * Commute travel.

Table 17. Summary for Variables in SJCOG (per Zip Code)

Variable type	Variable Description	Mean	SD	Min.	Max.
Demographics	Population (1k)	21.6	17.9	0.1	66.1
	Median age	35.2	5.6	19.8	48.5
	White population percentage (%)	65.5	17.4	33.5	90.8
	Median household income (1k dollars)	57.7	19.7	14.7	98.6
	Median house value (10k dollars)	23.3	9.3	4.0	45.5
	Adults using public transit (per 1k)*	12.3	7.8	0.0	25.8
Establishments in NAICS sectors	493 establishments	2.3	4.3	0.0	15.0
	32 establishments	5.2	6.8	0.0	21.0
	48 establishments	17.8	17.8	0.0	79.0
	72 establishments	35.7	36.3	0.0	134.0
	Neighboring 493 establishments	13.4	13.0	0.0	41.0
	Neighboring 32 establishments	29.3	20.1	2.0	77.0
	Neighboring 48 establishments	99.5	67.0	4.0	246.0
	Neighboring 72 establishments	196.2	97.5	9.0	451.0
Accessibility	Distance to highway (miles)	1.0	1.0	0.0	3.7
	Distance to seaport (miles)	12.1	7.1	0.2	26.2
	Distance to airport (miles)	37.8	7.6	24.7	53.2
	Distance to intermodal (miles)	8.9	4.4	1.1	19.3

Note: * Commute travel.

Appendix B. Weighted Geographic Centers

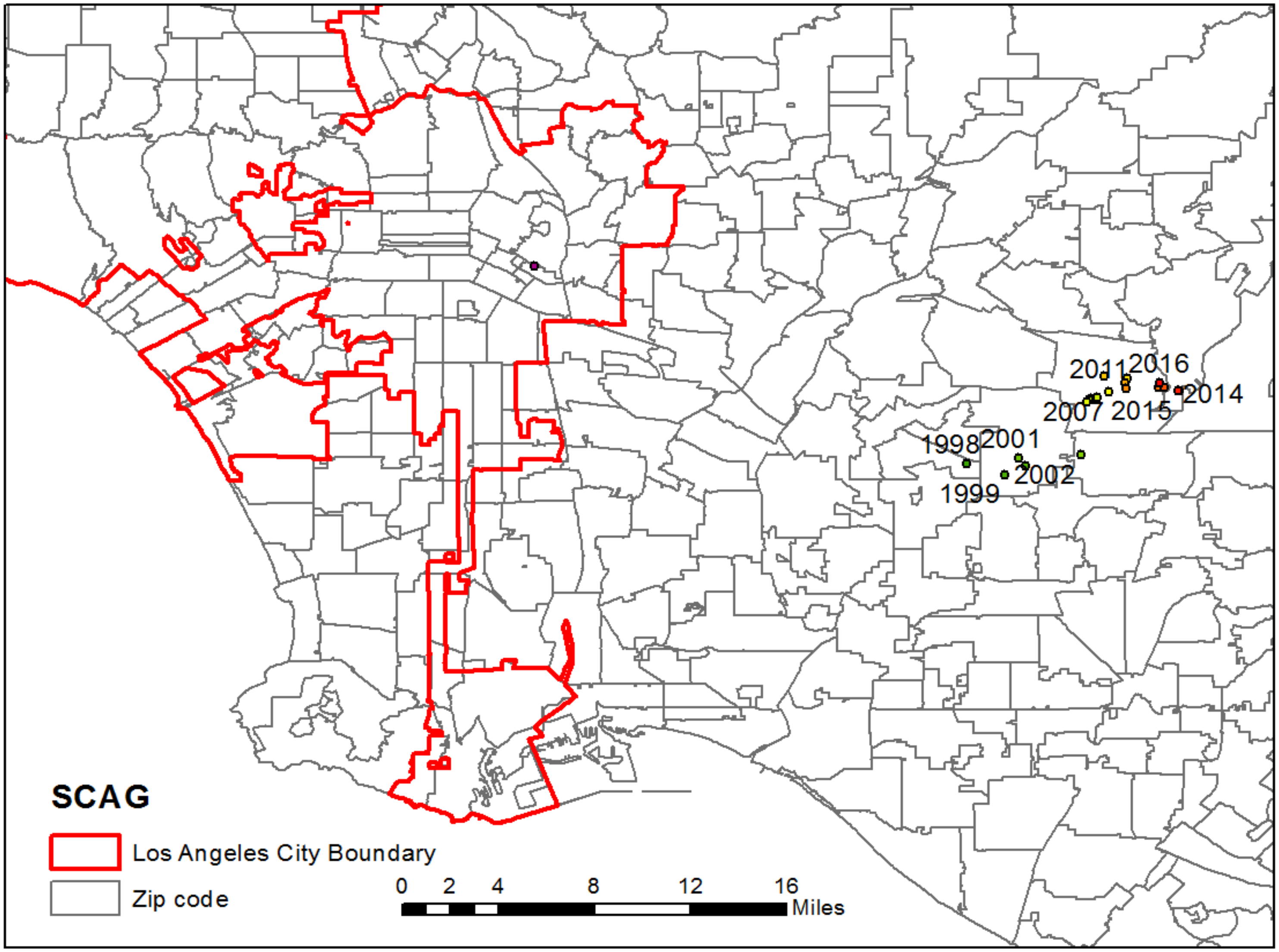

Figure 81. Location of weighted geometric centers for NAICS 493 in SCAG (1998–2016)

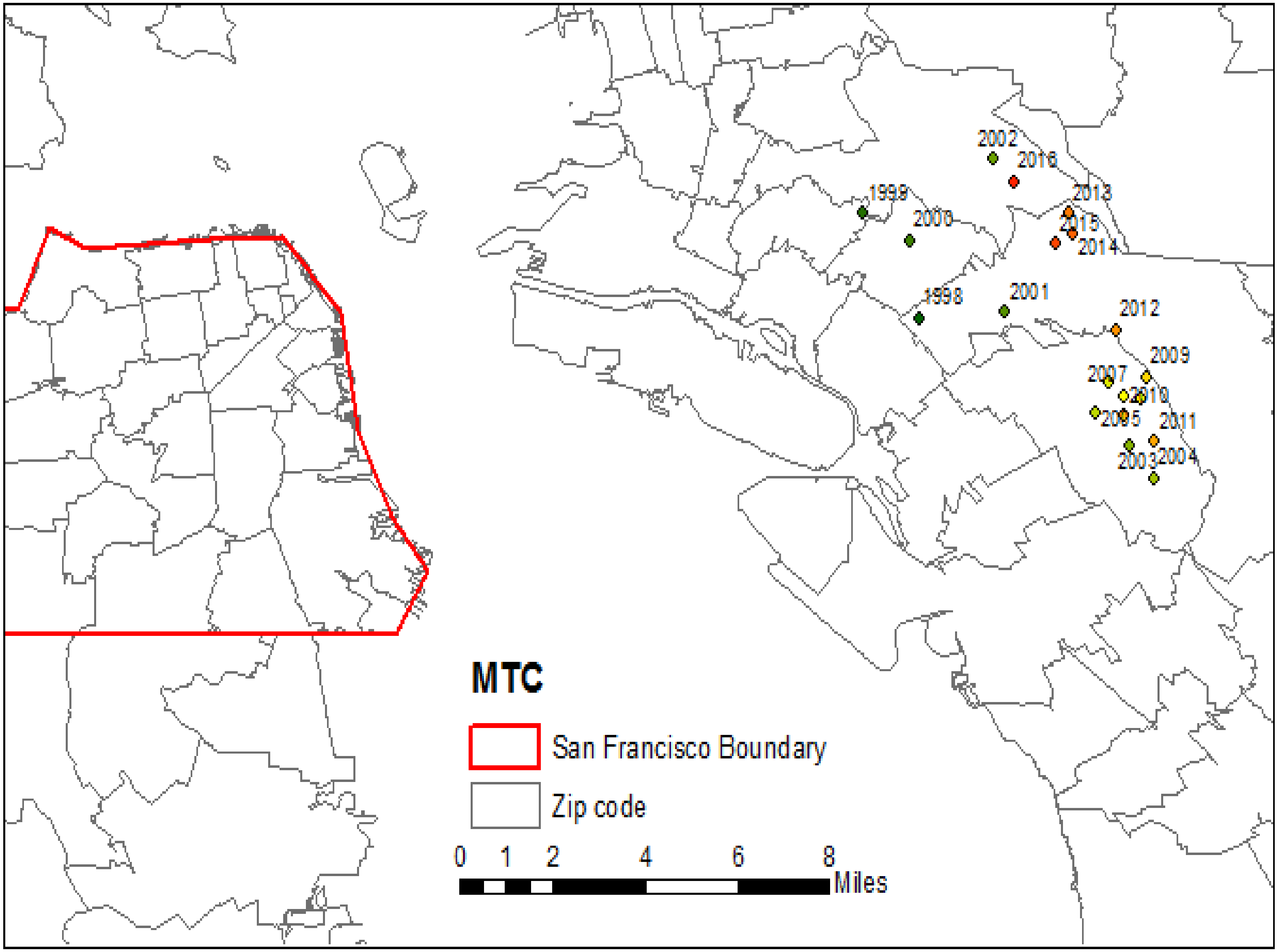

Figure 82. Location of weighted geometric centers for NAICS 493 in MTC (1998–2016)

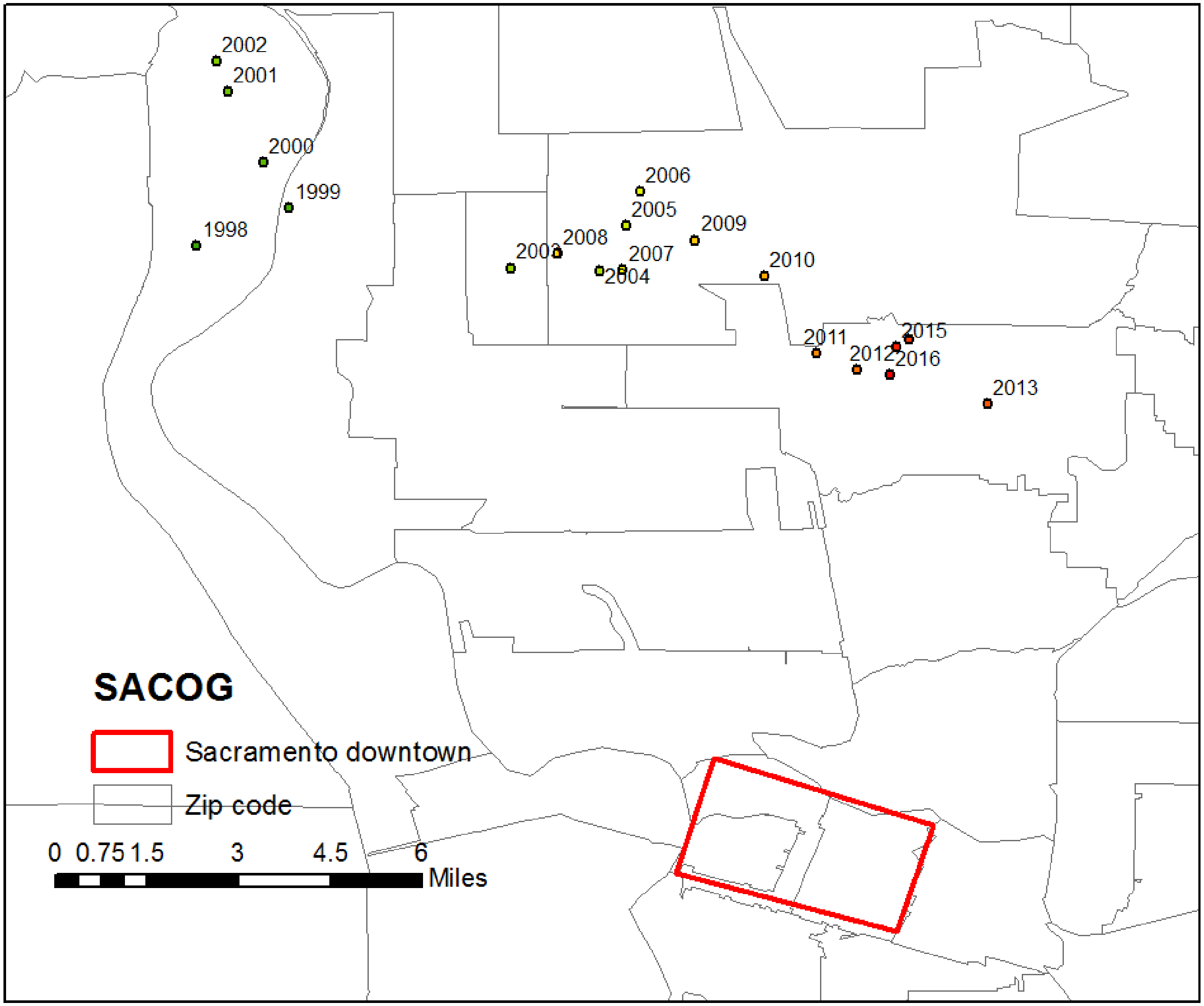

Figure 83. Location of weighted geometric centers for NAICS 493 in SACOG (1998–2016)

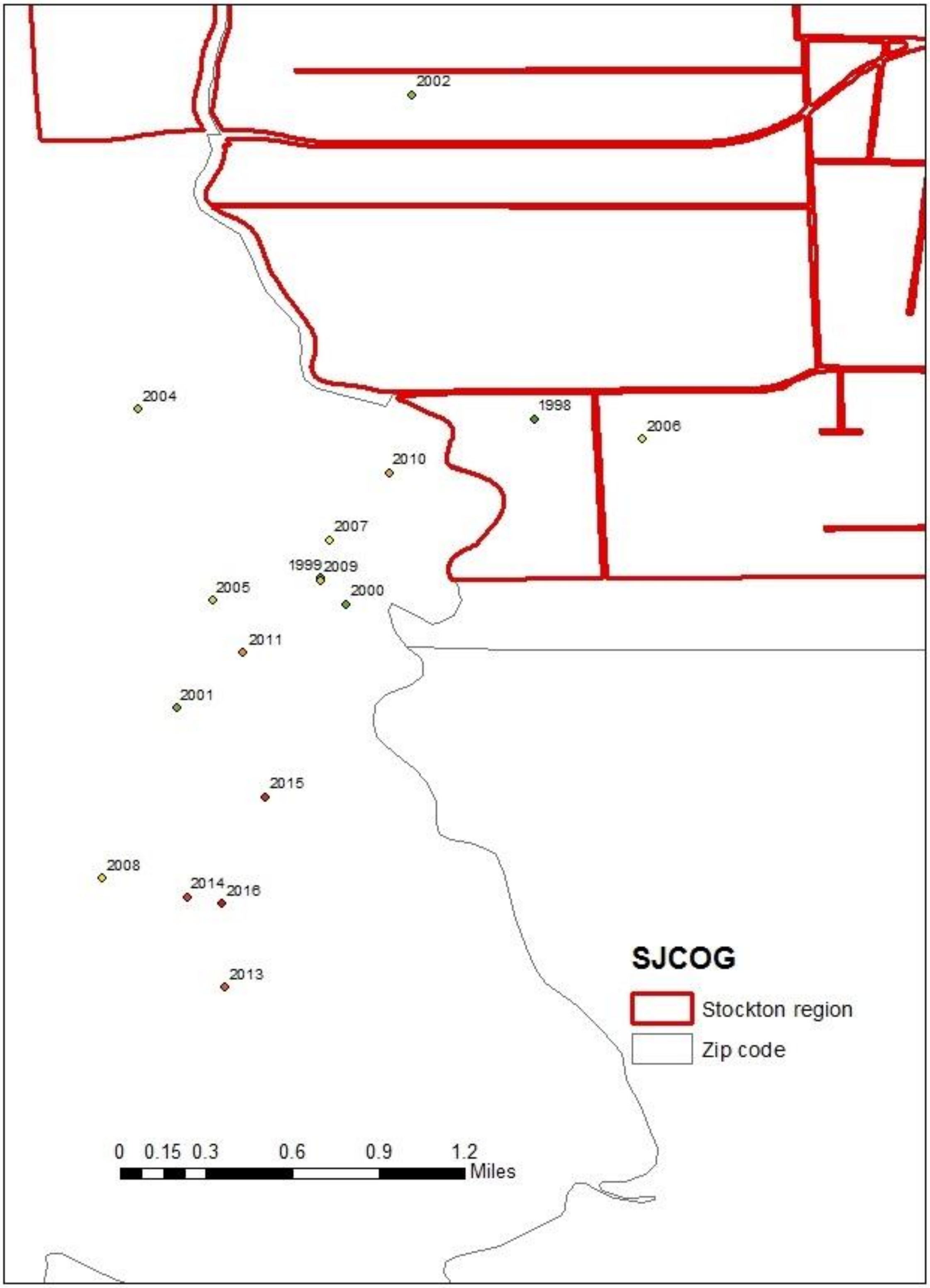

Figure 84. Location of weighted geometric centers for NAICS 493 in SJCOG (1998–2016)

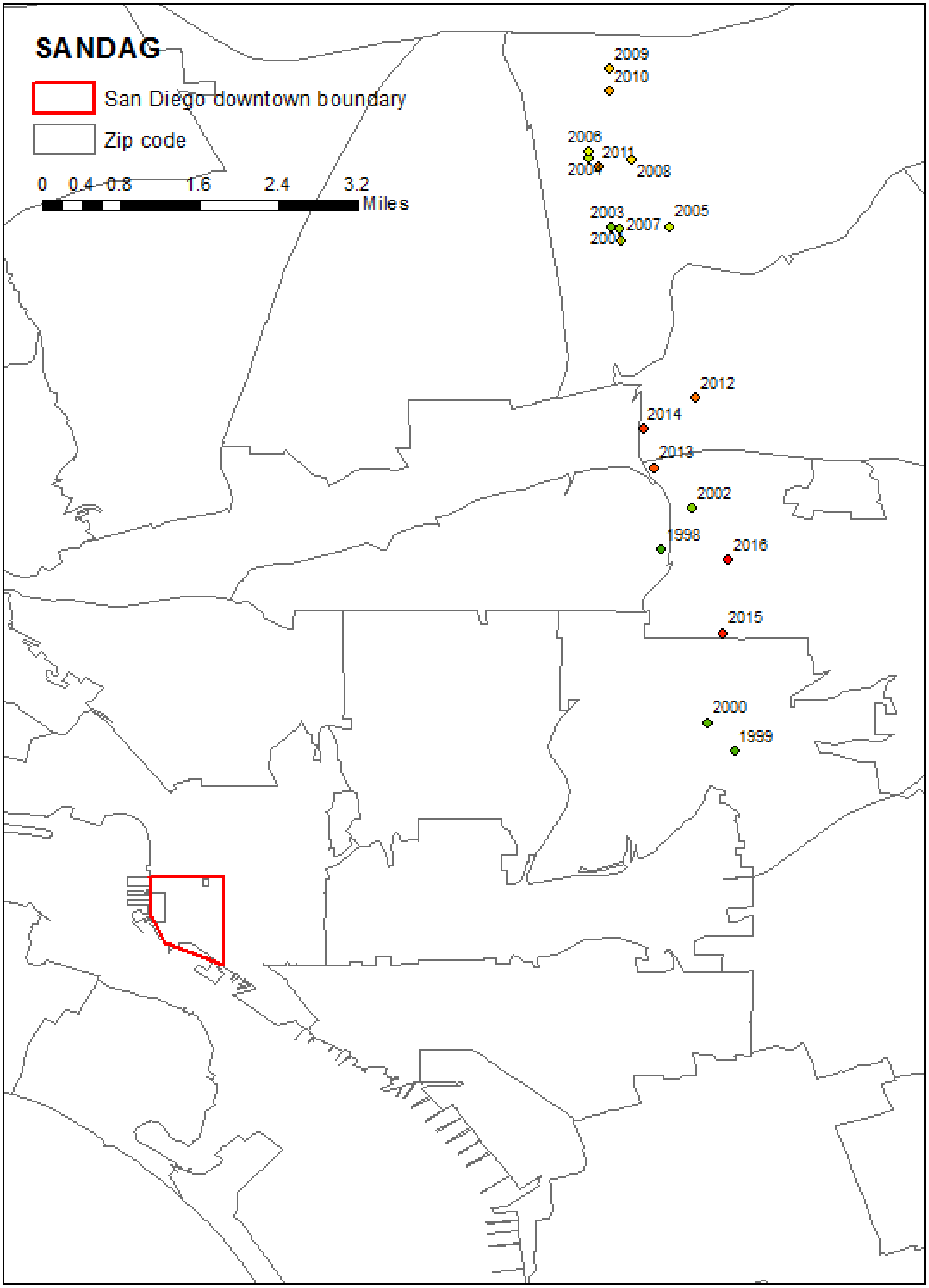

Figure 85. Location of weighted geometric centers for NAICS 493 in SANDAG (1998–2016)

Appendix C. Correlation between Industries

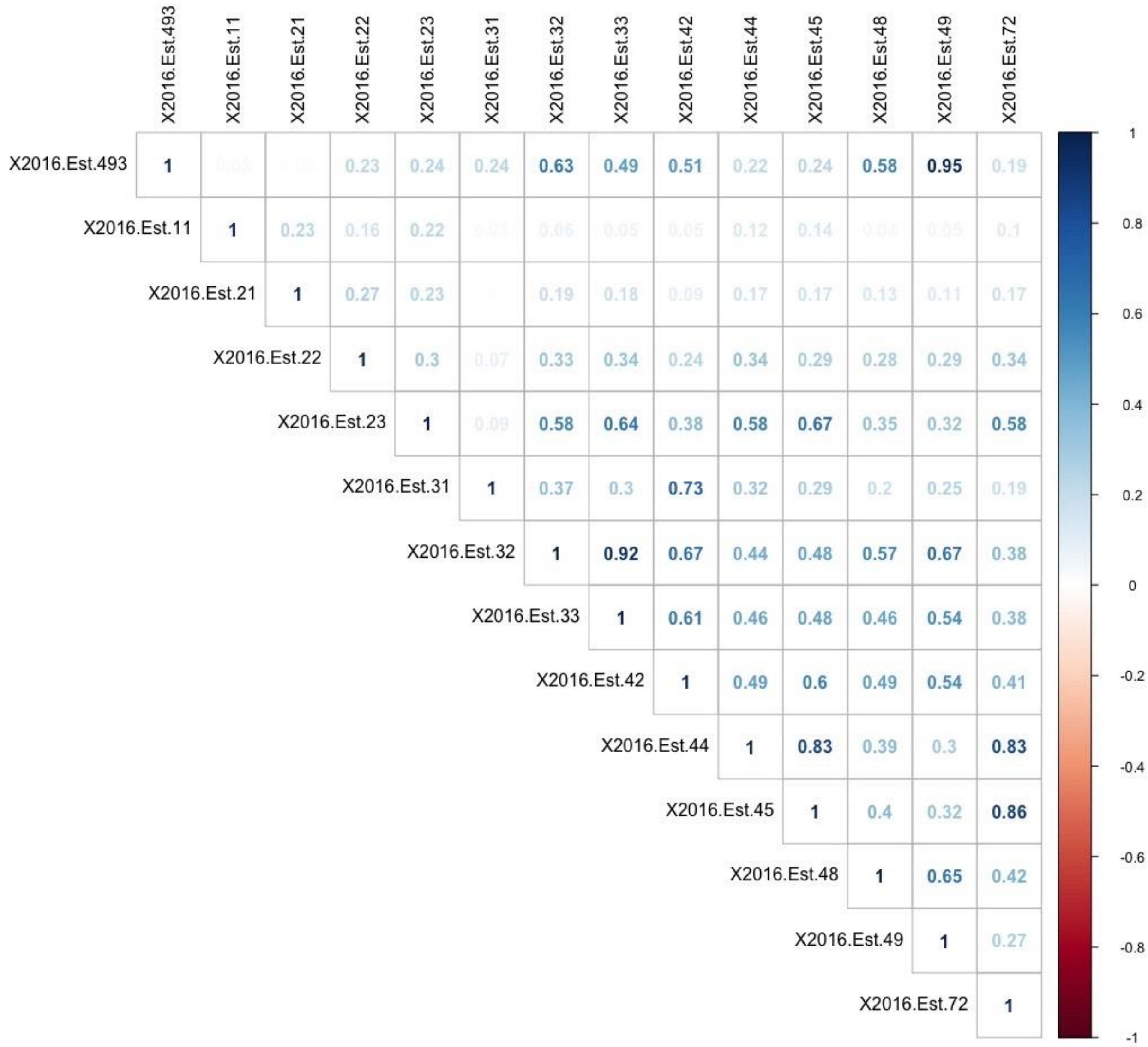

Figure 86. Correlation matrix of the number of establishments under different departments in SCAG

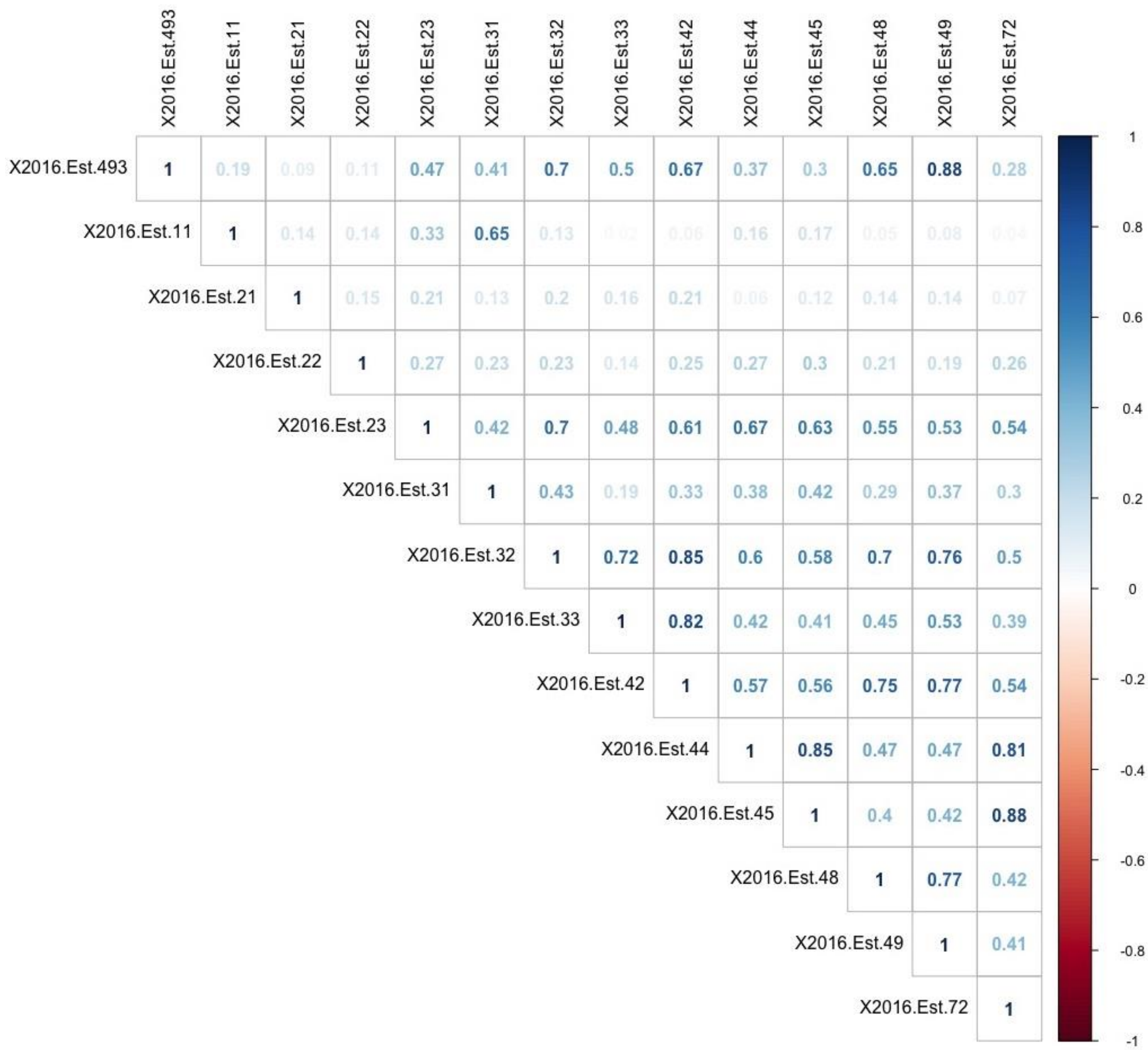

Figure 87. Correlation matrix of the number of establishments under different departments in MTC

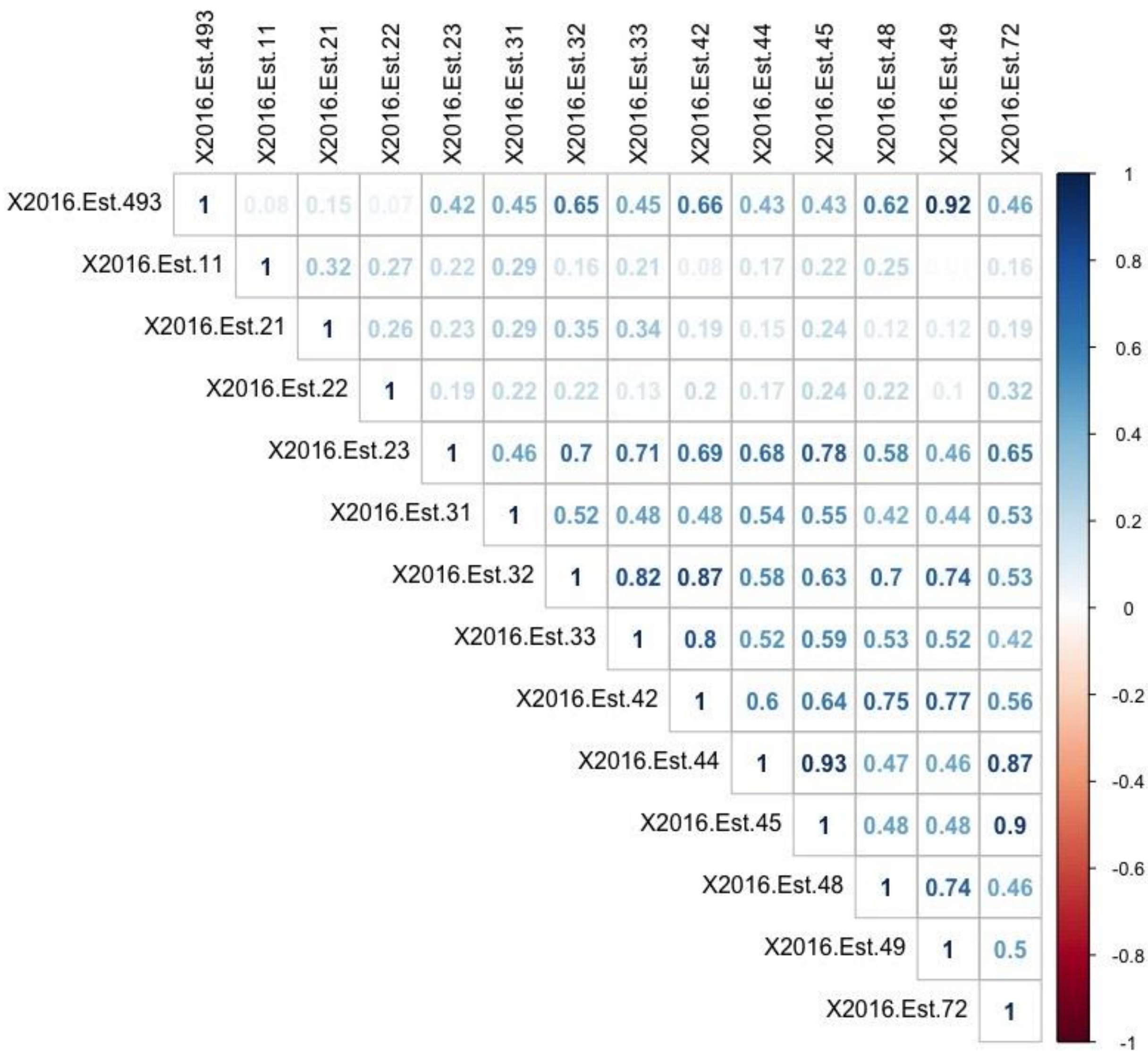

Figure 88. Correlation matrix of the number of establishments under different departments in SACOG

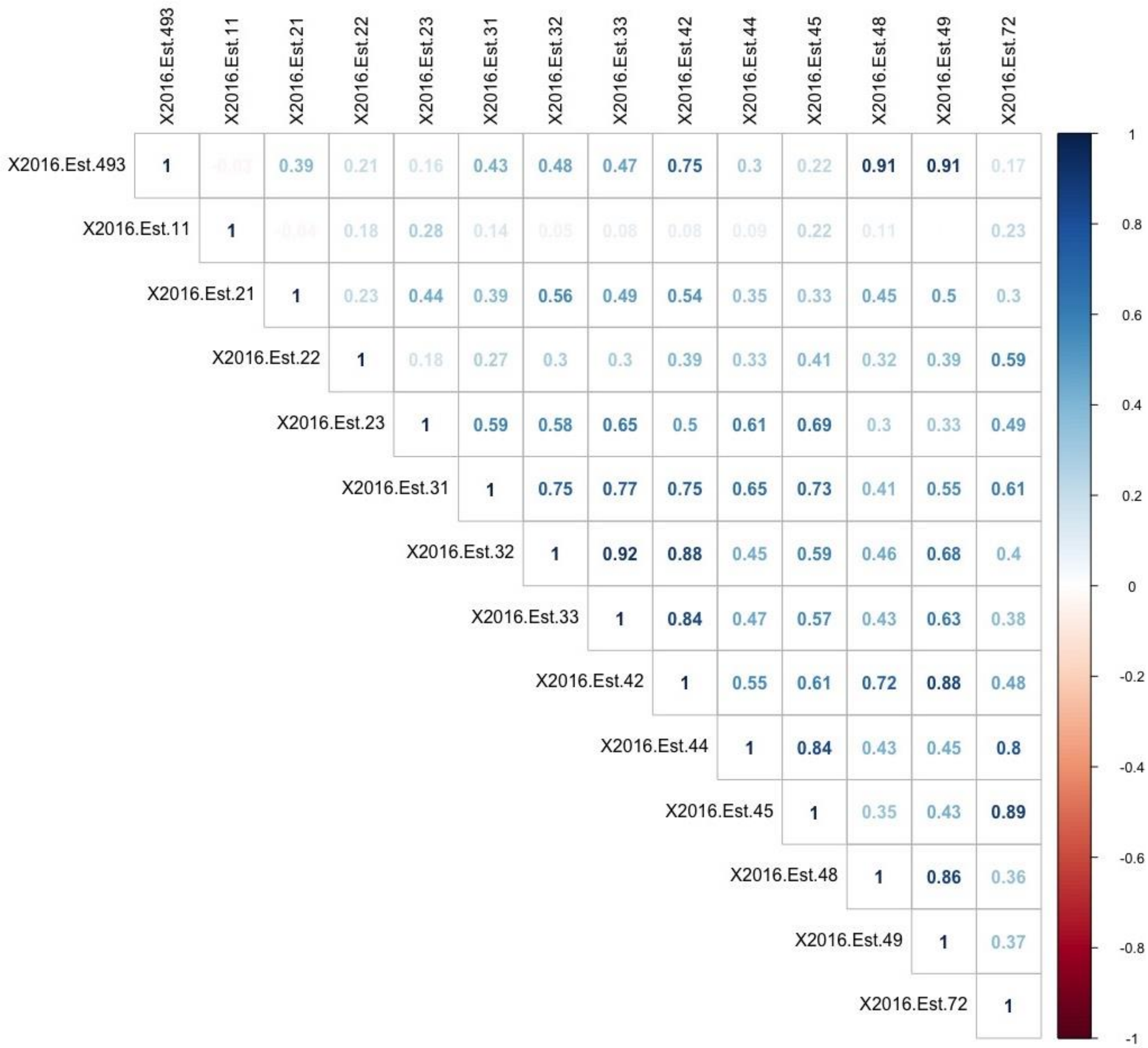

Figure 89. Correlation matrix of the number of establishments under different departments in SANDAG

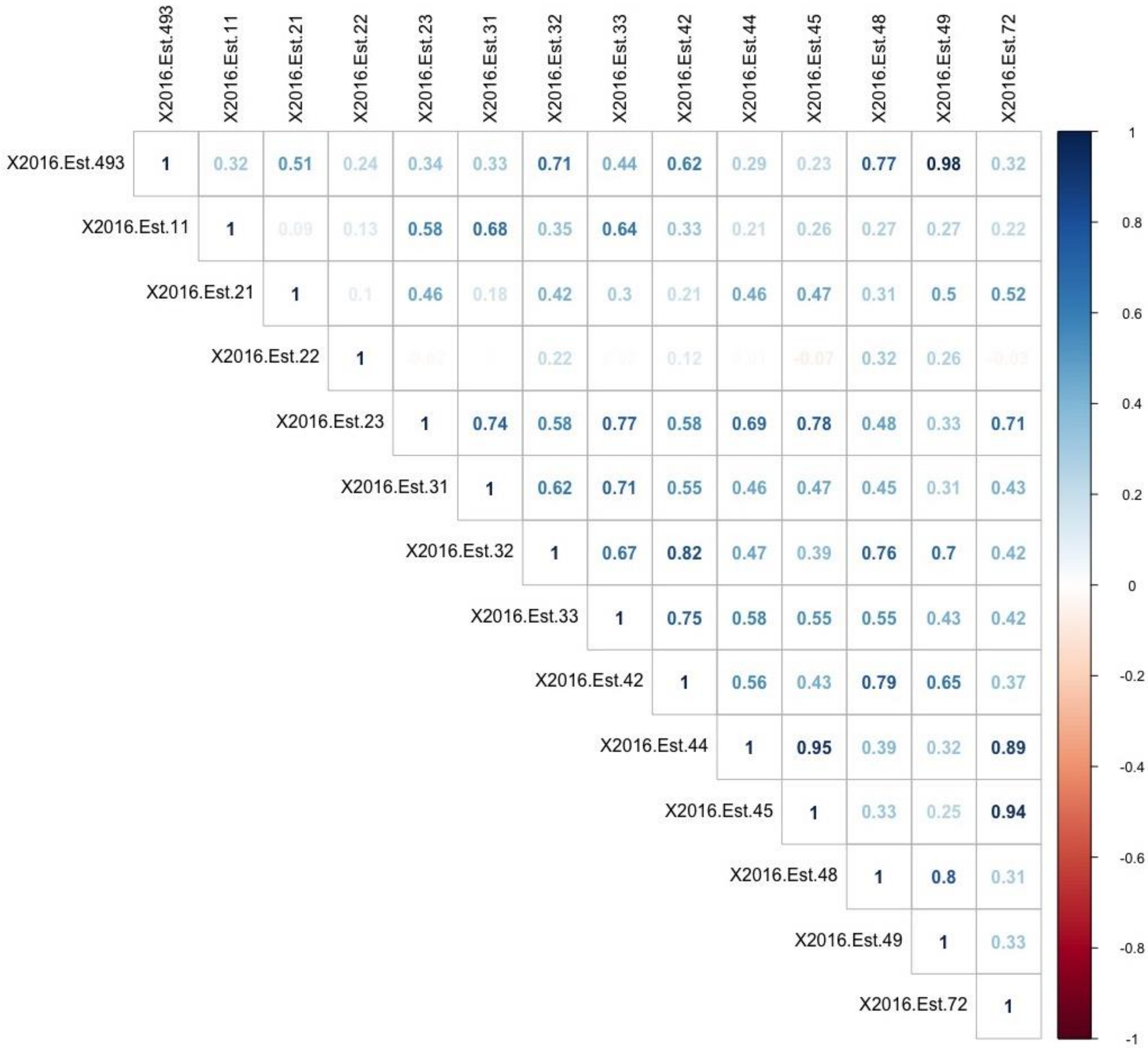

Figure 90. Correlation matrix of the number of establishments under different departments in SJCOG