Warehousing and Distribution Center Facilities in Southern California: The Use of the Commodity Flow Survey Data to Identify Logistics Sprawl and Freight Generation Patterns

July 2017

A Research Report from the National Center for Sustainable Transportation

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National Center for Sustainable Transportation

ITS UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

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Disclaimer

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Warehousing and Distribution Center Facilities in Southern California: The Use of the Commodity Flow Survey Microdata to Identify Logistics Sprawl and Freight Generation Patterns

EXECUTIVE SUMMARY

This work addresses an important research topic of freight modeling by analyzing the freight patterns, in terms of freight generation and logistics sprawl, of warehouses and distribution centers in Southern California. Specifically, this work analyzes the concentration of Warehouses and Distribution Centers (W&DC) (NAICS 493) in five counties in Southern California between 1998 and 2014; and explores spatial relationships between W&DC and other industry sectors through centrographic and econometric modeling techniques. Furthermore, the authors estimate factors that explain the concentration of W&DC in the area.

The work uses both disaggregate and aggregate approaches considering the nature of the information available. For the aggregate approach, the analyses used aggregate establishment, employment and other socio-economic data for different industries, complemented with transportation related variables. The results: 1) confirm the existence of logistics sprawl, though the analyses indicate that this trend has not continued to increase after 2007; 2) W&DC show a lower spatial correlation compared to other industries; 3) the locations of the weighted geometric center has shifted slightly differently for the W&DC industry and within its sub-industries; 4) concentration levels for some sub-industries are much lower than for the aggregated NAICS 493; and 5) the number of W&DCs could be explained by: the number of establishment in manufacturing and transportation service industries, proximity to highways and intermodal facilities, the number of W&DC and accommodation and food services in neighboring zips, population, the number of adults using public transit, , and per capita income.

Using the Commodity Flow Survey (CFS) Microdata and other Census products, the team estimated disaggregate econometric models to characterize the amount of freight generated by NAICS 493 establishments as a function of economic variables of the establishments (i.e., employment). Moreover, using disaggregate shipment distance data, the authors estimated and compared the trip length distribution of shipments originating in Southern California with a destination inside the State of California. The team compared the results with survey data collected throughout the project and interviews with various stakeholders.

The results are expected to have great planning and policy implications and be of interest for practitioners, public and private entities and the academia. Caltrans, Metropolitan Planning Organizations and the affiliated institutions of the National Center for Sustainable Transportation will directly benefits from the results as they will allow for the development of policies and sustainable strategies for the freight transportation system.

I. Introduction and Background

The freight transportation system could be termed as the economy in motion, since economic transactions translate into physical movements of goods or services (Holguín-Veras and Jaller, 2014). Therefore, an efficient and effective freight system is a necessary condition for a vibrant economy. This relationship is even stronger at the urban level, where the dynamics between different socio-demographic variables exhibit more important interdependencies. Individuals decide where to live and conduct other activities depending on the accessibility to the transportation system and the availability of goods and services (brought by the freight transportation system). However, the system is responsible for many externalities including congestions, large consumption of energy and oil, and the emission of different pollutants, among others. In the U.S., the costs of truck related congestion accounts for twenty three billion dollars (2010 data), which in many dense and congested cities translates into higher prices for goods and services (Texas Transportation Institute, 2011). Although, there are no exact estimates, the freight system is responsible for a large percentage of the transportation sector share in terms of total emissions of carbon monoxide (54%), nitrogen oxide (36%), volatile organic compounds (22%), and sulfur dioxide (1.4%) (Bureau of Transportation Statistics, 2007). In France, a research study conducted in three small to medium cities found that although only representing between 13% to 19% of all the vehicle traffic, trucks were responsible for 60% of the particulate matter, 53% of NOx, and 33% of CO_2 (Segalou et al., 2003). Similarly, in Mexico City, large freight vehicles, representing only 1% of the fleet, were responsible for almost 40% and 45% of the emissions of PM10 and PM2.5, respectively. Medium freight vehicles, representing 3% of the fleet, generated 20% of the particulate matter (SMA-DF, 2010).

The impacts of the freight system on environmental justice, safety and mobility have dominated, in many cases, the general attitude towards the system, completely disregarding its link to the economy and quality of life. Therefore, it is imperative that public and private efforts are invested to achieve a more sustainable system that maximizes its efficiency while minimizing the negative effects. There are other factors that have contributed to this phenomena, including the complexity of the system, lack of supporting knowledge and data, and appropriate decision support tools (e.g., models, planning guidelines). To this effect, this work intends to fill a gap by analyzing the freight patterns of one of the key economic agents of the freight transportation system: warehouses and distribution centers.

Studying warehouses and distribution centers is important to improve the freight system because: they are fundamental to goods movements, especially after the changes in logistics process experimented in the last few decades (Hesse and Rodrigue, 2004); this sector has grown very rapidly in recent years (Bowen Jr, 2008); modern distribution centers are very large facilities with sizes exceeding 500,000 square feet (Andreoli et al., 2010); due to the large freight volumes handled, they generate (produce and attract) a large number of consolidated freight trips; and 5) low freight costs have allowed them to move away from the markets they serve, finding the required land without paying a premium (Rodrigue, 2004b). These factors have resulted in logistics sprawl or the deconcentration of logistics facilities and distribution centers in metropolitan areas (Dablanc and Ross, 2012; Dablanc et al., 2014).

Logistics sprawl produces additional vehicle-miles traveled to reach the service areas where households, jobs and commercial and retail establishment concentrate, thus increasing the amount of externalities produced (Dablanc, 2014). This process has received special attention during the last few years (Bowen Jr, 2008; Hesse, 2008; Cidell, 2010; Dablanc and Ross, 2012; Dablanc et al., 2014). Some of these analyses have paid particular attention to the California case, especially to Southern California due to the sheer volume of cargo moved in and out the region demanding warehousing space (SCAG, 2011). Moreover, recent data have evidenced the importance of considering internal truck trips, especially those originated at W&DC with a destination inside the study region. For instance, the internal truck traffic in the Southern California represents almost 85% of the truck traffic (SCAG, 2016). Therefore, the location of W&DC will determine vehicle-miles travelled, emissions, and the impact on surrounding communities. Consequently, the work builds on recent research to:

1. Provide an updated analysis on the concentration of W&DC in Southern California between 1998 and 2014. This is important because: previous analyses that identified the issue of logistics sprawl considered the period up to year 2009; the 2008 and 2009 economic crisis affected several industries in the region, and throughout the country; additional requirements of larger facilities, e.g., high cube warehouses; and recent trends on e-commerce and the need to provide shorter delivery times, could have affected W&DC location decisions. The work also provides complementary assessments to those presented in a recent report (Giuliano et al., 2016).
2. Discuss the sprawling patterns of different types of W&DC.
3. Explore the spatial relationship between W&DC and establishments in other industries.
4. Analyze the factors that could explain the concentration of W&DC in specific geographic area through econometric modeling. To conduct the analyses, the authors used aggregate establishment, employment and other socio-economic data for different industries in Southern California, complemented with transportation related variables identified using Geographic Information Systems. The analyses are based on centrographic and econometric techniques.
5. Considering the limitations of analyses conducted at higher levels of aggregation (i.e., zip code level), this work also uses other relevant and granular datasets such as the electronically available editions of the CFS micro-data (1993, 1997, 2002, 2007, and 2012) and matching data from the Census of Manufacturers (CMF), Longitudinal Business Database (LBD), and Standard Statistical Establishment List – Name and Address File (SSEL). Using the information in these datasets, the team analyzed the case of Southern California. Specifically, the team estimated econometric models to characterize the freight patterns of warehouse and distribution centers in terms of freight generated, and using disaggregate shipment distance data, the authors

estimated and compared the trip length distribution of shipments originating in Southern California with a destination inside the State of California.

Understanding the freight patterns of warehouses and distribution centers and the impact of logistics sprawl will help to plan and develop appropriate measures to contend the negative impacts generated by their operations. This in turn will help achieve a sustainable economy with an improved, sustainable and more efficient freight transportation system.

This report is organized as follows, Section 2 discusses the literature regarding logistics sprawl and the factors determining this phenomenon. This section also focuses on the warehouse and distribution facilities and planning implications and concentrates on the warehouse and distribution centers sector. Section 3 conducts a review of the factors influencing logistics sprawl. Section 4 discusses the type of data used for the analyses and provides information about the survey instrument developed as part of this project. Section 5 describes the methodologies used in this work. Section 6 analyses the results. The report ends with a conclusions section.

II. Literature Review

The freight transportation system allows for the physical movements of goods or services (Holguín-Veras and Jaller, 2014) that are necessary for the economy. In doing so, the system generates congestion, consumes large quantities of energy and oil, and emits different pollutants to the environment, among other negative factors (Segalou et al., 2003; Texas Transportation Institute, 2011). While most of the impacts are associated to the vehicles transporting the cargo, usually managed by carrier companies, the characteristics and movement patterns are determined by the decisions made by other components of simple or complex supply chains. In a simplified exposition, shippers of the cargo are in charge of one end (origin) of the supply or logistics structure. At the other end, final or intermediate receivers and consumers of the cargo dominate logistics decisions. These agents exhibit diverse freight and freight trip generation patterns, affecting frequency of distribution, and vehicle type selection, among other factors (Holguín-Veras et al., 2012; Jaller et al., 2015). Along the continuum, a diverse number of agents and ancillary facilities also affect the physical movement of goods.

Supply Chain Configurations

The configuration of supply chains is creating a demand for more and bigger logistics facilities. The characteristics of distribution centers are “directly responsible” for logistics sprawl and polarization in urban regions (Dablanc and Ross, 2012). Bowen Jr (2008) highlights four factors that explain the evolution of supply chain management (SCM) and the impact on warehouses: the globalization of production networks, time based competition, demand driven supply chains, and online shopping. These factors are creating more complex challenges to companies trying to get goods to the right place and time while lowering transportation costs. According to Glaeser and Kohlhase (2003) the cost of transporting goods has been reduced by over 90%.

Wagner (2010) also recognizes the roll of production globalization and the flexibility that companies seek to meet the changing demand. For instance, contracts with logistics providers are shorter in order to have flexible responses.

As reported on the literature reviewed, there is an increasing trend for larger distribution centers which aim for greater markets, either at a regional, national or international level. Mega-urban regions (or mega-regions) defined by the flow of freight movements are "logistically integrated entities" where a concentration of warehouses and distribution centers encompass local, regional, and global economic processes (Rodrigue, 2004a). Accordingly, local freight activities are explained by larger scope interactions with other markets and regions. Rodrigue (2004a); Andreoli et al. (2010); Dablanc and Ross (2012) note that warehouses and distribution centers have established in suburban areas and close to air and road transportation networks. They require bigger land space and access to regional markets. Therefore, logistics facilities located at these sites have a larger distribution sphere.

Supply chain management has evolved rapidly in the last decades to aggregate its different components from the materials and parts supply, manufacturing processes, storage and distribution, information technologies until the final consumer is reached. In this mixture of activities, warehouses and distribution centers allocate several functions in the same building requiring larger spaces of land and integrated transportation networks especially in ports, airports, and highways. They become a key component in the configuration of the supply chain. Hesse and Rodrigue (2004) identified that transportation becomes an integrated demand of the "physical distribution and materials management".

Vertical and horizontal structures have also affected the way goods move, or wait for other logistics operations. Vertical and horizontal integration refer to the size and level of organization of the supply chain. The vertical structure relates to the number of segments or "tiers" in a supply chain where different processes take place, i.e. materials supply, manufacturing or processing, storage, and distribution. The horizontal structure encompasses the array of entities that belong to each tier of a supply chain (Rodrigue, 2013). Figure 1 shows an example of the vertical and horizontal structures. The adequate integration of both levels will deliver efficient, reliable, and timely processes while taking advantage of economies of scale. Companies may select different configurations creating associations with other companies or extending their own activities or scope to stretch their horizontal or vertical structure.

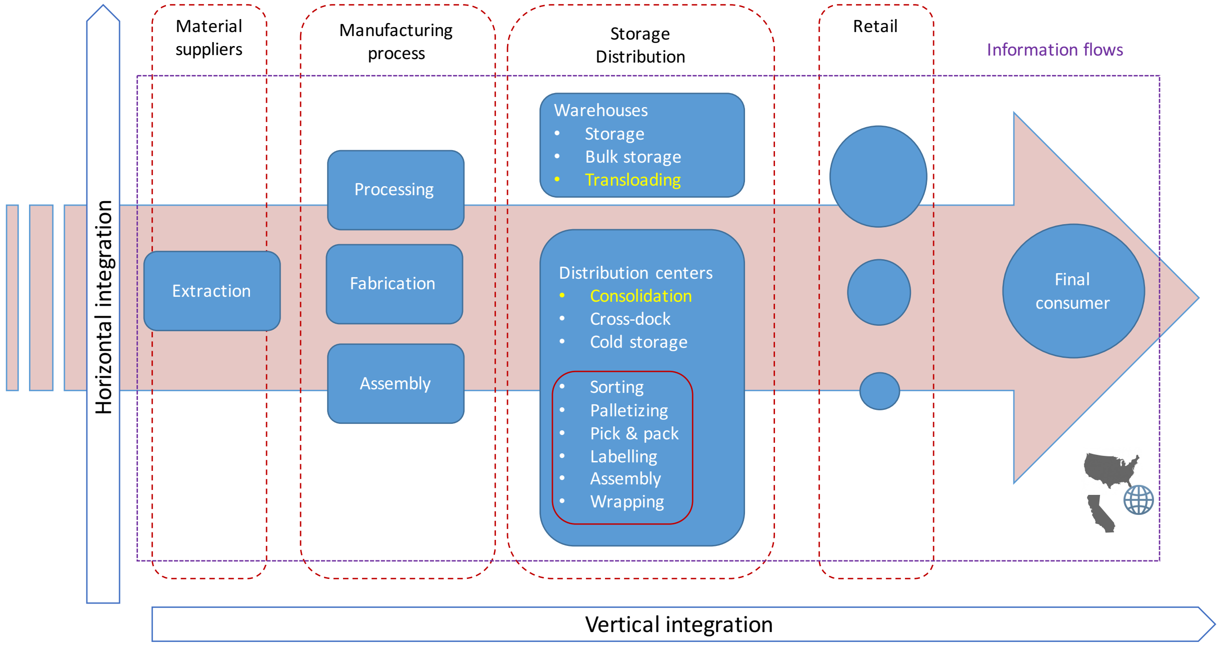

Figure 1. Vertical and Horizontal Structures in Supply Chains [Source: Adapted from "Transport Geography on the Web", Jean-Paul Rodrigue. Accessed May 2016 https://people.hofstra.edu/geotrans/eng/ch5en/conc5en/scope_supply_chain.html]

Warehouse and Distribution Centers (W&DCs)

According to the stage in the supply chain, freight facilities carry different activities adding value to the goods handled. These facilities can host operations such as manufacturing processes that include from transforming raw materials to the assembly of products. Terminals (facilities) storage goods and act as buffers between modes in order to balance throughputs, they can be intermodal or transloading facilities. Some of these terminals are known as warehouses and distribution centers. There are key characteristics to each of them, though in some cases it is not clear how to identify them.

In general, warehouses store goods for longer periods of time anticipating demand, shipments are larger and less frequent, and automation of operations is "minimal". DCs, on the other hand, have more frequent shipments but in smaller quantities that respond to time constraint schedules. They are usually larger than warehouses, hosting many operations or value-added activities rather than just storage of goods, such as pick and pack or multi-vendor consolidation, and make high use of automation and information technologies (Bowen Jr, 2008).

The cluster of so many different activities has led to the expansion of "mega distribution centers" that as classified by Andreoli et al. (2010) employ more than 100 workers and facilities are greater than 500,000 sq. ft. They promote economies of scale, accommodate higher volumes of traffic, extend hours of operation, reduce labor costs and serve larger markets. DCs functioning at off hour times encounter less congestion problems. As information technologies provide more accurate real time data, time and cost operations can be improved. Current company strategies rely on long-term demand forecasts that feed distribution centers. There, last leg of the supply chain is served by a pull approach reducing uncertainty. This final stage is usually delivered by truck and it accounts for the longer leg of the supply chain (Andreoli et al., 2010). Parcel (fulfillment) facilities mainly respond to online orders, where goods are sorted accordingly and are constraint to time sensible schedules.

Despite the differences exposed beforehand, warehouses and distribution centers are classified under the same NAICS group, 493. The only difference among these facilities relates to if they are for general warehousing storage (49311), refrigerated (49312), for farm products (49313), or other types of warehousing and storage (49319). Refrigerated facilities are important in cold chains and present additional challenges and operational patterns. These cold chains require specific technologies, transportation and location characteristics. Since the fabrication of goods up to the end of the supply chain, the integrity of the product must be met. A number of commodities in the food, pharmaceuticals, and chemicals industries are examples of cold chains. Transport technologies usually include refrigerated containers or “reefers” to transport these type of goods. Container loading, unloading and transloading represent challenges to companies that have to consider factors such as size, weight, safety, product packaging and monitoring controls for temperature, power generators and location through storage, transportation and handling processes in the supply chain (Rodrigue and Notteboom, 2015).

W&DCs in Southern California

In Southern California, the Southern California Association of Governments (SCAG) classifies W&DC in industrial/warehouse, distribution facility, cross dock trucking terminal, and bulk warehouses. In 2014, there were 1.2 billion sq. ft. of warehouses, distribution centers, cold storage facilities and truck terminals in the region (SCAG, 2016).

Around 62% of this area (approximately 4,900 buildings) are facilities larger than 50,000 sq. ft. mainly serving non-port related services. Most of the flow of goods by truck (85% of trips) found in the area is associated with local or intra-regional trips while international shippers have a higher use share of rail and air networks. Activities at port-related warehouses which locate in the Gateway cities focus mainly in transloading, deconsolidation and some value-added services. National and international distribution centers are found mainly in the Inland Empire region.

Among the six counties (Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura) that comprise the SCAG region, Los Angeles (31.2%), Riverside (21.2%) and San Bernardino (30.2%) account for the largest share of total miles of primary freight network (SCAG, 2016). Consequently, the majority of the facilities (larger than 50,000 sq. ft.) are located in these counties. In terms of the available land for new warehouses, the Inland Empire shows the highest availability (Figure 2) (SCAG, 2009). 56% of the facilities receive goods from the Port of

Los Angeles and Long Beach, and around 50% deliver to Southern California warehouses, retail stores or manufacturing plants.

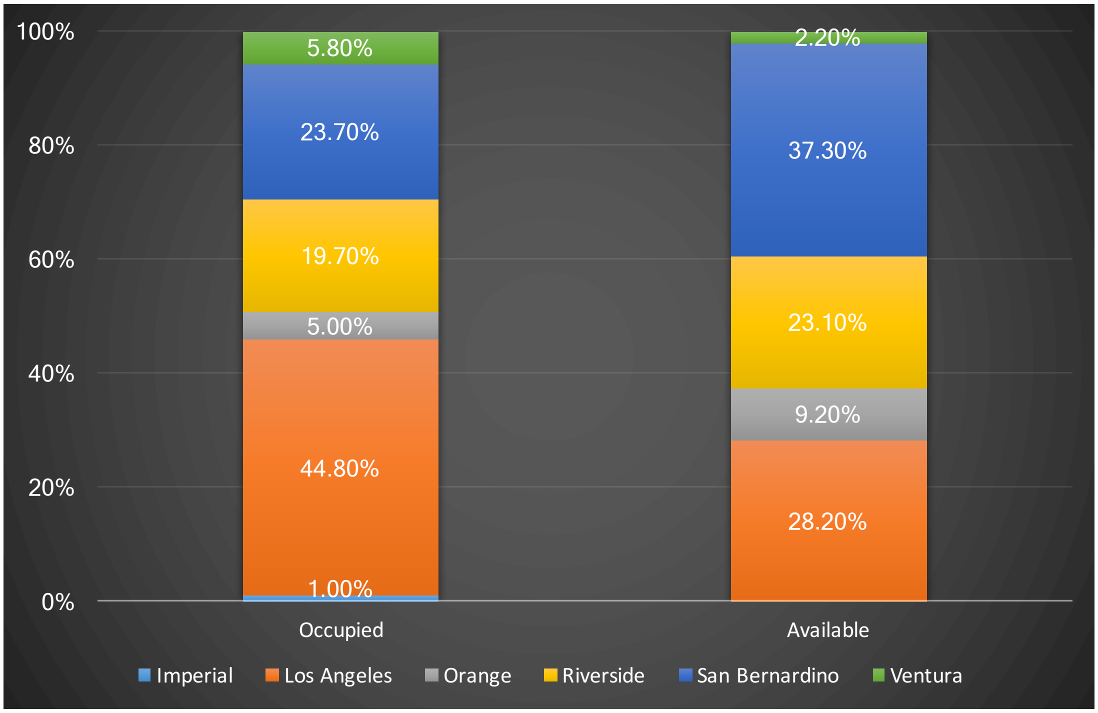

Figure 2. Percentage of Occupied and Available Land Space (50,000+ sq. ft. facilities) [Source: Adapted from Industrial Space in Southern California (SCAG, 2009)]

Existing and related studies about warehousing industry were consulted to compare the results found in this project as well as to complement the results found. The main highlights of these studies are presented:

SCAG warehousing facilities survey

SCAG also carried out a **Warehousing facilities survey** (SCAG, 2009) that contains information of 61 businesses matching the distribution of firms from a larger business database of about 7,600 records that integrates facilities with area of 40,000+ sq. ft. The information is from SCAG and Lee and Associates. Some of the main features of the facilities obtained from the survey were:

- Employment:
    - The mean average annual employment is 76 people.
- Size: area and height
    - 60% of facilities are 50,000+ sq. ft. The most common building size is between 50,000-99,999 sq. ft. (30% of the total) followed by 100,000-499,999 sq. ft. size (25.5% of the total).
    - 56% of companies have a height between 21-30 feet, with a mean height of all firms of 27 feet.

- Use: Includes: warehousing, manufacturing, truck operations, retail and other (Figure 3).
- Goods handling operations: storage, transloading and cross-docking (Figure 4):
    - Half of the companies carry goods handling operations and those who do, focus mainly on storage services and some include transloading.
    - The majority of goods that are stored are delivered within Southern California but the largest share of storage space is for national destinations.
    - Most transloading is from ocean to landside containers.
    - Nearly 50% of cross-docking are LTL (Less than truck load).
- Goods handled:
    - Services offered are cold storage, hazardous material handling, customs inspection and other special functions.
    - LA and Ventura carry mostly cold storage, the main activity at Orange is customs handling and for the rest of the counties hazardous material handling.
    - Figure 3 shows the details regarding the added-value operations.
- Origin and destination of goods:
    - 56% of the firms receive goods from the Port of LA and Long Beach.
    - Around 50% of the firms deliver in Southern California warehouses, retail stores or manufacturing plants.
- Facility operator:
    - Classification shows type of firms operating as trucking firm, retailer, 3PL, LTL, package delivery firm and other.
    - 49% of the firms are classified as "other" that involve manufacturing, wholesale trade or distribution.

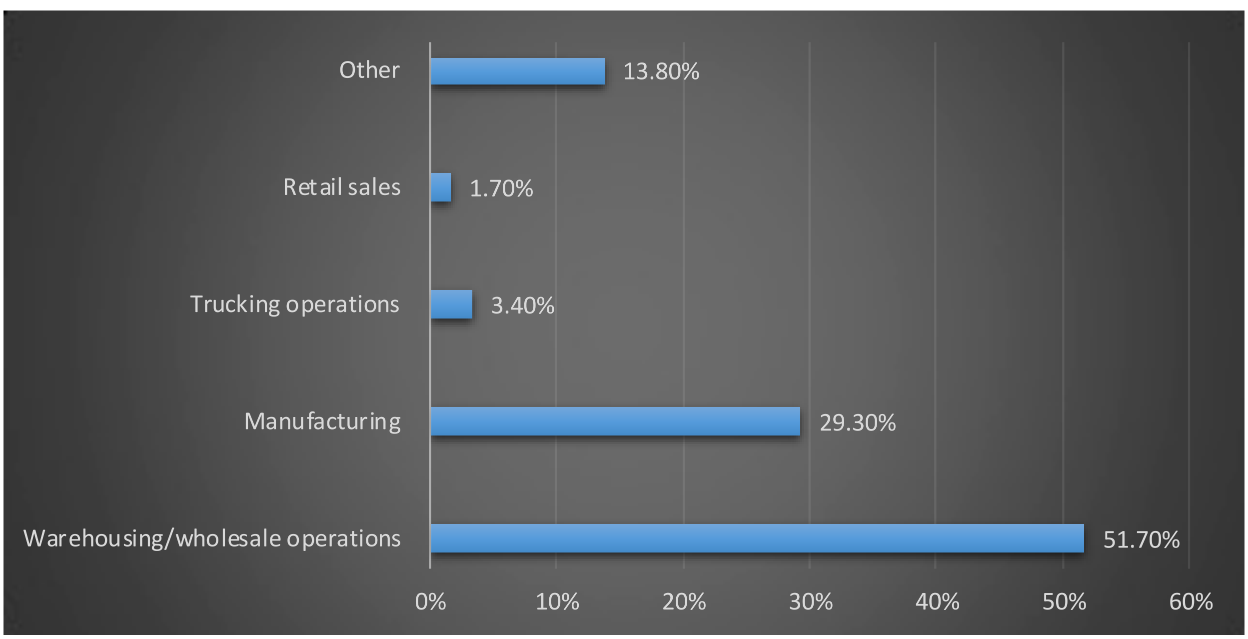

Figure 3. Primary Use of Facility (%) [Source: Industrial Space in Southern California (SCAG, 2009)]

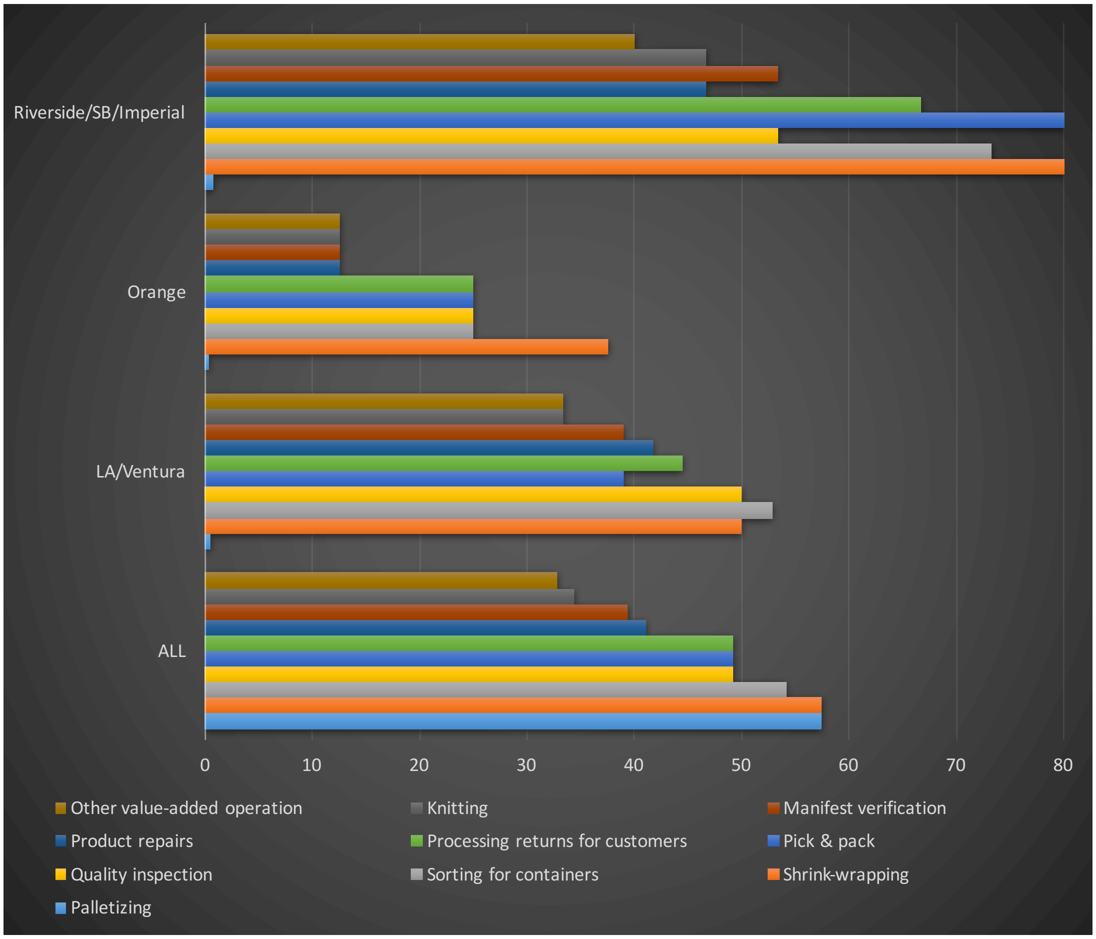

Figure 4. Percentage of Added-value Operations by County [Source: Industrial Space in Southern California (SCAG, 2009)]

SCAQMD high cube warehouse truck trip study

A different study[1] from the South Coast Air Quality Management District (SCAQMD)–the **High cube warehouse truck trip study**–in 2013 analyzed the truck trips rates of high cube facilities. They sent out a survey to 400 warehouse operators in the region but only 63 of them participated. More than half of the respondents (34) managed high cube facilities that are defined as having more than 200,000 sq. ft. of floor area, 24 ft. of minimum ceiling height, more than 1 door dock per 10,000 sq. ft., and the main activity of the facility is the distribution of goods with a high level of automation.

The distribution of facilities by county in the sample shows different results from SCAG studies where LA has the biggest share. In this case, Riverside and San Bernardino account for the highest share. The differences could be attributed to the small sample of the study and should be considered when interpreting the results.

[1] http://www.aqmd.gov/docs/default-source/ceqa/handbook/high-cube-warehouse-trip-rate-study-for-air-quality-analysis/business-survey-summary.pdf?sfvrsn=2

- Facility size: Since the definition for high cube warehouses was set to be more than 200,000 sq. ft. all companies have that minimum floor area.
  - 41% of buildings has > 200,000 sq. ft.
  - 38% of buildings has > 500,000 sq. ft.
  - 21% of buildings has >1,000,000 sq. ft.
- Turn over time: 60% of the facilities have a turn over time of less than 3 months, specifically, 1 to less than 3 months for 28% of the facilities followed by 1 week to almost a month for the 32% of the facilities.
- Utilization of facility: All facilities use 50% of the space available and 54% of the facilities have an 80% level of utilization. Regarding the average amount of space dedicated to certain activities the breakdown is shown in Figure 5. Supporting activities are referred to as pallet handling, forklift battery charging, and cardboard handling, among others. Value added includes labeling. No more detail about the categories used in the survey is provided in the SCAQMD report.

Forty percent of companies that reported the type of goods they handle, manages multiple types of goods, being the most common non-perishable goods (clothing, toys) followed by perishable goods (food, drink), durable goods (furniture, appliances), parcel, raw materials and other.

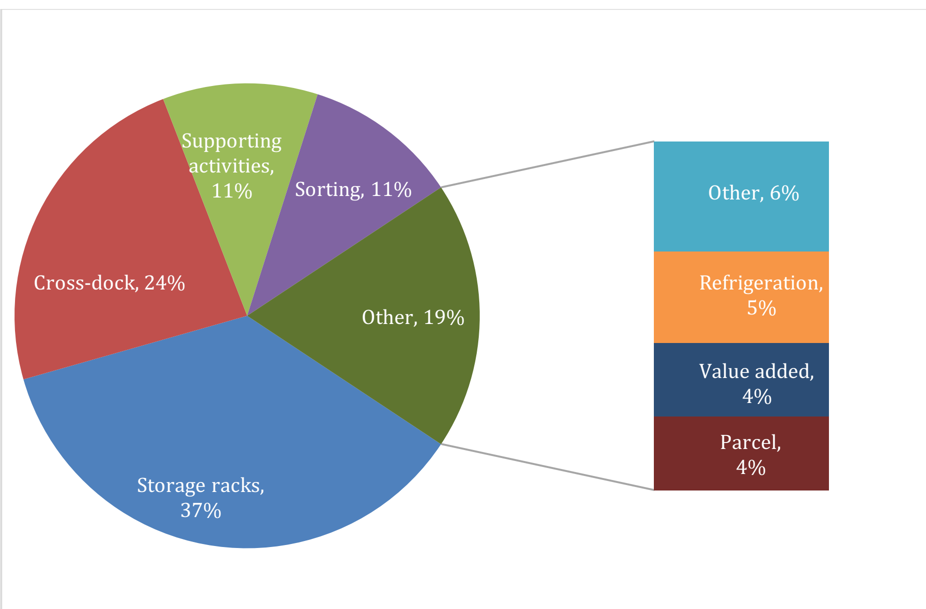

Figure 5. Floor Space Dedicated for Warehousing Activities [Source: Adapted from SCAQMD, 2013]

- Automation: To measure automation, facilities reported the activities they carry using a certain type of technology. These are in descending order of frequency use: barcode scanning, automated sorting, conveyor belts that load directly into trailers and automated storage. Although more specifically, 54% of facilities reported using conveyor belts and in the case of larger facilities they tend to use more forklifts.
- Origin and destination of goods: Most goods have an origin at the Ports of Long Beach and LA and the main destination of all goods is within the State of California, confirming what SCAG reports have shown.
- Seasonality: Most companies reported that the months with major or peak activity were September, October and November which could be attributed to back to school and holidays periods. In this context, these companies also reported an increase in the truck activity that in average is about 27% with a maximum of 100%.
- Trip rates: A trip was defined as a vehicle crossing the limits of the facility. Total trip rates include all types of vehicles from cars to trucks and truck trip rates just the number of trips by truck. The trip rate and truck trip rate is then calculated by the total number of trips in the busiest day of the week divided by the total size of the warehouse. Table 1 shows the information related to the trips rates. It is worth noting that facilities handling perishable goods and cold storage show the highest truck rate.

Table 1. Trips Rates of Warehouses [Source: Adapted from SCAQMD, 2013]

Trip rates per 1,000 sq. ft.	
Average trip rates (car+trucks) for all warehouses	1.22
Average truck trips for all warehouses	0.53
Average truck trips with onsite rail	0.57
Reported truck trips for warehouses with cold storage (perishable goods)	0.65
Reported truck trips for warehouses with cold storage (non-perishable goods)	0.45

III. Logistics Sprawl

Logistics sprawl is the phenomenon of relocation and concentration of logistics facilities (warehouses, freight terminals and etc.) towards suburban areas outside of city centers, i.e., spatial deconcentration (Dablanc and Rakotonarivo, 2010; Dablanc and Ross, 2012). There are mixed attitudes towards logistics facilities because they could generate jobs and economic development, but they could also generate noise, emissions, traffic congestion, reduce parking availability, and foster night time and early morning activities that can be disturbing to the community (Wagner, 2010). For example, (Grobar, 2008) found that household unemployment and poverty rates were higher in surrounding metropolitan areas than in port districts. More specifically, logistics sprawl and the operation of W&DC in suburban regions have significant health impacts in the surrounding communities. (Dablanc and Rakotonarivo, 2010) measured the sprawl impacts of logistic facilities in the Paris region to be about 14,700 additional CO2 tons per year and 400 vehicle-km every day. Other concerns relate to the loss of land used for warehousing purposes instead of community development projects (Betancourt and Vallianatos, 2012). According to the (U.S. Equal Employment Opportunity Commission, 2004) study, about retail distribution centers and their impact in minority labor, in less populated regions, the percentage of women and minority workers hired tends to be smaller.

Factors Determining Logistics Sprawl

Multiple studies have identified the factors influencing logistics sprawl. In general, these could be categorized in terms of land availability and affordability (e.g., land costs), proximity to customers and transportation networks, accessibility to labor and supply chains, and the regulatory environment (e.g., development requirements, incentives) and zoning plans found in the region. Table 2 shows examples of specific factors identified in previous research. The reader is referred to the studies discussed in this section for additional details on the myriad of factors. The following sections discuss previous research.

Land availability and affordability

Several studies in the U.S., Europe and Japan (Cidell, 2010; Dablanc and Rakotonarivo, 2010; Dablanc and Ross, 2012; Sakai et al., 2015) have found that warehouses and distribution centers tend to locate farther from their urban centers where jobs and population are usually concentrated. Consequently, locating in suburban areas where (usually) land availability, cheaper rent, less congested areas and accessibility to important transportation networks are present.

Specifically, Cidell (2010) confirms that logistics facilities are moving inland and into the suburbs where there is space availability to develop one-single story distribution centers (DC) as a response to “containerization” and management of higher throughput. Bowen Jr (2008) also noted that the growth of W&DC developments was oriented to suburban regions. In their study, Andreoli et al. (2010) corroborate the findings of Cidell (2010) and Bowen Jr (2008) and show that the growth in mega DCs is rising due to the economies of scale they provide in serving larger markets and time constraint operations.

Other case studies in Seattle and Toronto (Dablanc et al., 2014; Woudsma et al., 2016) have found contrasting conclusions where logistic sprawl is not evident in those regions. This may occur due to geographical conditions, land use availability or local policies that guide logistics facilities locations decisions. Comparing Los Angeles and Seattle regions, Dablanc et al. (2014) found that both cities share common geographical characteristics but come up with different results when analyzing logistics sprawl. They measured the distance of the logistics facilities to their barycenter, finding that warehouses in LA have moved out over the time of study (1998-2009), while in Seattle, the distance of warehouses to the barycenter even decreased.

Accessibility to labor and supply chains

Hesse (2008) identified the geography of the region; specifically, the advantages the region has to offer in terms of labor markets and accessibility to both suppliers and customers as one of the key factors. Micro-level considerations include the size of a lot, the land rents demanded and the existence of a “robust‟ operating environment where 24/7 operations are available (Jakubicek, 2010). However, in Demirel et al. (2010), along with lead time and responsiveness, transportation cost is a highly important factor in locating warehouses according to the experts surveyed in the study. With that note, regardless of how important delivering distance is compared to delivering time, both parameters are important to shippers. Demirel et al. (2010) also found labor characteristics to be a “slightly unimportant” factor in locating warehouses. Though, Jakubicek (2010) found availability of skilled workers near the top of the list of the most important factors in locating warehouses.

Proximity to customers and transportation networks

Population and spending power of customers in surrounding areas is an important logistics facility locator factor in (Vlachopoulou et al., 2001) geographic model. Woudsma et al. (2016) noted that existing facilities in urban areas benefit from the proximity to their customers and there is no evidence that existing facilities in the region moved out of suburban areas.

To logistics operators, reliability of mode of transportation to customers is more important than the reliability of the mode for them to receive goods. This is because inbound transportation is not as time-sensitive as outbound (Jakubicek, 2010). This is essentially due to the fact that service level is considered as a value for the product (de Magalhães, 2010). (Vlachopoulou et al., 2001; Demirel et al., 2010; Olsson and Woxenius, 2012) indicated that proximity to highways is an important factor in locating logistic facilities. It is noteworthy that rail services are perceived as risky, so locating logistic facilities next to railyards is not an important factor. Proximity to highway and airport transportation networks have become more relevant (Bowen Jr, 2008; Dablanc and Rakotonarivo, 2010; Dablanc et al., 2014). Similar to the previous case, some studies have found contrasting results. In their Paris study of parcel and express transport facilities, (Dablanc and Rakotonarivo, 2010) concluded that proximity to clients was not a major factor to determine location, as it used to be in the past. (Wagner, 2010) also found that traffic generation was not a major driver for selecting a location, since limited space availability is increasingly a major constraint.

Table 2. Summary of Factors Determining Logistics Sprawl

Factors	Definition	Rationale
Land Available for Expansion	Space that can be acquired or existing space be converted to intensify usage or storage capacity onsite. Zoning can affect this factor (e.g., parking requirements onsite reduces storage capacity)	Flexibility to expand or contract depending on the state of business. The ability to expand onsite rather than purchasing or renting a separate facility
Number of Dock Doors	Number of Dock Doors	Appropriate amount of dock doors for operation needs
Proximity to Highways	On-road distance to the highway and time it takes to get to the highway	To allow for the ease of good transports by trucks
Public Transit Availability	On-road distance to the public transits and time it takes to get to public transit	For workers (typically unskilled) to get to work
Long Combination Vehicle Accessibility	Surrounding roads and facility's yard wide enough for long combination vehicle to manuever	Infrastructures (e.g., large enough surrounding roads) available for operators to utilize long combination vehicles
Proximity to Airport	Distance and travel time by truck to airport	To take advantage of flight cut-off time for shipping materials and lower drayage cost
Proximity to Sea Port	Distance and travel time by truck to sea port	To reduce truck drayage cost and time
Rail Intermodal Facility	Distance and time to rail intermodal facility	To reduce truck drayage cost and time
Ability to Operate 24/7	The ability to increase and decrease operation depending on the state of the economy	More control of operation
Trailer Parking/ Truck Staging Areas	Land available for staging areas and outside storage	A reduction in the amount of floor space required by just in time (JIT) firms is often offset by more land being required for outside storage, and staging areas
Telecommunication systems	Communicative technologies between the warehouse, suppliers and customers	Certain regions do not have good telecommunication systems:major requirement in modern economy
Quality and reliability of modes	Quality of the transportation services between the warehouse, suppliers and customers.	Ability to have timely deliveries, delivery to the correct location and undamaged goods
Access to Customers	Distance and time to deliver goods to customers	To allow for constant and on-time deliveries
Access to Suppliers	Distance and time to obtain goods from suppliers	Minimization of traveling time and distance
Customer population in surrounding area	Customer population in surrounding area of the facility	Maximize distribution zone and penetration of such zone
Spending power of this population	Income of the population in the surrounding area of the facility	Maximize distribution zone and penetration of such zone
Distance competitor to customers	Distance from competitor to customers	For competitive edge
Availability of Skilled Workers	Sales, administrative staff, trained forklift drivers and etc..	Nessesary personnel
Availability of Unskilled Workers	Workers that would have to be trained before they can be operational	In event that not enough skilled workers are hired
Pro-business regulatory environment	How active municipalities are in attracting business through various incentives	Reduced cost and have more control of operation
Zoning and construction plan	Different development plans, implementations and arrangements at alternative locations	To ensure that the zoning and regulator's vision for the land that the facility to be built on matches the vision of the firm.
Land costs/tax rates	Operating cost	Reduce operating cost
Proximity to other similar businesses	Logistics campuses - where similar businesses are in the same complex	Logistics campuses were seen as a way for companies to reduce costs
Labor Costs	Wages, salaries and etc..	Operating cost
Transportation Costs	Fuel and equipment cost	Cost of transporting goods
Handling Costs	Cost of good storage	Operating cost

Regulatory environment

Another important aspect is related to the regulatory environment. This is reflected in the policies that promote or limit the development of logistic facilities and freight terminals. Land use, environmental and safety regulations and tax schemes play a key role in setting some constraints or advantages. (Dablanc and Rakotonarivo, 2010; Jakubicek, 2010; Dablanc and Ross, 2012; Diziain et al., 2012; Dablanc et al., 2014; Woudsma et al., 2016)

Planning Implications

Freight planning is usually left aside or not addressed comprehensively in regional and local plans. Land use zoning, traffic generation, environmental and social impacts, and economic development are common factors that coexist in the establishment of logistics facilities and in many cases few guidelines are in place to incorporate them. Understanding logistics sprawl requires an analysis of current policies and attitudes at local and regional level. Most of the literature consulted reaffirms the need to include inclusive transportation plans where freight is a key component. Land use and transportation policies should be aligned and provide adequate solutions.

In the case of a Paris study, Diziain et al. (2012) found opposition in the development of logistic facilities in denser areas. As industries face competition with other more profitable operations for land use, the idea of a “multi-story real estate” (e.g., Sogaris logistics hotel) that provides a mixed-used building accommodating more profitable commercial operations and logistic services, seems a viable option. But this has to be accompanied with the support of public authorities to encourage participation of local governments, real estate and industrial companies in the development of promising projects. In a study in the same region, Dablanc and Rakotonarivo (2010) highlight the example of supermarket developments as a reference of an inclusive and comprehensive evaluation project process that includes building permits and traffic mitigation strategies.

In their study of mega regions in Atlanta, Dablanc and Ross (2012) made a remark about the need of greater coordination among public and private sectors to develop more congruent policy planning instruments to optimize the location of warehouses and distribution centers. They found a lack of regional coordination to promote a congruent metropolitan planning. Regions are competing among each other to attract more companies to settle in their locations, thus strategies just remain as a local policy. In the same context, some central areas do not account for logistic facilities in their zones, overlooking freight and related activities in terms of requirement of land. Zoning rules within adjacent regions can be opposed to each other, enabling in one case the development of logistics and industrial facilities while the others do not. Coordination at the interior of a region can be a challenge, different departments within the local government may have different attitudes towards a project. Dablanc and Ross (2012) analyzed some regional transportation plans finding that in most cases, freight is not significantly addressed at a mega regional scope. Encouraging collaborative work within public and private stakeholders will promote comprehensive transportation plans that include freight as an important component. Not just assuming and addressing the environmental impacts and concerns from the communities but providing adequate infrastructure to logistics operations and identifying opportunities to improve overall efficiency in supply chains at a regional level.

A case study in Germany (Wagner, 2010) confirms the findings of the Atlanta's study: "the distribution of planning power and economic competition between local authorities" is one of the hurdles to overcome traffic generation in logistics facilities. A lack of information about traffic generation of potential new locations limits the ability to plan accordingly in the short and long term. Traffic assessment and land use considerations are an important planning tool to support project decisions, therefore a better integration of land use and planning policies should be considered to minimize impacts of logistics activities.

However, a Los Angeles and Seattle study showed opposite results in the spatial analyses (Dablanc et al., 2014). The Washington State adopted in 1990 the Growth Management Act that provides constraints about characteristics and location of warehouses that governments are required to consider which according to the authors, cannot be compared to the Sustainable Communities Strategy required in the SB375 legislation in California. As a result, an increase of warehouses and DCs have taken place in the "Inland Empire" region, promoted as well by local policies supporting the development of warehousing (e.g. Coachella Valley Economic Partnership and the City of Moreno Valley).

Sakai et al. (2015) analyzed the sprawl of logistics activities within the Tokyo Metropolitan Area and compared it with documented cases from U.S. and Europe. They also assessed the relationship between the spatial distribution of logistics facilities and the origin and destination of the generated shipments. The authors also compared the potential ideal location of these facilities with the current location. They found that the data showed some facilities already at their optimal location. To contribute to land use planning, they proposed a market based mechanism to reduce the impact of increasing shipment distances and to incentivize the efficiency of logistic operations given the particular characteristics and locations of the facilities, e.g., distance-based truck pricing. Moreover, they note that land use planning for logistics facilities is crucial.

IV. Data Collection, Gathering and Assembly

The work considered both aggregate and disaggregate data. Aggregate data (at the zip code level) included employment and socio-economic characteristics of establishments, infrastructure, and population in Southern California between 1998 and 2014. The main data sources used were the Zip Code Industry Detail Files of the U.S. Census County Business Patterns (CBP), Census datasets, the 2013 5-year American Community Survey, and Geographic Information System (GIS) layers (e.g., network, logistics facilities). For the disaggregate analyses, the main source was the Commodity Flow Survey microdata.

Aggregate Data

The spatial analyses were performed for W&DC in 5 counties of the SCAG region: Los Angeles, Ventura, San Bernardino, Orange, and Riverside. After analyzing empirical data of a bigger area including San Diego and Imperial counties, the authors found that the Greater LA area and the two borderline counties show different freight and logistical patterns and should be assessed differently.

Several datasets were considered for the analyses: the Zip Code Industry Detail Files of the U.S. Census County Business Patterns (CBP) datasets that provide information about the number of establishments including their employment size and industrial classification (U.S. Census Bureau, 2011). These datasets are organized under the North American Industry Classification System (NAICS). The information consulted for the analyses spans over the years 1998 to 2014. The W&DC data of interest related to those establishments within NAICS 493, which aggregates warehouses and distribution centers into a single industry; other studies have already identified this as a limitation for this type of analyses (Bowen Jr, 2008).

The establishment data was complemented with socio-demographic information at the zip code level and the authors used geographic information systems to estimate additional attributes and variables needed to account for the potential impacts of logistics sprawl (as discussed in Table 2) using various sources. These include access or distance to highways, ports, airports, parking, and intermodal facilities for each zip code, among others. Despite the efforts, the authors were not able to secure land value or availability data for the analyses, the reader is referred to (Giuliano et al., 2016) for a discussion of the impact of such variables. The final dataset is comprised of observations for 596 zip codes.

For the centrographic analysis, the authors also considered establishments in NAICS 44, 45, 492, and conducted the analyses for the aggregate 3-level NAICS 493, as well as for the corresponding 5-level NAICS 49111, 49312, 49313, and 49319. When conducting econometric modeling the authors included all other industry sectors (see Table 3). The establishment data was complemented with socio-demographic information at the zip level using the 2010 U.S. Census data and the 2013 5-Year American Community Survey. The authors used geographic information systems to estimate additional attributes and variables needed to account for the potential impacts of logistics sprawl (as discussed in Table 2). These include access or distance to highways, ports, airports, parking, and intermodal facilities for each zip code, among others

(IANA, 2016; California Department of Transportation (CALTRANS), 2016). Despite the efforts, the authors were not able to secure land value or availability data for the analyses, the reader is referred to (Giuliano et al., 2016) for a discussion of the impact of such variables. The final dataset is comprised of observations for 596 zip codes within 90000 and 93600.

Table 3. NAICS Industry Classification

NAICS classification	Description	NAICS classification	Description
11	Agriculture, Forestry, Fishing and Hunting	53	Real Estate and Rental and Leasing
21	Mining, Quarrying, and Oil and Gas Extraction	54	Professional, Scientific, and Technical Services
22	Utilities	55	Management of Companies and Enterprises
23	Construction	56	Administrative and Support and Waste Management and Remediation Services
31-33	Manufacturing	61	Educational Services
42	Wholesale Trade	62	Health Care and Social Assistance
44-45	Retail Trade	71	Arts, Entertainment, and Recreation
48-49	Transportation and Warehousing 4921.- Couriers and Express Delivery Services 4922.- Local Messengers and Local Delivery 49311.- General Warehousing and Storage 49312.- Refrigerated Warehousing and Storage 49313.- Farm Product Warehousing and Storage 49319.- Other Warehousing and Storage	72	Accommodation and Food Services
51	Information	81	Other Services (except Public Administration)
52	Finance and Insurance	92	Public Administration

Disaggregate Data

U.S. Census Commodity Flow Survey (CFS)

The team, through a project with the Census Bureau had access to several Census products. These include:

- Commodity Flow Survey (CFS) micro-data; and
- Longitudinal Business Database (LBD).

The available information includes five CFS datasets (1993, 1997, 2002, 2007, and 2012), and corresponding (based on year) datasets for the other products.

The Commodity Flow Survey is one of the most important freight data sources in the US, and is conducted every five years (with the latest one conducted in 2012). Most of the freight plans, analyses, and modeling efforts are based directly or indirectly on the data. However, they are based on the aggregate data published by the Census Bureau. Having access to the microdata provides another dimension of knowledge. It is important to note, that the data is protected under Title 13 and 26 of the U.S. code, and according to the federal law, data collected cannot be disclosed in any way or form that permits identifying individual firms or establishments. Therefore, the type of models developed in this project follow a strict disclosure process from the Census Bureau. The CFS provides information on commodities shipped, their value and weight, mode of transportation, and origin and destination for shipments generated by domestic establishments in: manufacturing, wholesale, mining, and other selected industries. It excludes: crude petroleum and natural gas extraction, farms, service industries, government establishments (Fowler, 2001; Bureau of Transportation Statistics, 2008). In addition, considering the availability of origin and destination, the Census Bureau estimates shipment distances. This is vital to estimate the effects on logistics sprawl.

Specifically, the team used information related to:

- Shipment weight (CFS);
- Shipment value (CFS);
- Shipment distance (CFS);
- Shipment mode (CFS);
- Shipment origin and destination (CFS, LBD)
- Employment (LBD); and,
- Industry sector (CFS, LBD).

W&DC Freight Survey

Additionally, the team designed a freight generation survey to capture additional information not included in the CFS and other public products. The survey focused on freight and freight trip generation, the type of vehicles used to distribute goods to and from W&DC establishments, and information about the location and relocation decisions made by individual companies.

The survey implementation used an online portal designed by the team (see Figure 6), and a mail-in mail-out physical survey instrument (see Annex A). The online survey can be consulted at the following address: https://its.ucdavis.edu/wdc-survey/

Figure 6. Online Survey Portal

During the survey instrument design, the team also acquired data from a data aggregator (INFOUSA) to identify the mailing address of warehouse and distribution centers. Interestingly, although establishments in a specific NAICS can be purchased (e.g., NAICS 493), the raw data is categorized using the Standard Industry Classification (SIC) coding system. As a result of using a crosswalk between NAICS and SIC, different establishments in NAICS 493, are categorized differently (different industries) under SIC. The team received from the vendor, about 1,500 records for NAICS 493 establishments in Southern California. After careful analyses and considering the expected low response rates, the team randomly selected the establishments to to be surveyed. Table 4 shows the number of establishments for different industries and counties in the sample (see

for their location).

The survey instrument was deployed in mid-November 2016.

Table 4. Sample of Establishments

3-dig NAICS	Imperial	Los Angeles	Orange	Riverside	San Bernardino	San Diego	Ventura	Grand Total
236		2	1	1	1		1	6
238		2		1	1		1	5
333		1	1	1	1	1		5
423		14	7	4	2	6	4	37
424		7	2		1	2		12
441		4	5			2		11
442		6	2	1	1	1	3	14
444		2	1		1	1	1	6
445		6	2		1		1	10
448		5			1		1	7
451		4	3		1		1	9
452		6	3	2	4		1	16
453		5	3	1				9
484	1	22	10	3	7	8	3	54
488		10	2		1	1	2	16
493	11	216	72	49	77	67	20	512
518		2		1	1		1	5
531	4	27	15	15	12	15	10	98
532	1	38	16	11	8	10	5	89
541	1	25	2	1	9	4	2	44
561		5	1	1	1		3	11
713		2		2	3	2		9
722		3	1			1		5
811		5	2	1	1		1	10

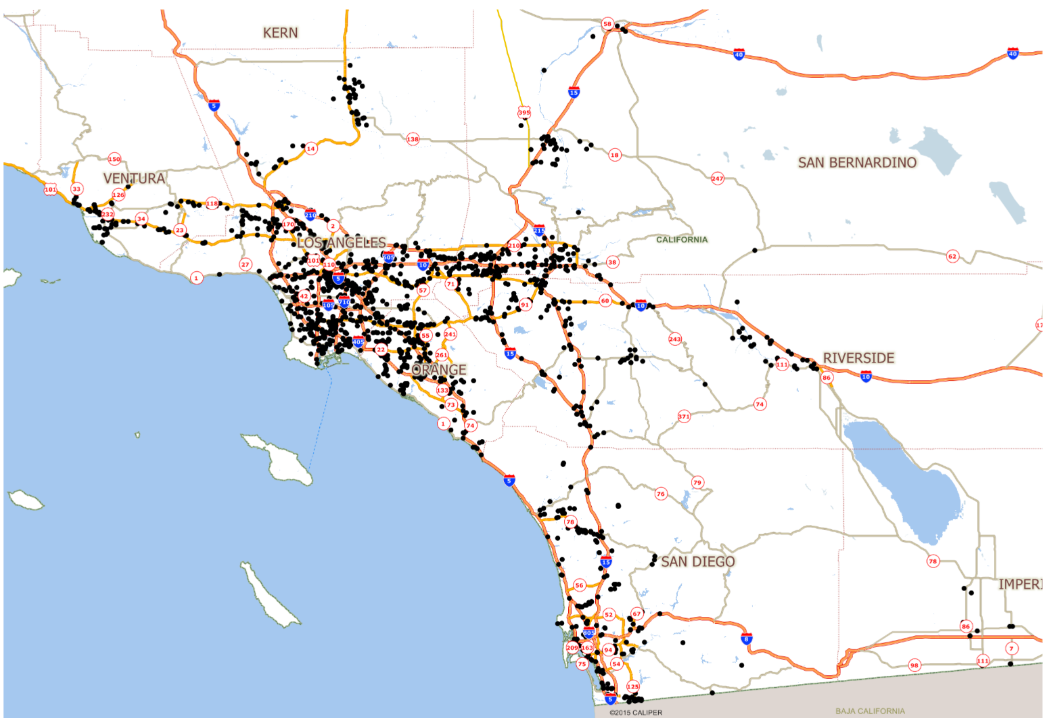

Figure 7. Location of Establishments in the Sample

V. Methodology

The authors implemented a multi-pronged approach that included spatial and econometric analyses based on the aggregate nature of the data. With the aggregate data, the first step included an exploratory evaluation to determine the location and distribution of the warehouses under NAICS 493 and other related industries. Following, the authors performed a centrographic analysis to calculate yearly barycenters or geometric centers weighted by the number of establishments in each zip code. The authors estimated other statistical measures of concentration such as the Gini coefficient. The spatial analyses were intended to offer insights about shifts and levels of concentration of the facilities in the study region. Finally, the authors estimated econometric models to quantify the spatial relationship between W&DC and other industries, and they identified factors that could explain the concentration of W&DC in specific areas. With the disaggregate data, the authors concentrated on the estimation of freight generation models for establishments in NAICS 493, and the comparison of shipment distance distributions for the available years (i.e., 1993, 1997, 2002, 2007, and 2012).

Spatial Aggregate Analyses

Centrography

Centrography is a commonly used methodology to assess the distribution of logistics facilities in order to measure the distance of the facilities' location to their barycenter and the dispersion from that point (Dablanc et al., 2014). The mean center of the various facilities in an area can consider different point coordinates. The basic case is when the coordinates (x_i, y_i) or latitude and longitude values for each of the i facilities of a distribution are just averaged ($\bar{x}$, $\bar{y}$) (Yeates, 1973). When there is a weight (w) or relevant value on the coordinates of the facilities, the centroid is calculated by incorporating this condition (Yeates, 1973):

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

Where,

$\bar{x}w$ latitude coordinate of the weighted barycenter for a particular year
$\bar{y}w$ longitude coordinate of the weighted barycenter for a particular year
x_i latitude coordinate of facility i (zip code)
y_i longitude coordinate of facility i (zip code)
w_i number of facilities for a particular zip code

In this study, the authors estimated the weighted geometric center using the information of number of establishments per year for a particular NAICS (w_i), at the zip code level. The weighted method was the preferred alternative as it allows for the consideration of the number of facilities in each zip code. The authors also estimated the standard distance ellipse as a measure of dispersion (Yeates, 1973). The standard distance ellipse provides information about the orientation of a distribution by computing the standard deviations of the major and minor axes to create an ellipse from the mean center (Soot, 1975). The authors used the weighted method again for the estimation of the standard distance ellipse.

$$s_c = \sqrt{\frac{\sum_{i=1}^{n} w_i (x_i - \bar{x})^2 + \sum_{i=1}^{n} w_i (y_i - \bar{y})^2}{\sum_{i=1}^{n} w_i}} \quad (2)$$

Where,

- s_c standard distance from the barycenter.
- x_i, y_i geographical coordinates for each facility in the region.
- $\bar{x}, \bar{y}$ geographical coordinates of the barycenter.
- n number of total facilities in the region.
- w_i weight or number of facilities (x_i, y_i) of the distribution.

Gini coefficient

The Gini coefficient was developed as a measure of income distribution or inequality (Ceriani and Verme, 2011). Generally, it is used to measure the concentration in a given distribution of observations or variables in a Lorenz curve (Cidell, 2010; Rodrigue, 2013) with respect to a perfect equality scenario where each observation has the same level of contribution or value. It ranges from 0 to 1 where the first case is the perfect equality scenario, and 1 indicates total concentration. In this study the number of establishments in each zip code was the parameter used to estimate the Gini coefficient.

Spatial correlation

One of the objectives of the paper was to explore the existence of spatial relationships between the number of W&DC in particular regions and identify the factors that explain their numbers. The Moran's I statistics helps identify spatial correlation between W&DC for a particular zip code with those in the neighboring zips. In order to compute the Moran's I, the authors identified the neighboring zips (Anselin, 1988), constructed the standardized weighted matrix, w_{ij}, using the number of establishments in each zip (Briggs, 2010), and estimated the spatial lag with the neighbor's information. The interpretation of this measure is similar to correlation, its range goes from -1 to 1, where 0 shows no spatial correlation.

$$I = \frac{N}{S_0} \frac{\sum_i \sum_j w_{ij} (\pi_i - \bar{\pi})(\pi_j - \bar{\pi})}{\sum_i (\pi_i - \bar{\pi})^2} \quad (3)$$

Where,

- I Moran's I
- $\bar{\pi}$ mean value of the number of facilities in a zone π
- N total number of observations.
- S_0 sum of all the elements in the weight matrix w_{ij}.

For the econometric modeling, the objective was to identify zip level variables (and from the neighbors) that could explain the number of W&DCs in the area. With this dependent variable, the authors attempted different approximations for the discrete models. An analysis of the data revealed the presence of excess zeros and overdispersion (see **Error! Reference source not found.**). Although the number of facilities is a positive number, there could be zip codes without W&DCs. As a result, truncated (e.g., zero-truncated, positive-truncated) models were not selected. The authors estimated a Zero-Inflated Negative Binomial (ZINB) model (Cameron and Trivedi, 2013). A ZINB is basically, a two-level model where the first part tries to identify the nature of the zeros (data generating process), usually estimating a binary logit model, while the second parts relates to the frequency or count model, a negative binomial model in this case for those zips that are not zeros (Cameron and Trivedi, 2009).

Disaggregate Analyses

As mentioned before, the disaggregate analyses used the different data products available to the team (e.g., CFS, LBD). The team estimated freight generation models for different industry sectors in the State of California. Due to data limitations, the models are for the average establishment in the State and not only in Southern California. This is due to Census disclosure restrictions. For example, the total number of establishments sampled in California in NAICS 493 is 125, once additional filters are used to identify those within Southern California, the numbers drop resulting in disclosure avoidance (for the sample and implicit samples).
The team conducted the analyses using the Census microdata at the UC Berkeley Census Research Data Center (RDC). For a detailed description of the methodologies and limitations using the microdata, the reader is referred to (Holguín-Veras et al., 2017).

Shipment distance

The team conducted statistical tests to compare the average shipment distance for shipments originating in Southern California, and with a destination within the State. In doing so, the team conducted pair-wise Welch's (two-sample) t-test (unpaired, unequal-variance t-test) of hypothesis for the means assuming that the condition of independence is met with an assumption that a 5-year minimum gap between estimates (e.g., 1993 and 1997) is long enough to capture changes in the industry. Moreover, the surveyed establishments were not necessarily the same in the different survey years. These tests allow identifying any changes in the freight patterns of the W&DCs related to the concentration of the destination of the shipments and could potentially indicate the relative movement of these facilities compared to their clients (establishments, residences).

In addition, the team estimated shipment distance distributions (SDDs) for these establishments (Pearson et al., 1974) (Benson et al., 1979). A careful analysis showed that the frequencies of shipments for different distances fitted a probability Gamma Distribution function (Cox, 2005; Cox, 2008; Cox and Jenkins, 2011). As a result, the team fitted a two-parameter (i.e., shape and scale parameters) gamma distribution for each survey year using maximum likelihood.

Freight generation

The team evaluated different statistical techniques, including Ordinary Least Squares and its variants (e.g., Weighted, Generalized Least Squares) to relate freight generation with shipment and establishment characteristics. These techniques have been successfully implemented to estimate disaggregate freight production and attraction models (Holguín-Veras et al., 2011; Holguín-Veras et al., 2012; Lawson et al., 2012; Holguín-Veras et al., 2013a; Holguin-Veras et al., 2013b; Jaller et al., 2013). Specifically, the team evaluated the relationship between freight generated (total shipment weight in pounds/year) as a statistical function of employment. The modeling process considered several structural forms including linear and non-linear (Holguín-Veras et al., 2017). Linear functions are of the form:

$$FG_i = \alpha + \beta E_i \quad (4)$$

Considering the results during a recent project, the team estimated models using a power function, where the amount of cargo generated by the establishments increases as a power function of its employment. Mathematically:

$$FG_i = \alpha^* E_i^{\beta} \quad (5)$$

Where,

FG_i = Freight generated by establishment *i*

E_i = employment at establishment *i*

The adjustment parameter, α^*, is estimated as $e^{\alpha + \frac{S^2}{2}}$ to account for exponential transformation biases.

VI. Empirical Analyses

Centrographic analyses

Figure 8 shows the growth and concentration of W&DC (NAICS 493) for the 1998 and 2014 years; the red circle in the figures indicates the location of the weighted geometric center (barycenter). Los Angeles and San Bernardino counties host the zip codes (91761, 90058, 91730, 91730, 91752, 90670, 90220, 91710, 90040, 90810, and 90023) with largest concentration of warehouses over the years; however, the largest recent growth and development of establishments has been in San Bernardino and Riverside counties, in that order. The results from from the standard ellipse analyses clearly evidence the effects of this growth by showing a larger larger semi-minor axis that spans over a larger geographic area in the San Bernardino county (see Figure 8. ***Number and Location of W&DC for 1998 (top) and 2014 (bottom)***

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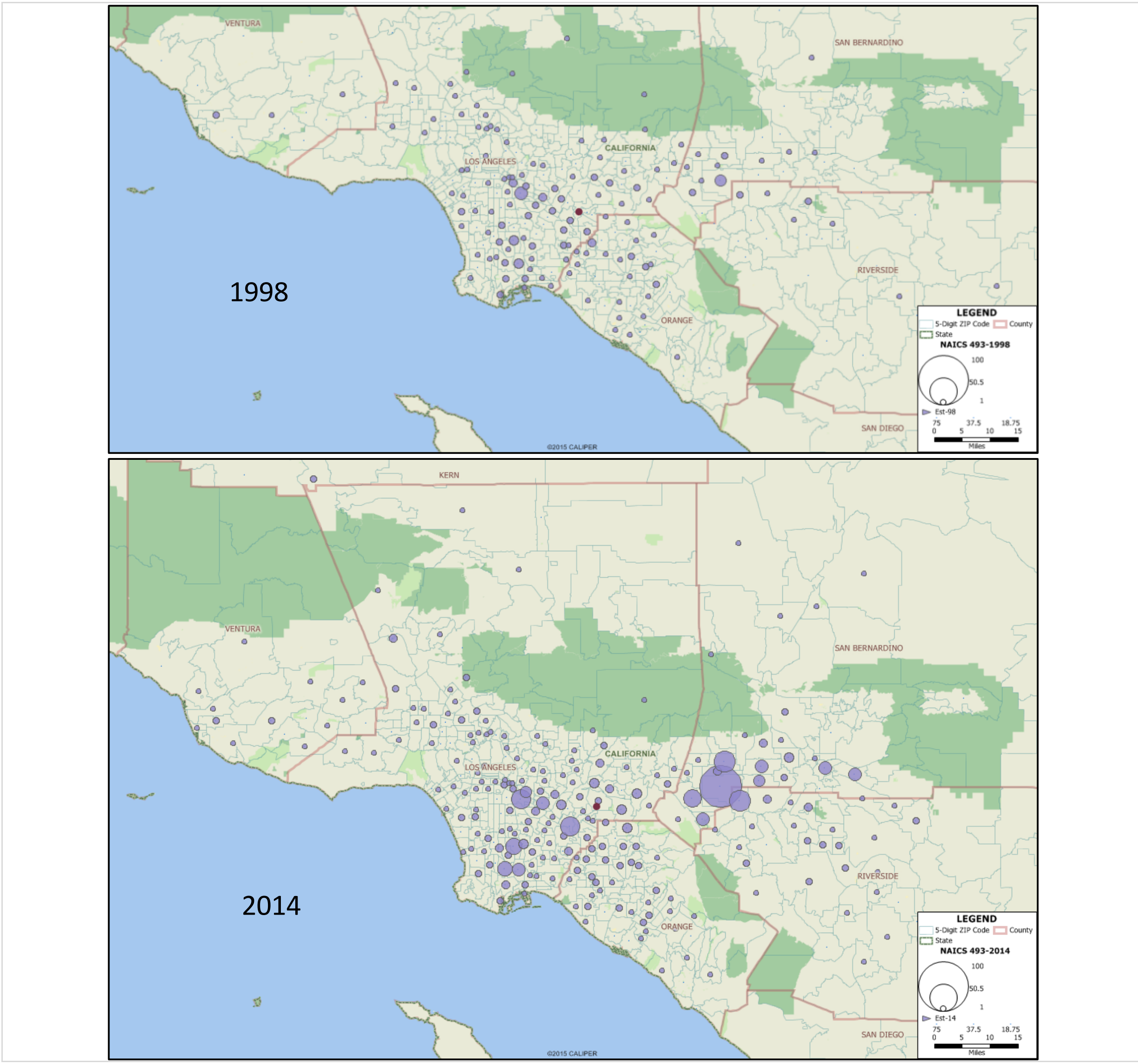


Figure 8. Number and Location of W&DC for 1998 (top) and 2014 (bottom)

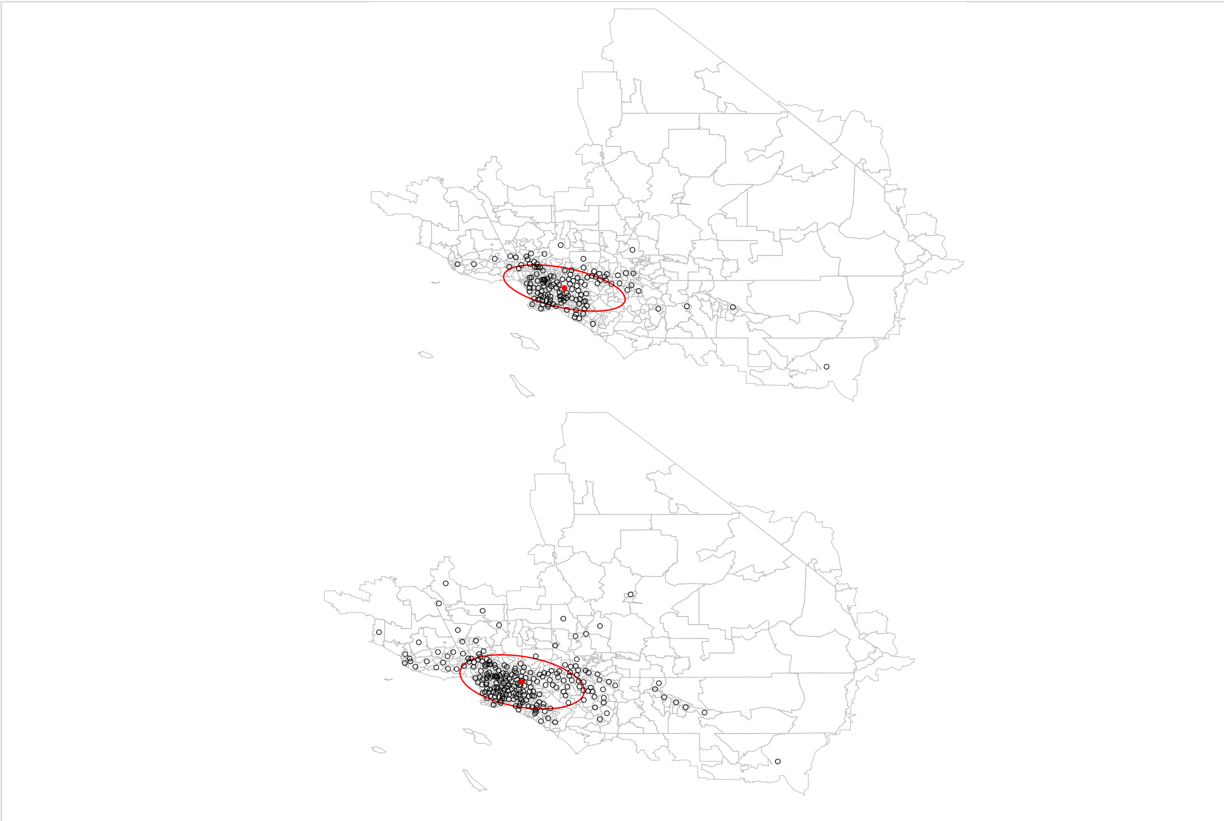


Figure 9. Standard Deviation Ellipse for W&DC for 1998 (top) and 2014 (bottom)

Figure 10 (and Figure 23 in Annex B) compares the movement of the weighted geometric centers for various sub-industries. There are some differences between 49312 (triangles) and 49313 (squares) with the other sub-industries and the aggregate classification 493, with these two experiencing the largest changes in spatial concentration. An analysis of the barycenter for NAICS 493 throughout the year indicated a movement in the North-East direction from 1998 until 2008 as previously identified (Dablanc, 2013; Dablanc, 2014; Dablanc et al., 2014). However, subsequent years showed the weighted geometric center moving slightly west towards the Los Angeles area. This type of aggregate analyses does not allow for a full understanding of the causal effects for this trend in logistics sprawl.

To identify potential changes in the deconsolidation trends, the authors estimated the average distance from all establishments (aggregated at zip code) to the estimated centroid for every year (distances from the geographic center to all the establishments averaged over the total number of establishments) for the 493 establishments. The results are consistent with other studies (Giuliano et al., 2016) and show a 23% increase in the average distance between 1998 and 2014, increasing from 18.5 to 22.7 miles. The results indicate that since 2007, this distance has remained almost constant with 22.3, 22.4, 22.8, 22.7, 22.7, 22.5, 22.9, and 22.7 miles between 2009 and 2014 (see Figure 11a). Similarly, the authors estimated the average distance between the centroids and the Los Angeles Central Business District using the same approach as above. This distance reflects the movement of the barycenter from a reference point. As in the previous case, the distances seem to remain constant since 2007 with 26.66, 27.38, 27.32, 27.35, 27.25, 27.94, 28.31, and 28.40 miles. Overall, the distance has changed from 20.94 miles in 1998, to 28.4 miles in 2014 (see Figure 24 in Annex B).

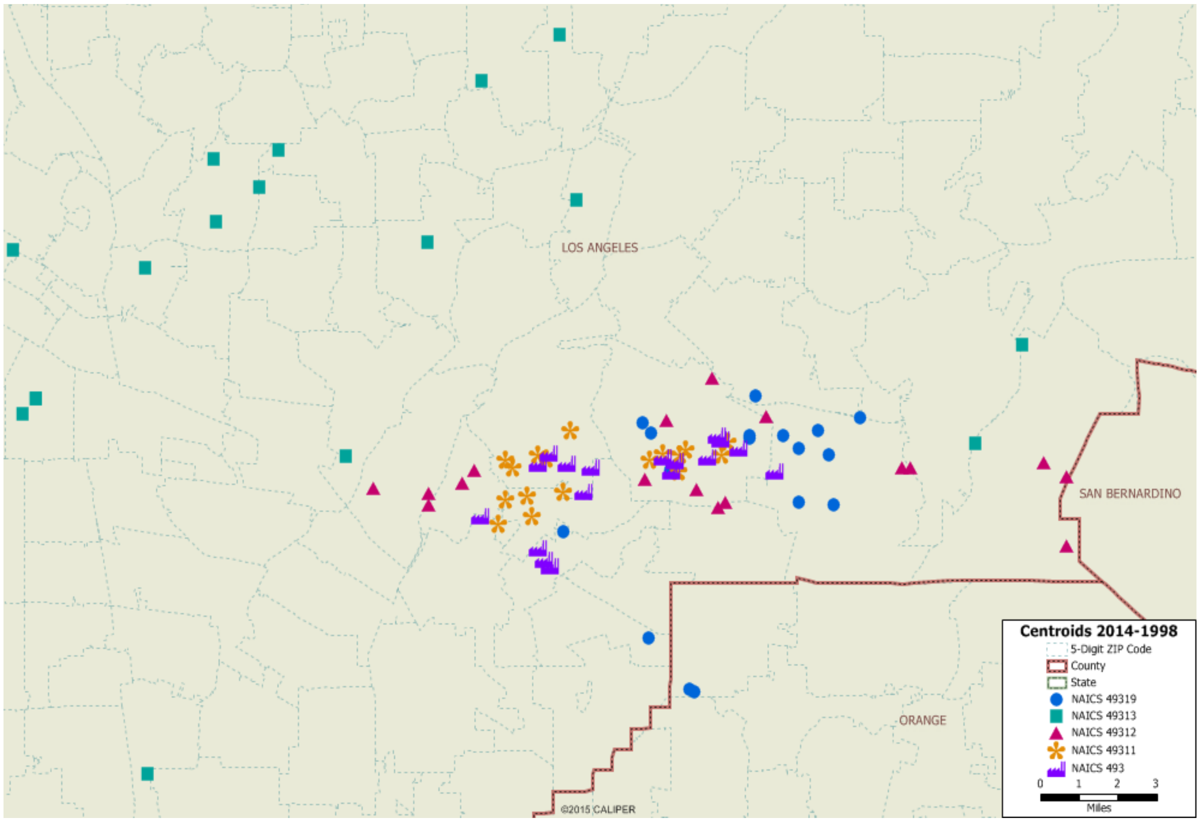
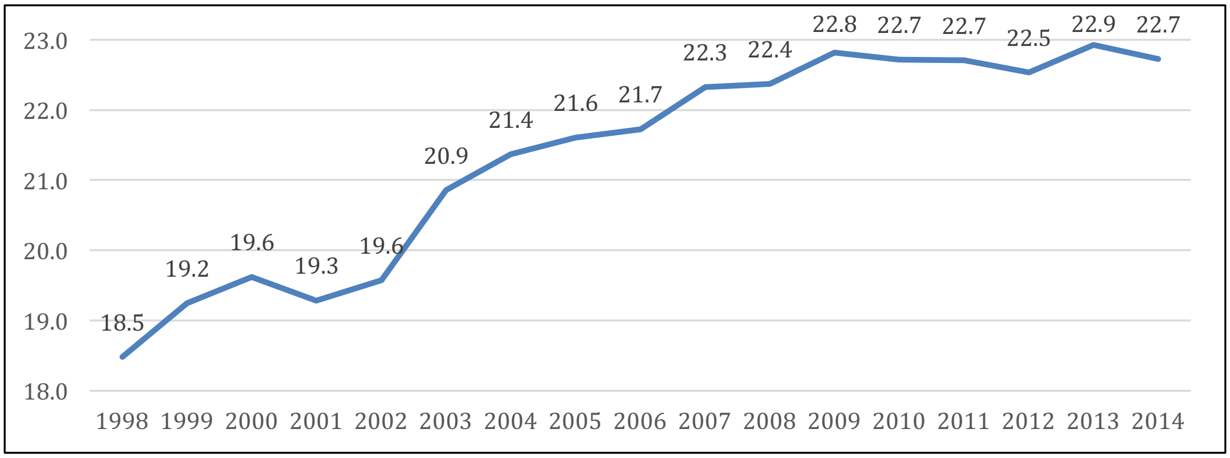
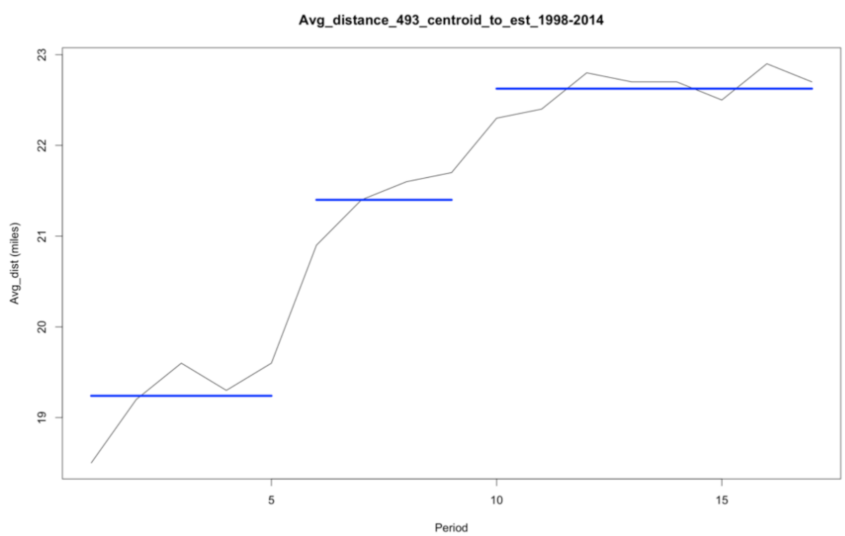


Figure 10. Movement of Weighted Geometric Center Between 1998 and 2014

Several tests were conducted to identify if the changes in the average distance between the centroids of the facilities and their aggregate (zip-code level) locations were statistically significant. There are some important considerations: 1) the number of facilities per zip code are correlated between years; and 2) the estimated mean distance exhibits unequal variance. As a result, the authors analyzed the data using two methods. First, pair-wise Welch's (two-sample) t-test (unpaired, unequal-variance t-test) of hypothesis for the means assuming that the condition of independence is met with an assumption that a 10-year gap between estimates (e.g., 1998 and 2008) is long enough to capture changes in the industry. This is consistent with methodologies adopted by previous researchers (Giuliano et al., 2016). The results of the analyses identified changes in the mean for the periods between 1998-2003 and 2003-2014. It is important to mention that the small dataset did not allow testing differences within the last few years considering a 10-year gap period. To try to identify additional changes, the authors used changepoint detection algorithms for Changepoint Analysis for the mean and used the Pruned Exact Linear Time (PELT) algorithm (Killick et al., 2012; Killick and Eckley, 2014). For these distances, the algorithm identified 3 changes: 1998-2002, 2003-2006, and 2007-2014 (see Figure 11b). These results indicate that although there has been an increase in the deconcentration of facilities, in the last 8 years, this trend has not continued.



a. Average distance from centroids to establishments 493 in miles (1998-2014)



b. Changepoint statistical test result

Figure 11. Average Distance Analysis from Yearly Centroids to all the Establishments of NAICS 493 and Changepoint Statistical Test (1998-2014)

The authors found different results when detecting changepoints for the sub-industries (see Figure 25 in Annex B). For general warehouse storage (49311) the algorithm identified a difference between the mean of the 1998-2002 and 2003-2014 periods with the latter period showing a higher mean. Refrigerated warehouses (49312) exhibit a mean change for the following periods: 1998-2002, 2003-2009, 2010-1012, and 2013-2014. In this case, the peak (higher mean) was during the 2010-2012 period, while the subsequent period (2013-2014) shows a mean change that is lower than the 2003-2012 period. The PELT algorithm was not conclusive when analyzing the farm related warehouses (49313). In this case, the period from 1998 to 2002 exhibits a similar mean, though the algorithm findings changepoints after 2002 for single or duplets of years.

The level of detail of the data limited the ability to draw conclusions about the factors such as the 2008-2009 economic crisis, and the increase in e-commerce and associated levels of delivery service, which could have produced this change in the deconsolidation trend. However, information consulted from (Bonacich and De Lara, 2009; United States Bureau of Labor Statistics, 2016) supports some of these assumptions showing that unemployment rates peaked after the event and have been improving throughout the years after. Another important aspect to highlight is the increase in temporary employments which suggests uncertainty for the labor force in those regions. In addition, empirical evidence from the location of warehouses and distribution centers of companies such as Amazon, Walmart and Target, shows that in recent years, these companies have opened (smaller) facilities much closer to the central business district of LA (MWPVL, 2016). The latter assumption is in line with findings from (Woudsma et al., 2016) where facilities benefit from the proximity to customers, and that service level is valuable to the product (de Magalhães, 2010). Albeit not finding this as an important factor in (Dablanc and Rakotonarivo, 2010), their data precedes the period under analysis.

Gini coefficient

An additional set of analyses estimated Gini coefficients for the various industries. Similar to the centrographic results, the methodology shows that the concentration at the zip code level has been increasing throughout the years for NAICS 493 (see Figure 12). For comparative purposes, the results show similar concentration levels between W&DC and NAICS 45 retail establishments, while NAICS 44 exhibits a lower concentration. Meanwhile, the results for 4921 (couriers and express delivery services), 49311, 49313, and 49319 show a significant drop in concentration in the years following 2009. These aggregate analyses show consistent results, where both the concentration and spatial location changed since 2009.

Spatial correlation

For the regression analyses, a total of 138 independent variables were evaluated to estimate a model to explain the number of W&DC per zip code in 2014 (see Table 5**Error! Reference source not found.**). These variables represent those found to be important factors in previous research (see Table 2). In addition, and to account for the potential of spatial relationships, the authors estimated a number of variables associated with the neighboring zip codes. The neighbors' definition considered a neighbor if it touches, at any point, the contour or shape line of a specific zip code (Anselin, 1988).

The results for the Moran I statistic show the presence of spatial correlation for the different industries (see Table 6). Although the correlation is generally low, it is positive, representing a clustering effect. This effect is not the same across the industries. For instance, the number of light manufacturing (NAICS 31) and information (NAICS 51) related establishments in one zip code show the highest spatial correlation with similar establishments in neighboring areas; on the other hand, mining, quarrying and oil (NAICS 22), and medium (NAICS 32) and heavy manufacturing (NAICS 33) show the lowest values. The results show the coefficient of W&DC among the lower values, and a higher coefficient for the transportation related establishments (NAICS 48).

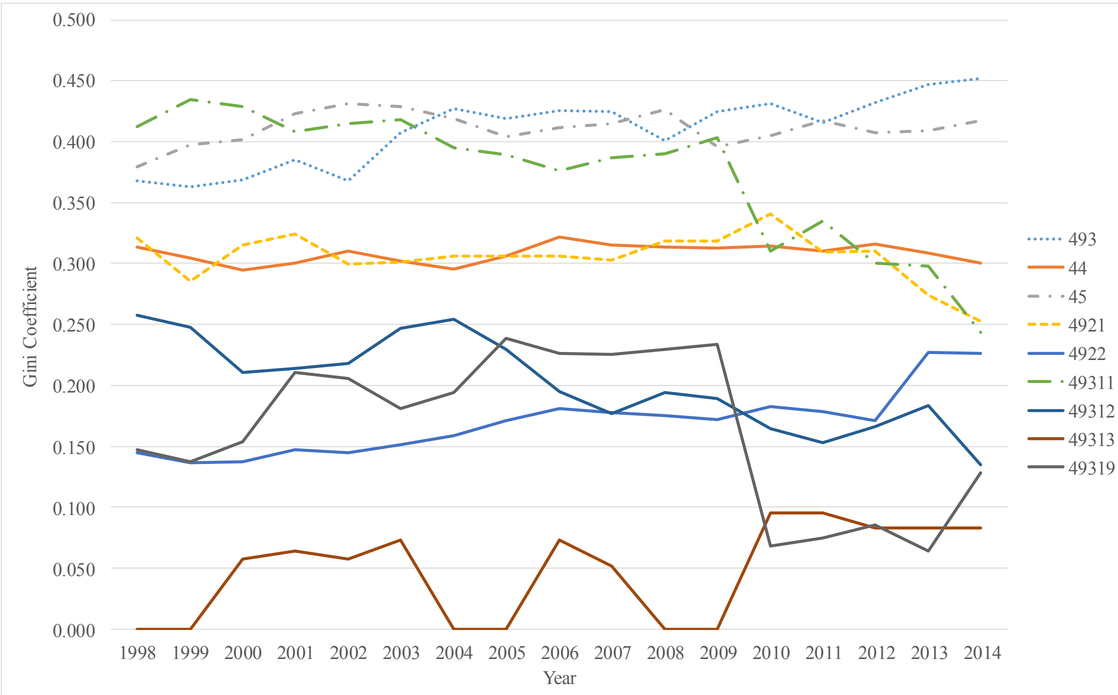


Figure 12 Gini Coefficient for Different Industries (1998-2014)

Table 5. Independent Variables Considered

Description	
Number of Establishments in NAICS 493 sector	
Information regarding:	o Transportation
o Population	o Travel time
o Gender	o Occupation
o Age	o Income
o Education	o Housing units, ownership and rental
o Employment	o Housing value
Number of establishments in year 2014 for all the NAICS industries (2 digit level)	
Number of establishments in the neighboring zip codes by NAICS industry	
Distance from each zip code to the closest port, airport, highway and intermodal facility in miles	

Variables used in the Model				
Variable	Mean	Std. Dev.	Min	Max
493 Establisshments	1.74	5.63	0.00	92
Per Capita Income	28707	17805.17	0.00	109023
Population	30163	22940.42	0.00	106026
Adults Using Public '	639	1154.90	0.00	9816
Median Home Value	417943	236098.30	25000	1000001
32 Establisshments	8.09	13.50	0.00	134
48 Establisshments	15.83	23.44	0.00	286
nb493	1.74	5.63	0.00	92
nb72	382.64	229.07	0.00	1261
Distance intermodal	23.45	31.66	0.00	218.97
Distance highway	0.85	1.77	0.01	16.49

Table 6. Moran I Statistics

NAICS	Moran I	NAICS	Moran I	NAICS	Moran I	NAICS	Moran I
11	0.148	33	0.069	51	0.260	61	0.160
21	0.155	42	0.157	52	0.103	62	0.122
22	0.022	44	0.134	53	0.115	71	0.198
23	0.160	45	0.149	54	0.157	72	0.175
31	0.302	48	0.113	55	0.111	81	0.184
32	0.050	49	0.079	56	0.130	99	0.105

As mentioned before, the authors estimated a zero-inflated negative binomial regression model. The results of the binary logit component indicate that a zip-code is less likely to have W&DC (NAICS 493, as the median home value increases, has less accessibility to highway and there is a larger presence of establishments in the accommodation and food services in neighboring zips. On the contrary, those zip codes with a larger presence of manufacturing (NAICS-32) and other transportation services (NAICS 48) are more likely to host W&DCs. In terms of the number of facilities for those zips that are more likely to have W&DCs, the number NAICS 493 establishments in a zip code could be explained by the number of establishments in the manufacturing, and transportation sectors in the zip code (see Table 7). The explanatory power of NAICS 32 and 48 is consistent with the results in the literature as the proximity to manufacturing and retail facilities underlines the importance of being close to customers and the distribution channels, transportation services, and infrastructure to be served by the 493 sector. Another relevant variable is the number of W&DC establishments in the neighboring zip codes, this is also consistent with previous findings where the concentration of services enables the establishment of logistics clusters. Clusters are not only the result of land availability with access to transportation networks, but they also develop because of the benefits from the readiness of the operations in the same area. The model also shows the importance of proximity to the infrastructure and other logistics assets such as intermodal facilities (the negative sign indicates that facilities are less likely to be located in zip codes further away from these facilities). Although ports and airports did not provide the best statistical significance and explanatory power, in many cases, intermodal facilities allow the interconnection to these transport nodes.

Table 7. Zero-inflated Negative Binomial Regression Model

Variable		Coefficient	z-stat	p-value
(Inflate Model) Logit Model: Identify Certain Zeros				
Constant		-1.6397	-0.990	0.32
Demographics	Median home value (10,000s)	0.1130	2.950	0.00
Establishments in NAICS sectors	Medium Manufacturing (32)	-2.4004	-3.060	0.00
	Transportation (48)	-0.8643	-2.000	0.05
	Neighboring Accomodation and Food Services (72)	0.0056	1.440	0.15
Accessibility	Average distance to the highway	0.7951	2.650	0.01
Count Model: Negative Binomial				
Constant		-0.6761	-2.820	0.01
Demographics	Per capita income (1000s)	-0.0103	-2.160	0.03
	Population (1000s)	0.0090	3.270	0.00
	Adults using public transit mode (1000s)	-0.1672	-3.230	0.00
Establishments in NAICS Sectors	Medium Manufacturing (32)	0.0126	2.910	0.00
	Transportation (48)	0.0053	3.340	0.00
	Neighboring W&DC establishments (493)	0.1385	5.300	0.00
	Neighboring Accomodation and Food Services (72)	0.0007	2.550	0.01
Accessibility	Average distance to the intermodal facilities	-0.0050	-1.700	0.09
Alpha		0.5186		
Observations		594		
Zeros		361		
Inflation Model		Logit		
Log pseudolikelihood		-637.2649		
Wald chi2 (8)		297.87, Prob > chi2 = 0.0000		
Likelihood-ratio test of alpha chibar2(01)		278.53, Pr>= chibar2 = 0.0000		
Vuong test		z = 5.86, Pr>z = 0.0000		

The number of W&DC is also explained by population in the area. The authors suggest that populated locations favor the location of warehouses as a potential source of qualified manpower. However, the number of W&DC decreases as the income per capita increases. This could be explained by the fact that land prices tend to be (considering long-run affordability ratios) higher in areas with higher income per capita (there was high correlation between income variables and average home values). Finally, the model shows that there is an inverse relationship between the number of W&DC and the number of adults using public transit. A visual inspection showed that the density of public transit was lower in areas with a higher number of warehouses, however the causal relationship is not clear. The authors decided to keep this variable in the model as it could have important planning implications for sustainable transport and the availability of public transit options in locations where W&DC develop. The authors estimated the Variance Inflation Factor (VIF) for the variables included in the model to check for multicollinearity. The VIF ranges from 1.42 to 3.69. This is evidence that multicollinearity is not present; that is, no variable could be considered as a linear combination of other independent variables. Jaller et al. (2017) summarize these results.

Freight Generation

As mentioned before, the team estimated freight generation models for establishments in the W&DC industry in California. The team estimated models considering all modes, and road only modes. The final models follow a power function structural form, and express the amount of cargo (in pounds) generated per establishment per year, as a function of the employment levels. Consistent with general CFS results, the majority of shipments are performed using road modes, therefore, the models for all modes, and road-only are very similar (see Table 8). The team estimated additional models for the various industries considered in the CFS, though only those related to W&DCs are shown here.

Table 8. NAICS 493 Freight (Production) Generation Models

NAICS	Description	α	α*	t-stat	β	t-stat	Adj. R^2	F-stat	S^2	Obs.
CFS - California - All Modes [pounds/year]										
493	Warehousing and Storage	16.00	50,964,840	30.48	0.29	2.01	0.038	4.05	3.50	125
CFS - California - Road Modes [pounds/year]										
493	Warehousing and Storage	15.99	50,400,999	30.38	0.29	2.00	0.037	4.00	3.49	125

Note: $FG_i = \alpha^* E_i^{\beta}, \quad \alpha^* = e^{\alpha + \frac{S^2}{2}}$

These freight generation models indicate that, for instance, a NAICS 493 establishment with 10 employees generate approximately 156.25 tons of cargo every day, while another establishment with 100 employees generates 304.tons (assuming 318 days per year).

Shipment Distance Distributions

The first type of analyses compared the average shipment distance for every pair of survey years (e.g., 1993 vs 1997, 1993 vs 2012, 2002 vs 2007). The authors used an unpaired two-sample t-test with unequal variances. Table 9 shows the average shipment distance for shipments originating within the study area (zip codes between 90000 and 93600), using over the road modes, and with a destination within the State of California for establishments in the W&DC NAICS 493. It is important to mention that the average distances without constraining the destination to be inside the state, were around two to three times larger. However, they followed similar distributions with long right tails.

Table 9. Average Shipment Distance Within the State of California

Year	Obs.	Mean	Std. Error	Std. Dev.	[95% Conf. Interval]	
1993	2850	109.9	2.399	128	105.3	114.7
1997	1015	105.6	3.844	122.3	98.04	113.1
2002	1815	84.98	2.804	119.5	79.48	90.48
2007	5630	94.03	1.626	122	90.85	97.22
2012	2850	118.5	3.477	185.6	111.5	125.3

The data show that, in average, the shipment distances were about 102.6 miles during this period. Additionally, the authors estimated hypothesis tests to identify if the average shipment distances had changed between 1993 and 2012. The hypothesis tests focus on the difference between the means of two samples and the following null and alternative hypotheses:

Ho: difference in means = 0

Ha1: difference in means < 0
Ha: difference in means different than 0
Ha2: difference in means > 0

Table 10 shows the results of the two-sample t-tests with unequal variances. The results show the one-tailed p-values (Pr(T<t), Pr(T>t)) for the alternative hypotheses (Ha1 and Ha2) and the two-tailed p-values for the alternative hypothesis that the difference in means is different than 0, using the t distribution. Considering a confidence level of more than 90%, the results show that the average shipment distance in 1993 was statistically longer than in 2002 and 2007, though not statistically different from 1997. On the contrary, the results indicate that the distance in 2012 was longer than in 1993. When analyzing the shipment distances in 1997, the distances were longer than in 2002 and 2007, but shorter than in 2012. 2002 exhibits the shorter shipment distances in the sample. The 2007 distances were the second shortest after 2002, and the longest shipment distances correspond to the last sample year (2012). The statistical analyses show that the distances declined between 1993 and 2002, and started to increase by 2007 and 2012.

Table 10. Two-sample T-test with Unequal Variances (1993-2012)

Year		1997	2002	2007	2012
1993	t	0.9729	6.776	5.507	-2.006
	Welch's degrees of freedom	1855	4061	5478.06	5061
	diff < 0	0.8346	1	1	0.0224
	diff != 0	0.3307	0	0	0.0448
	diff >0	0.1654	0	0	0.9776
1997	t		4.329	2.768	-2.486
	Welch's degrees of freedom		2053	1399	2705
	diff < 0		1	0.9971	0.0065
	diff != 0		0	0.0057	0.013
	diff >0		0	0.0029	0.9935
2002	t			-2.79	-7.496
	Welch's degrees of freedom			3129	4666
	diff < 0			0.0026	0
	diff != 0			0.0053	0
	diff >0			0.9974	1
2007	t				-6.367
	Welch's degrees of freedom				4132
	diff < 0				0
	diff != 0				0
	diff >0				1

These results are contrasting with the spatial analyses of W&DCs discussed in the previous sections. It is important to discuss some differences between the data. First, while the originating establishments are located within the same area, the establishment count data used for the aggregate analyses did not consider the area of operations (locations of customers and destination) of each establishment. In this case, the shipment distances considered for all shipments with a destination within the State. Second, the commodity flow survey data is based on a sample of shipments from a sample of establishments, while the aggregate data considered all establishments. And third, due to disclosure avoidance requirements, the destination of the shipments could not be selected to be within the study area. The results show that the average shipment distance is much longer than the average distance between the establishments' centroids and the LA CBD estimated at 28 miles in 2014.

Additionally, the team fitted probability Gamma Distribution functions (Cox, 2005; Cox, 2008; Cox and Jenkins, 2011) to the shipment distance distribution functions (SDDs). Table 11 shows the estimated shape (alpha) and scale (beta) parameters for each distribution (survey year) using maximum likelihood.

Table 11. Two-parameter Gamma Distributions

	1993	1997	2002	2007	2012
alpha					
Coefficient	.8959***	.7773***	.7085***	.7929***	.7862***
t-statistic	(43.27)	(26.15)	(35.33)	(61.53)	(43.82)
ci_lower	0.8553	0.7190	0.6691	0.7677	0.7510
ci_up	0.9364	0.8355	0.7477	0.8182	0.8213
beta					
Coefficient	122.8***	135.8***	119.9***	118.6***	150.7***
t-statistic	(32.86)	(19.13)	(25.17)	(45.26)	(32.15)
ci_lower	115.4	121.9	110.6	113.4	141.5
ci_up	130.1	149.7	129.3	123.7	159.8
Observations	2850	1015	1815	5630	2850

Note: * p<0.05 ** p<0.01 *** p<0.001"
ci = confidence interval

In general, the SDDs have similar shape but differ in terms of scale. Figure 13 and Figure 14 illustrate the difference. Figure 13 compares the gamma distribution functions for the 5 years and shows the cumulative distribution. The sample indicates that 2002 exhibits the shortest shipment distances followed by 2007 (consistent with the results provided by the average distance). In general, a 100-mile shipment distance represents between 59.3% and 70.36% of the distances, and 200-mile shipment distance represent between 80.86% and 88.66%, for the different distribution functions. Considering that the average distance between the centroid of W&DCs is estimated at around 28 miles, between 25% and 36% of destinations fall within this distance. Moreover, using these results and considering that 80% to 85% of all freight trips in the SCAG region are internal, it could be expected that the trips would have distances up to 200 miles. Figure 14 shows the histogram for the estimated frequency of SDDs.

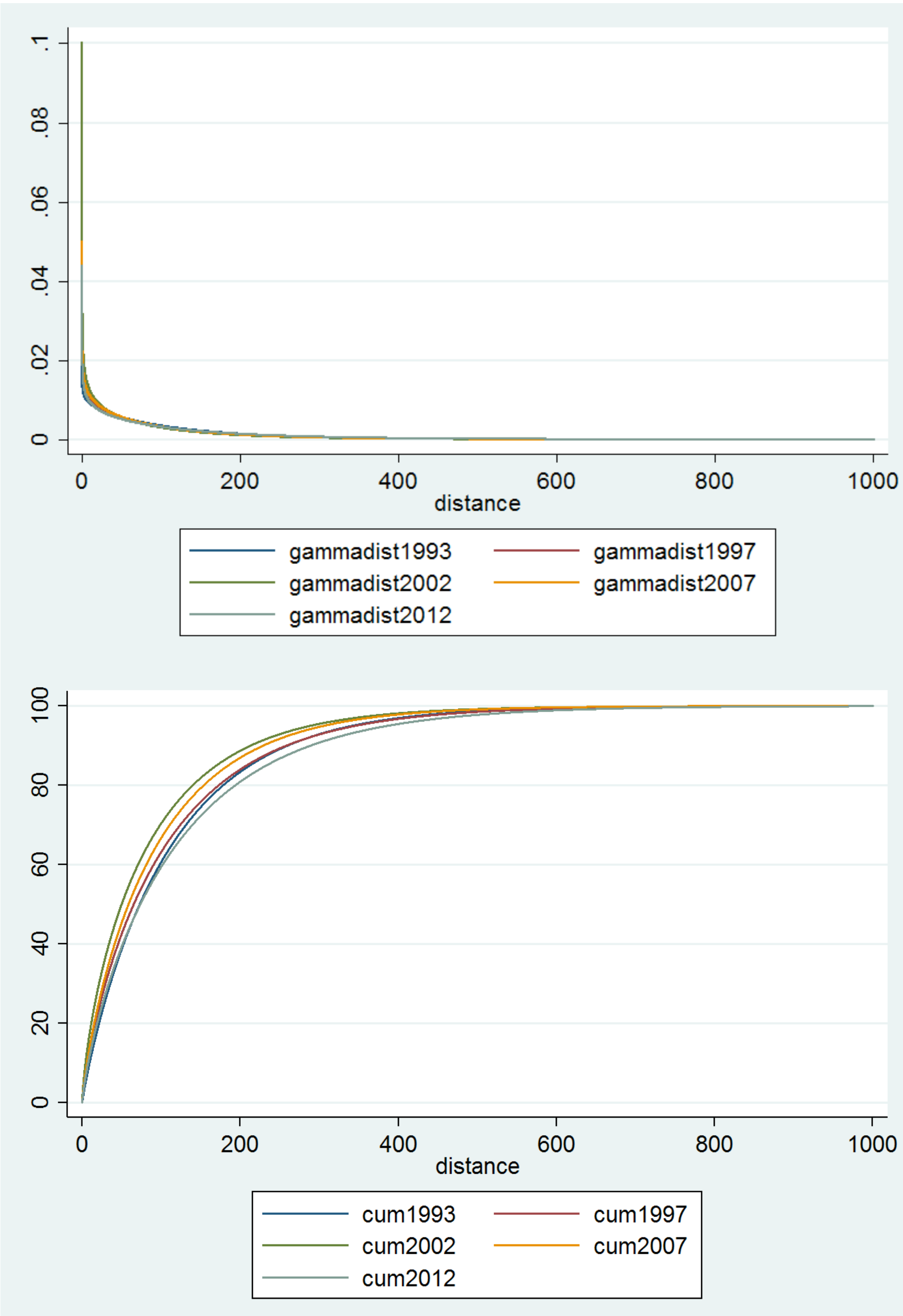


Figure 13. SDDs Gamma Distribution (top), Cumulative (bottom)

Figure 14. Simulated Shipment Distance Distributions (SDD)

Survey Responses

From the 1,500 records the team received from the vendor (INFOUSA), the team selected a sample of 1,000 establishments to send out the survey. The team also sent the web-based survey to the records that contained email addresses. During December 2016 and January 2017, the team received about 10% survey responses. Some of the received surveys were incomplete and the information deemed unusable. A large number of undelivered surveys due to wrong address or contact information contributed to the low response rates. Despite the limitations of the small sample, the gathered information provides additional insights to complement the analyses.

Figure 15 shows the composition of the main activities or functions of the facilities. The majority (65%) conduct warehouse and storage, followed by distribution center related activities (15%). The remainder have as the main activity: cold storage, e-commerce fulfillment, and value-added operations.

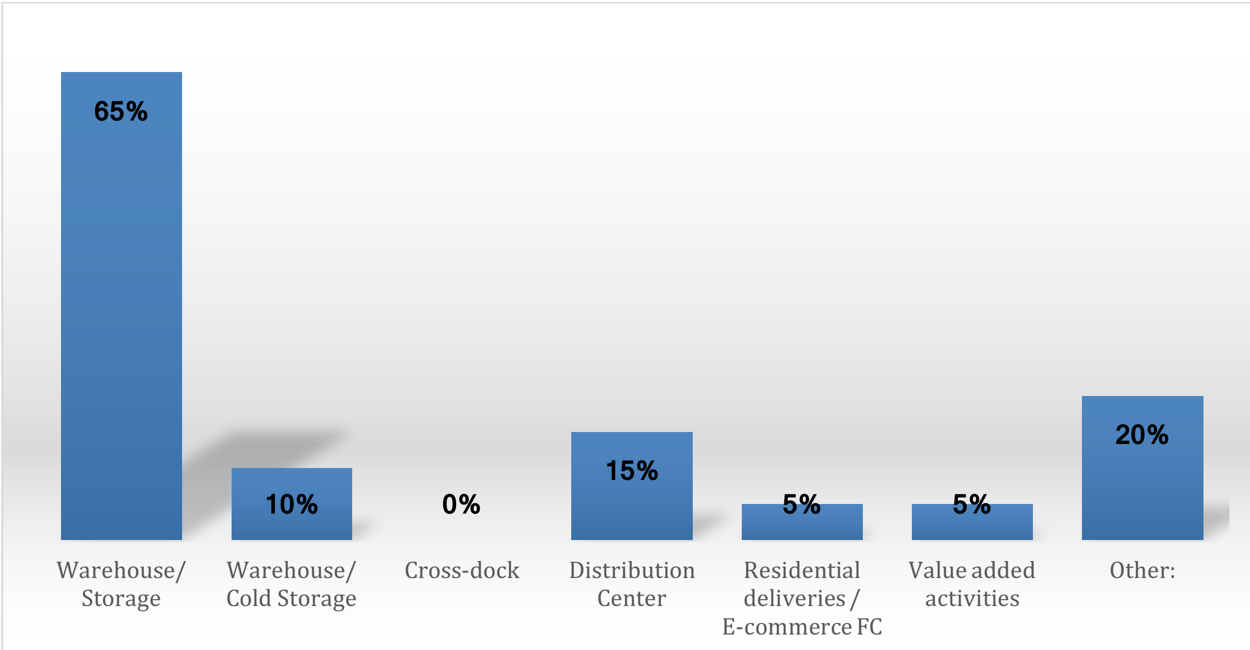


Figure 15. Main Activity of the Facility (Other: Storage operations, steel processing, order-pick)

Figure 16, identifying all activities carried out at the facilities, shows that general storage, sorting, value added, and cross docking operations. More importantly, about 60% of the respondents conduct activities related to parcel operations, residential deliveries, and e-commerce fulfillment. This is a significant percentage, and according to informal conversations, this is expected to increase. The type of goods handled at these facilities are predominantly non-perishable (see Figure 17)

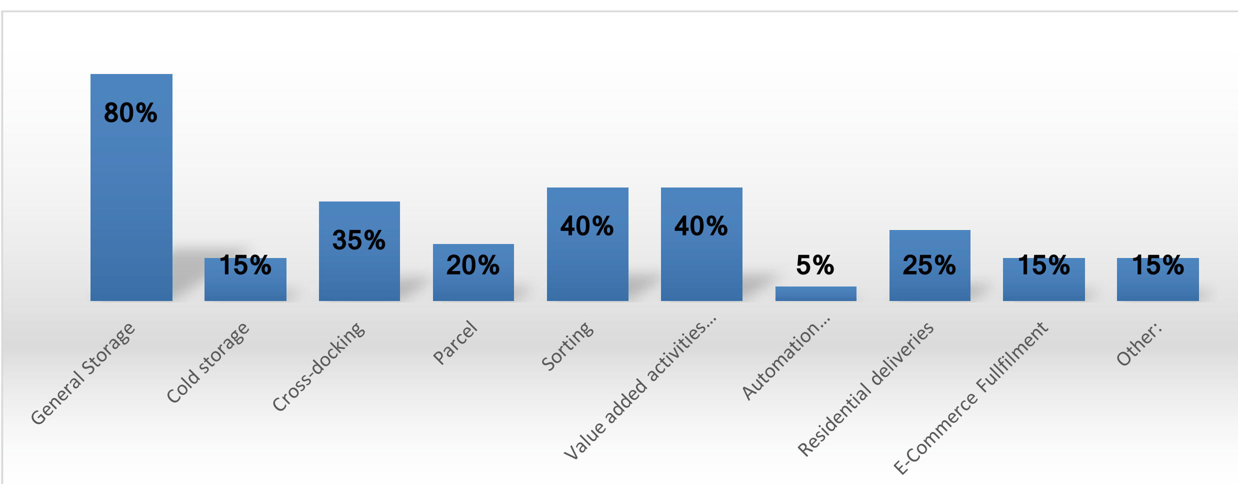


Figure 16. Types of Activities Carried Out at the Facilities (Other: RV Storage, Assembly & distribution)

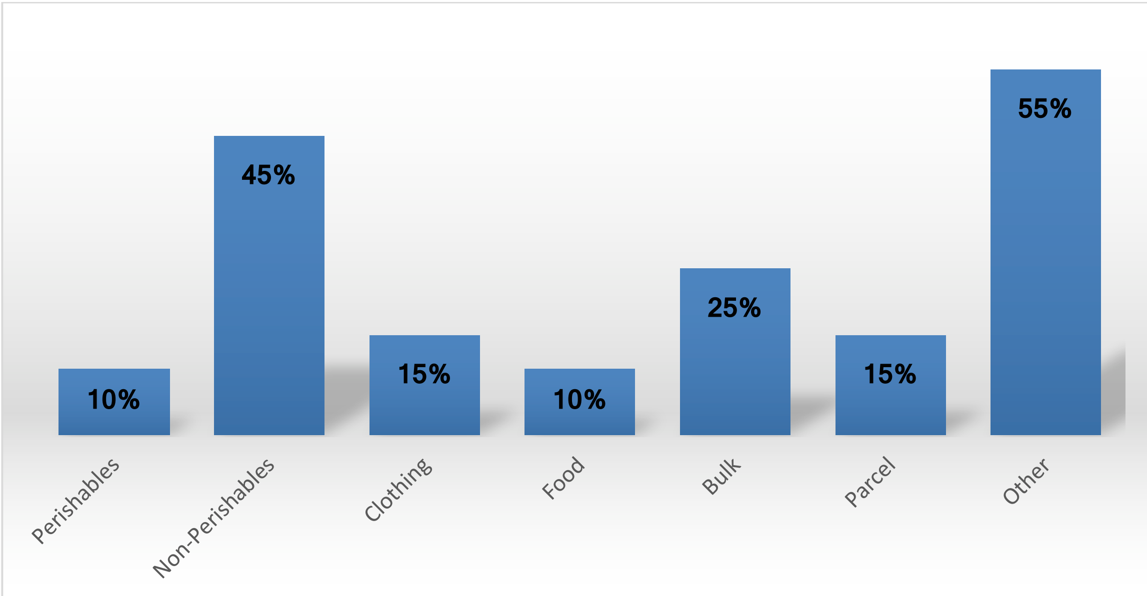


Figure 17. Goods Handled at the Facilities (Other: Household goods, Vehicles, Chemicals, Wine & spirits, Paper goods, Furniture, Steel, Pharma, Household goods, Storage only, Precision board)

Figure 18 shows the origin and destination of shipments, the data shows that a slight majority (50%-60%) of shipments originate/end at locations within the State, while 40%-50% out of the State. From the origins and destinations within the State, between 70% to 80% come from or go to nearby locations. A similar share is observed for out of State, with about 20% having Mexico as origin or destination, and the rest from other states.

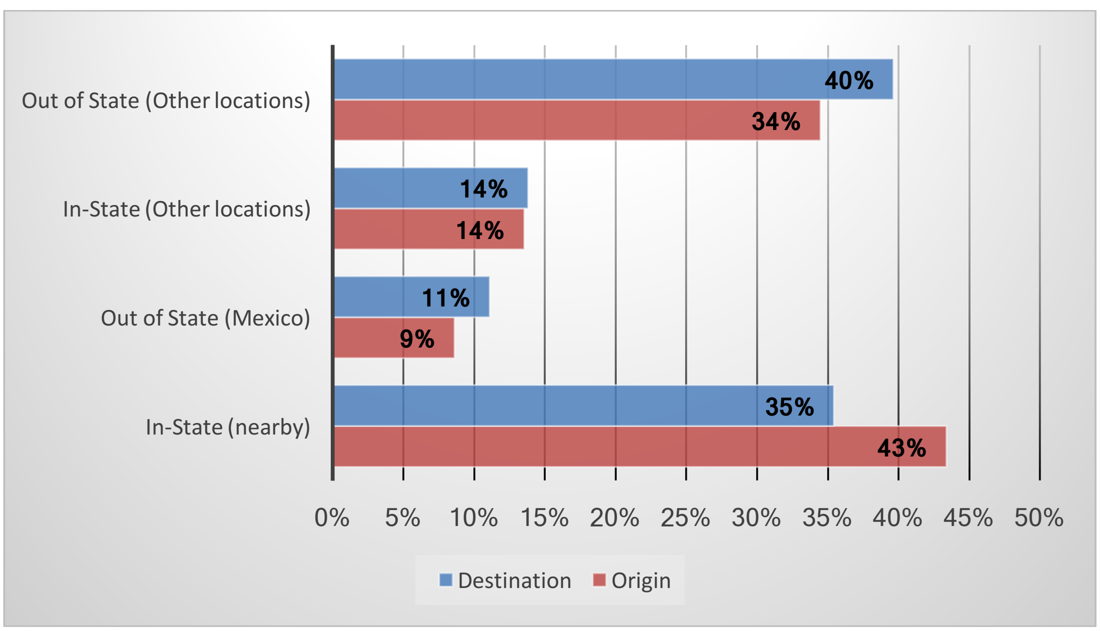


Figure 18. Origin and Destination of Shipments

Figure 19 shows the types of vehicle technology used to transport the cargo to and from the facilities. The sample indicates that small pickups and vans, and 2 axle single unit trucks are the vehicles most widely used. In these classes, gasoline fueled vehicles are a significant component of the fleet. However, diesel is the dominant fuel as the vehicle class increases. In the sample, hybrid vehicles are present in 2 axle single unit trucks and passenger vehicles. No respondent indicated gas- or electric-powered vehicles.

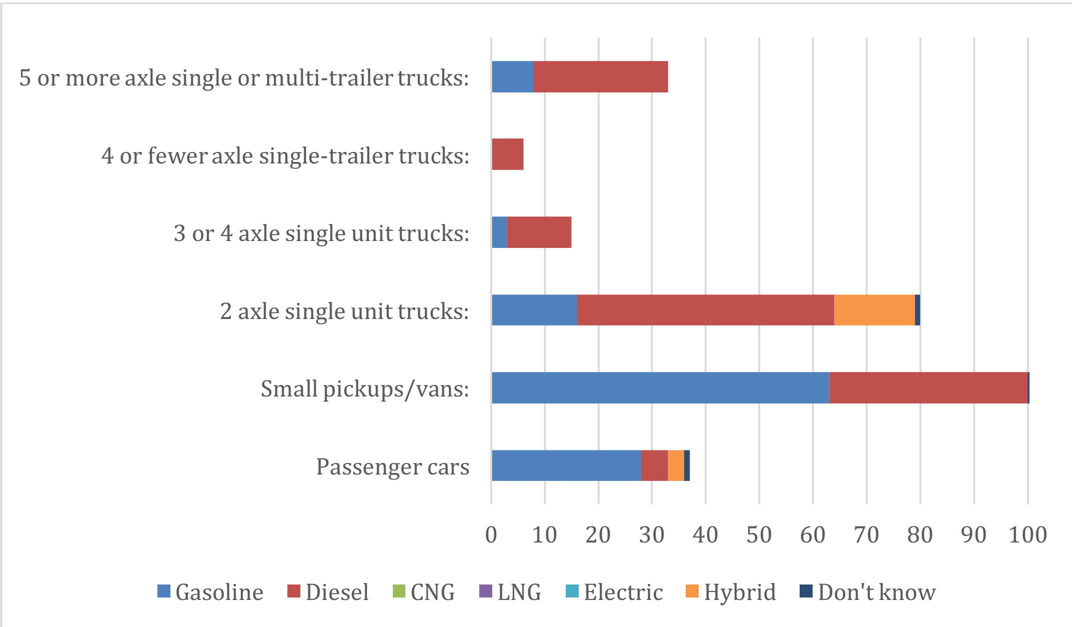
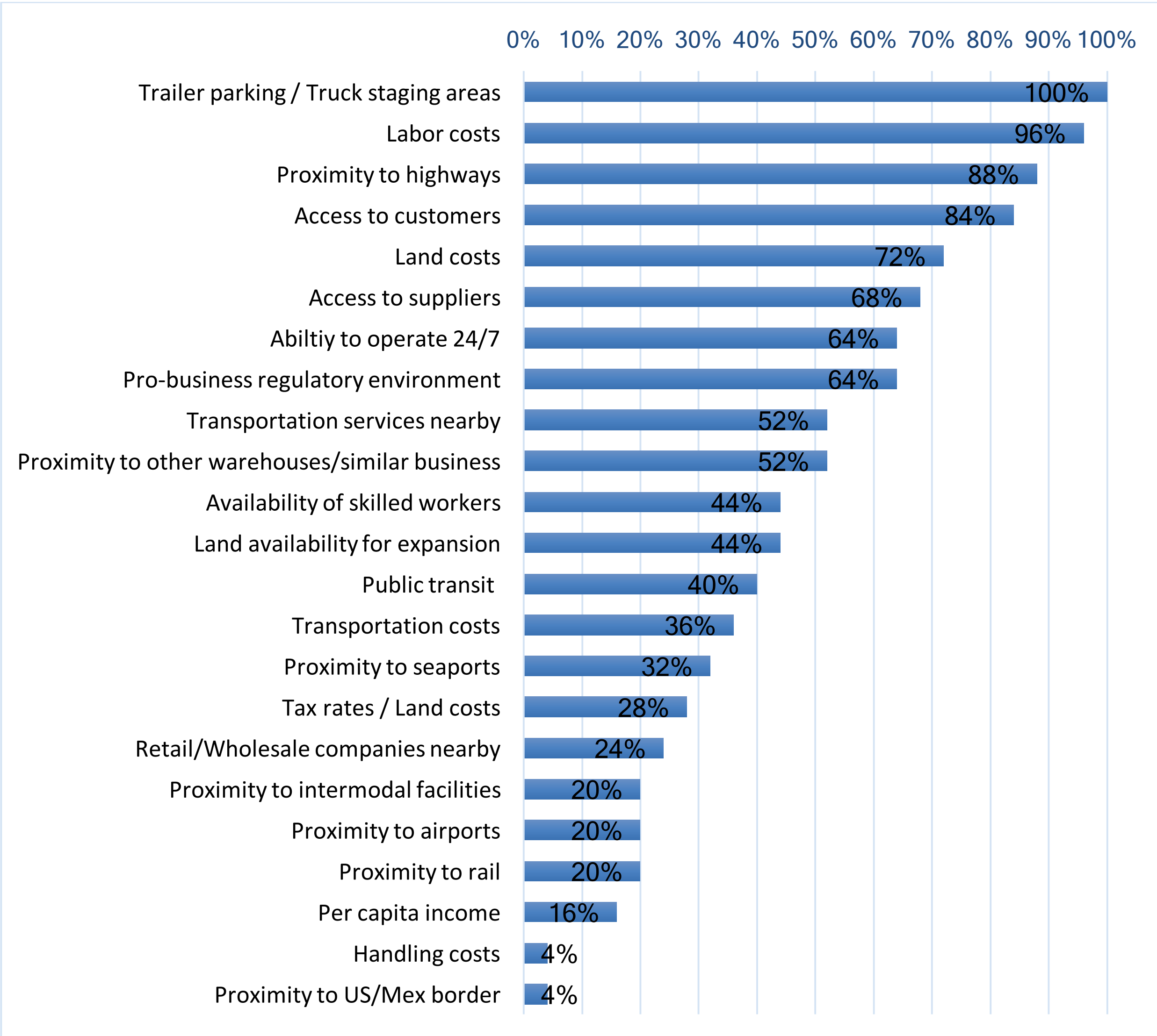


Figure 19. Vehicle Technologies

In terms of reveled preferences, Notes: 1. Standardized values based on maximum response for "Trailer parking/Truck staging areas"

2. "Proximity to US/MEX border" was added since a participant used that answered

Figure 20 shows the factors that influenced the selection of the current location of the facilities. The results show that availability of parking, proximity to highways, cheap labor, land cost, and accessibility to both suppliers and customers are important factors. Other important factors include the regulatory environment of the location, and the proximity to other services and W&DCs. As found in the literature, proximity to intermodal facilities, airports and rail, are less important than accessibility to highways and the road network. These results are consistent with those found during the econometric modeling effort.



Notes: 1. Standardized values based on maximum response for "Trailer parking/Truck staging areas"
2. "Proximity to US/MEX border" was added since a participant used that answered

Figure 20. Factors Influencing the Current Facility Location

In addition, the survey contained questions regarding the types of factors that are currently affecting the operations of the facilities. Figure 21 shows that the most important factor that negatively affects the operations is related to the 2008/2009 economic crisis, this is followed by the regulatory environment, network performance, port performance, and costs. Other macroeconomic variables are affecting the operations of these facilities.

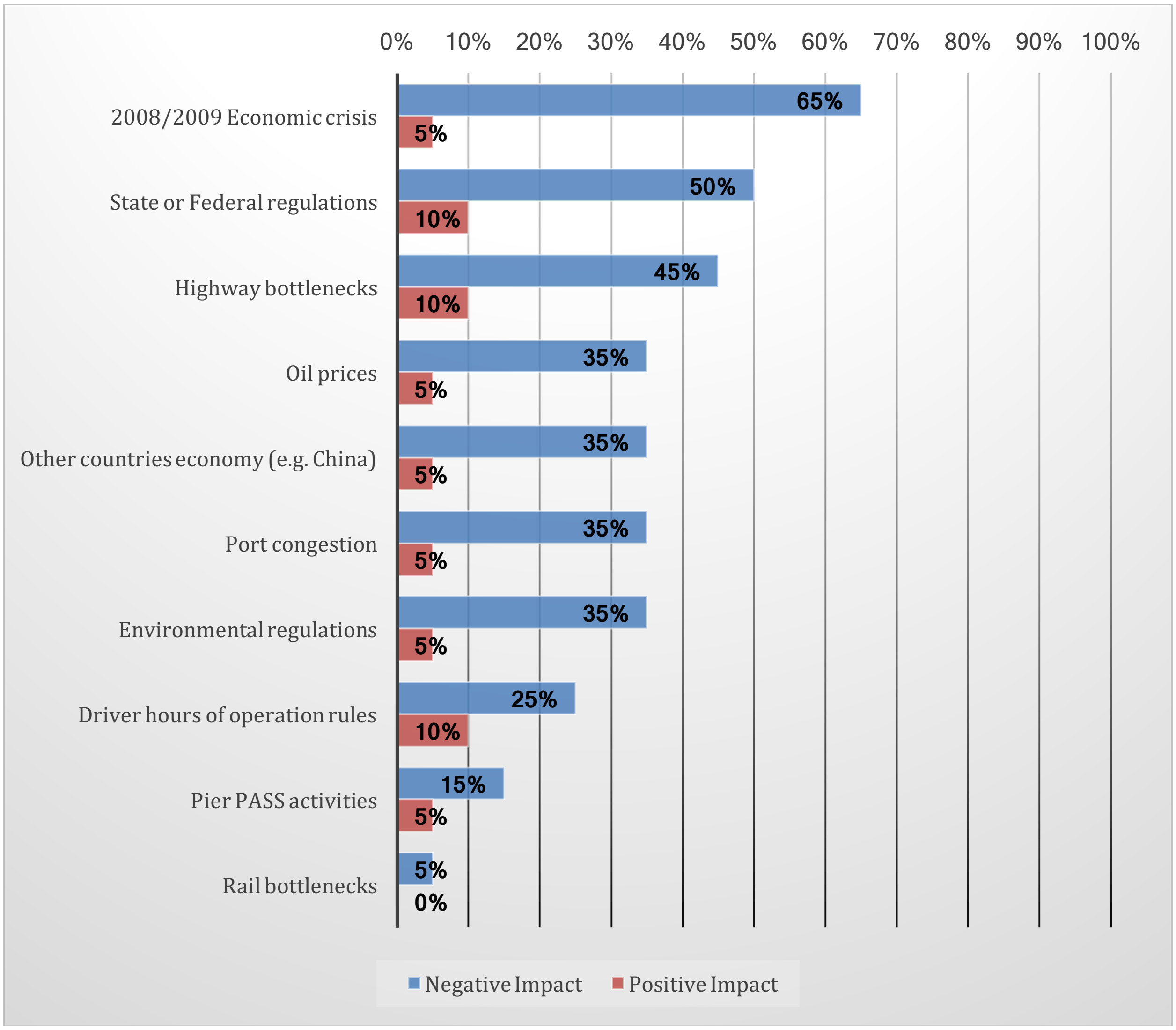


Figure 21. Factors Impacting Current Facility Operations

In addition to the results captured in the previous figures, the respondents expressed the following reasons for re-locating:

- "Landlord quadrupled the rent"
- "Opened second location in Northern California (SF)"
- "We need a bigger location/more space"
- "The price was within my budget. The location was better. The warehouse had an inside bathroom"
- "We are mainly an export company. We are close to the US/Mex border crossing for trucks"
- "We only run Southern California so drivers are home every night. Hours of operation don't usually affect us"

And among the factors that have influenced the location and/or operations of the facility:

- "Customers move in May thru Sept to get settled before school starts"
- "Housing development around our facility has had a very positive impact"
- "Rent is too high"
- "Environmental law is too much"
- "Labor law ($10.50/min) is too high"

VII. Summary and General Recommendations

The results are consistent with previous studies about the presence of logistics sprawl for W&DC in the SCAG region. However, the empirical analyses show that the deconsolidation trend did not continue after 2007. Moreover, estimates for the sub-industries General Warehousing and Storage, Refrigerated Warehousing and Storage, Farm Product Warehousing and Storage, and other Warehousing and Storage indicate that each of these sub-industries exhibits a distinct geographic concentration and temporal pattern (as illustrated by the movement of the weighted geometric center, see Figure 23). While the Gini coefficient is at around 0.4 for the W&DC industry, the sub-industries show concentration coefficients of less than 0.15.

This trend could be the result of new logistics needs such as trying to serve the markets in shorter delivery times; because disruptions in the industry after the 2008-2009 crisis; policy and environmental implications; and/or land value and availability. However, the aggregate nature of the establishment level data did not allow to explicitly identify the effects of these factors. The survey responses do offer some insights as respondents identified the economic crisis to be the factor with the highest negative impact to their operation, as well as the regulatory frameworks in the area.

As mentioned, in the SCAG region, the freight traffic is predominantly for internal distribution (SCAG, 2016). If the on-demand economy continues to grow, and express and rush distribution strategies become the norm, it could be expected that more logistics facilities will be located within dense areas, as opposed to the deconcentrating effect characteristic of logistics sprawl. For instance, Amazon has established a number of facilities (approximately 21) in Los Angeles and Orange County to fulfill orders to Southern California customers (MWPVL, 2016) in the last couple of years (2012-2016). During this period and considering the location of the facilities, the authors estimate that the average distance from the facilities to the Los Angeles CBD has dropped from 56.52 miles in 2012 to 33.9 miles in 2016.

The results also showed the presence of spatial effects. However, this effect is not as significant for the W&DC as it is for other industries such as light manufacturing and information. The work concludes that variables such as access to highway and intermodal facility networks remain relevant to the location of warehouse establishments, and that logistics clusters benefit from the services offered between industries.

The other significant demographic variables that explain the warehousing sector highlight important opportunities to improve the social conditions of the communities where this industry establishes. The implementation of Local Freight Plans consistent with Sustainable Communities Strategies will help determine specific policies to improve the economic, social, and environmental conditions in those regions. Special attention should be given to potential and existing land use conflicts in different neighborhoods. Environmental impact assessments and zoning ordinances should provide a comprehensive analysis about the impacts at an individual and aggregate level of industrial zone projects. This will also contribute to the efforts to implement the recently launched California Sustainable Freight Action Plan.

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ANNEX

Annex A: Survey Instrument

Figure 22. Survey

UC DAVIS
National Center for Sustainable Transportation

Warehouse and Distribution Centers Freight Activity Study

Information you provide will be kept confidential and will be used for research purposes only

CONTACT INFORMATION OF THE PERSON COMPLETING THE SURVEY

Name: ______________________ Position: ______________________

Phone number: ______________________ E-mail: ______________________

GENERAL COMPANY AND FACILITY INFORMATION

Company Name ______________________

Facility Name (if different than company name): ______________________

Address: ______________________ City: ______________________

State: ____________ ZIP: ____________

Does the company own or rent/lease the facility? ______________________

Do you carry your own business activity in this facility or do you serve other companies? ____________

How many docks does the facility have? ____________

Daily hours of operations: Open ____________ Close ____________ Days per week: ______

If e-commerce fulfillment activities are performed at this facility:

a. Who does the deliveries? Company ☐ Third party ☐

b. Do you do offer faster than same-day deliveries (e.g., rush, express)? Yes ☐ No ☐

WHICH ACTIVITIES ARE CARRIED AT THIS FACILITY?

Select all that apply:

- General Storage ☐
- Cold storage ☐
- Cross-docking ☐
- Parcel ☐
- Sorting ☐
- Value added activities (e.g. labeling, sorting) ☐
- Automation (e.g. conveyor, barcode scan) ☐
- Residential deliveries ☐
- E-Commerce Fullfilment ☐
- Other: ☐ ______________________

WHAT ARE THE MAIN ACTIVITIES OF THE FACILITY?

Rank the top three from 1 to 3 (i.e. 1 = highest, 3 = lowest)

- Warehouse / Storage ☐
- Warehouse / Cold Storage ☐
- Cross-dock ☐
- Distribution Center ☐
- Residential deliveries / E-commerce FC ☐
- Value added activities ☐
- Other: ☐ ______________________

NUMBER OF PEOPLE CURRENTLY EMPLOYED AT THIS FACILITY

Total employees in a typical day: ____________ Total office staff in a typical day (if applicable): ____________

Is the work done at the premises performed in shifts? YES ☐ NO ☐ Number of shifts: ____________

SITE AND FACILITY AREA

Is your establishment the only one at this facility? YES ☐ NO ☐

Total site area* ____________ Area excluding office space ____________

* Specify units (e.g., sq. yds, sq. ft, acres)

TYPE OF GOODS HANDLED IN THE FACILITY

Select all that apply: Perishables ☐ Clothing ☐ Bulk ☐ Other ☐

Non-Perishables ☐ Food ☐ Parcel ☐ ____________________

ORIGIN AND DESTINATION OF THE GOODS THIS FACILITY RECEIVES AND SHIPS OUT

Percentage of Origins (all add up 100%): In-State (Nearby) ________ In-State (Other locations) ________

Out of State (Mexico) ________ Out of State (Other locations) ________

Percentage of Destinations (all add up 100%): In-State (Nearby) ________ In-State (Other locations) ________

Out of State (Mexico) ________ Out of State (Other locations) ________

FACILITY'S TRUCK TRAFFIC (INBOUND AND OUTBOUND) IN A TYPICAL DAY

NUMBER OF VEHICLES **OPERATED FROM** THIS FACILITY BY TYPE AND ENGINE TECHNOLOGY

Who owns the vehicle fleet (select all that apply): Company or facility ☐ Leased by company or facility ☐

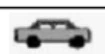
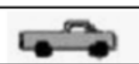
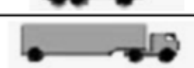
Third party ☐

Write the number of vehicles by type and engine technology where corresponds, if you don't know the technology use the **"Don't know"** column. Please exclude employee vehicles not used to ship goods.

	Gasoline	Diesel	CNG	LNG	Electric	Hybrid	Don't know	Total
Passenger cars	____	____	____	____	____	____	____	____
Small pickups/vans:	____	____	____	____	____	____	____	____
2 axle single unit trucks:	____	____	____	____	____	____	____	____
3 or 4 axle single unit trucks:	____	____	____	____	____	____	____	____
4 or fewer axle single-trailer trucks:	____	____	____	____	____	____	____	____
5 axle single or multi-trailer trucks:	____	____	____	____	____	____	____	____
6 or more axle single or multi-trailer:	____	____	____	____	____	____	____	____
Others/ not specified:	____	____	____	____	____	____	____	____

NUMBER OF TRIPS AT THIS FACILITY AS **ORIGIN** OR **DESTINATION** BY VEHICLE TYPE

In the table below, provide the **average** number of vehicle trips PER DAY/ PER WEEK
If no information is available use "n/a". If the answer is zero use "0"

Description	Example	MADE FROM this facility (OUTBOUND)		RECEIVED AT this facility (INBOUND)	
		# trips	select one	# trips	select one
Cars			☐ per day ☐ per week		☐ per day ☐ per week
Small pickups/vans			☐ per day ☐ per week		☐ per day ☐ per week
2 axle single unit trucks			☐ per day ☐ per week		☐ per day ☐ per week
3 or 4 axles single unit trucks			☐ per day ☐ per week		☐ per day ☐ per week
Single-trailer trucks (3 or more axles)			☐ per day ☐ per week		☐ per day ☐ per week
Other / Don't know			☐ per day ☐ per week		☐ per day ☐ per week

FACILITY LOCATION INFORMATION

What were the motivations to pick the location of this facility? Rank the top 5 (from 1 to 5, i.e. being 1 the most relevant)

☐ Access to customers	☐ Labor costs	Proximity to:
☐ Access to suppliers	☐ Tax rates / Land costs	☐ Highways
☐ Transportation services nearby	☐ Transportation costs	☐ Intermodal Facilities
☐ Retail/Wholesale companies nearby	☐ Land costs	☐ Airports
☐ Public transit	☐ Availability of skilled workers	☐ Sea ports
☐ Abiltiy to operate 24/7	☐ Per capita income	☐ Rails
☐ Trailer parking / Truck staging areas	☐ Handling costs	☐ Other warehouses / Similar businesses
☐ Pro-business regulatory environment	☐ Land availability for expansion	

If you are planning to relocate, please provide an approximate date, and please specify the main reason:

____

____

____

Have you relocated in the past 2 years? YES ☐ NO ☐

If YES, what was the previous address? ________________________

If YES, why? ________________________________

____

OTHER BUSINESS INFORMATION

Select which months have a higher activity from the average facility activity

January ☐	March ☐	May ☐	July ☐	September ☐	November ☐
February ☐	April ☐	June ☐	August ☐	October ☐	December ☐

Please indicate the impact of the following factors in your business or facility operations? Rate with 1 - highly negative impact, 2 - moderate/low negative impact, 3 - no impact, 4 - moderate/low positive impact, and 5 highly positive impact

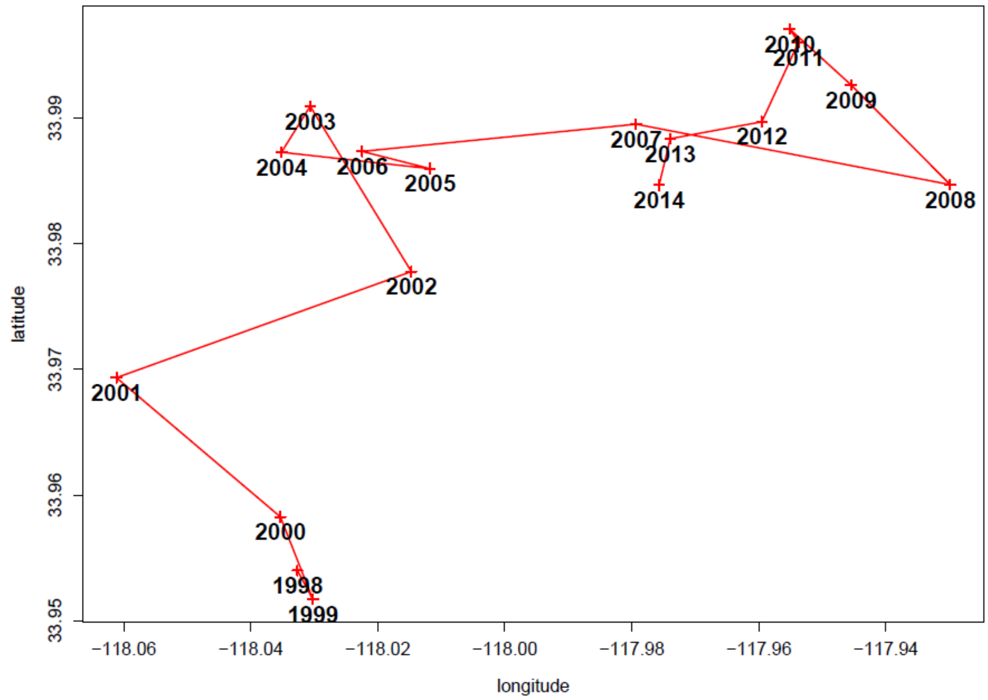
2008/2009 Economic crisis ____	Pier PASS activities ____	Rail bottlenecks ____
State or Federal regulations ____	Port congestion ____	Highway bottlenecks ____
Oil prices ____	Environmental regulations ____	Other: ____
Other countries economy (e.g. China) ____	Driver hours of operation rules ____	________

Do you have any additional comments about the factors that have influenced the location and/or operations of the facility?

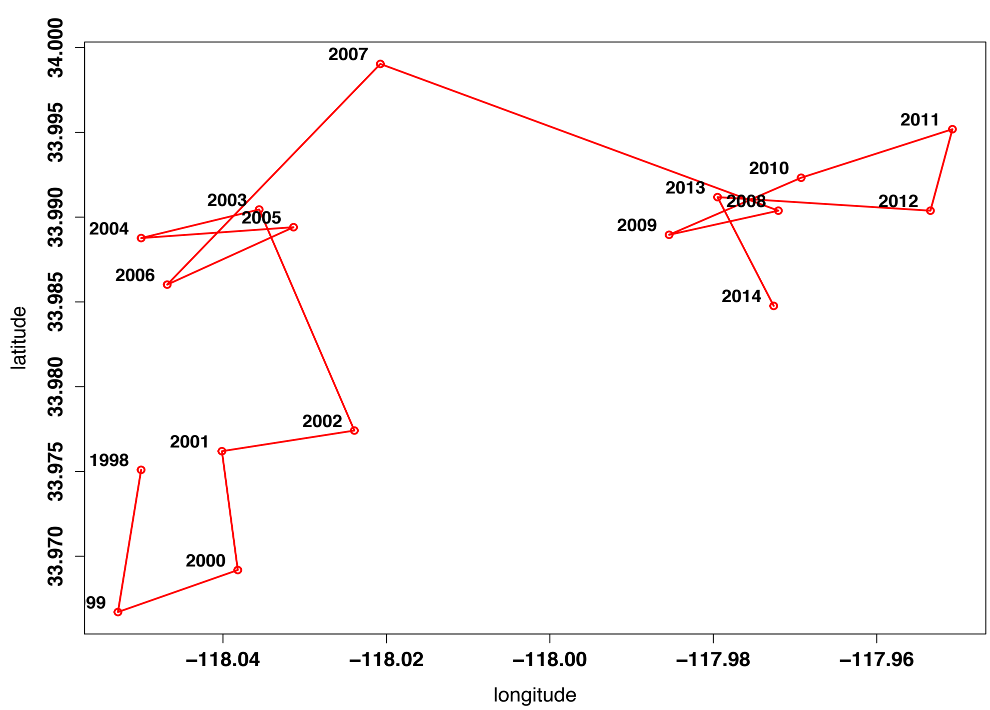
If you would like more information about the survey, please contact Professor Miguel Jaller at his e-mail address (mjaller@ucdavis.edu) or call 530-752-7062.
You can also access an online version of this survey at: https://its.ucdavis.edu/wdc-survey/

Annex B: Centroid Distance and Change-point Detection

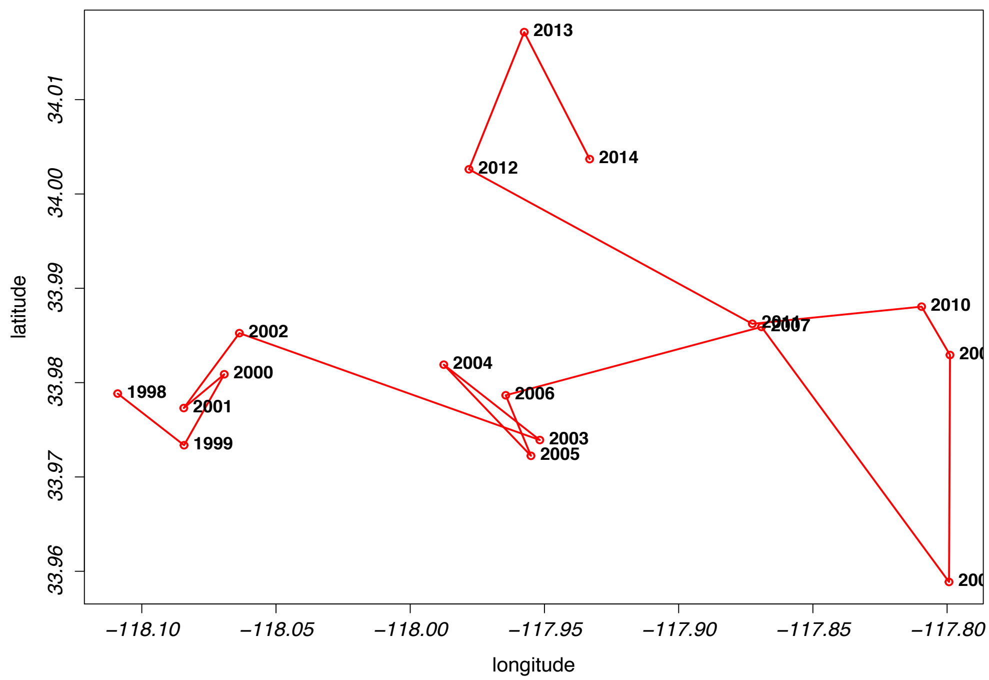
Figure 23. Movement of the Weighted Geometric Center Between 1998 and 2014



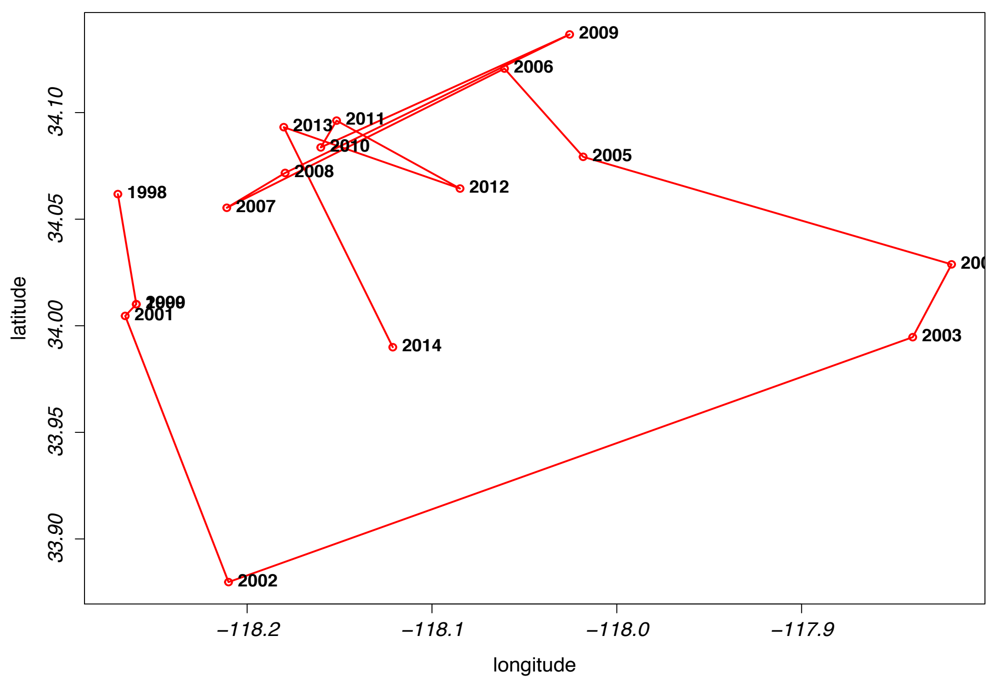
a. NAICS 493



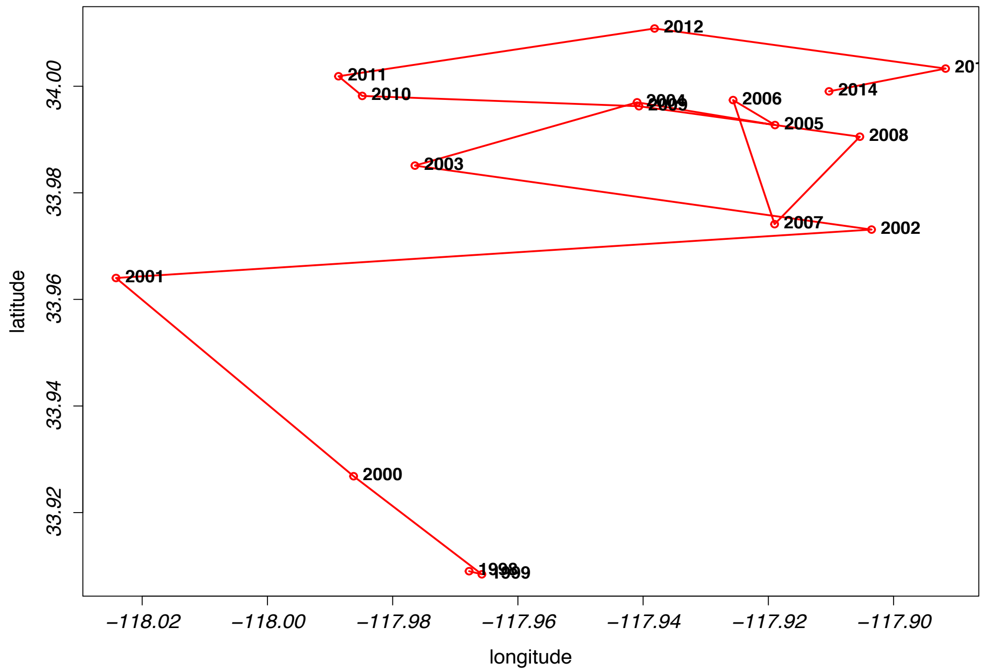
b. NAICS 49311



c. NAICS 49312



d. NAICS 49313



e. NAICS 49319

Figure 24. Average Distance Analysis from LA CBD to all of the Establishments of NAICS 493 and Changepoint Statistical Test (1998-2014)

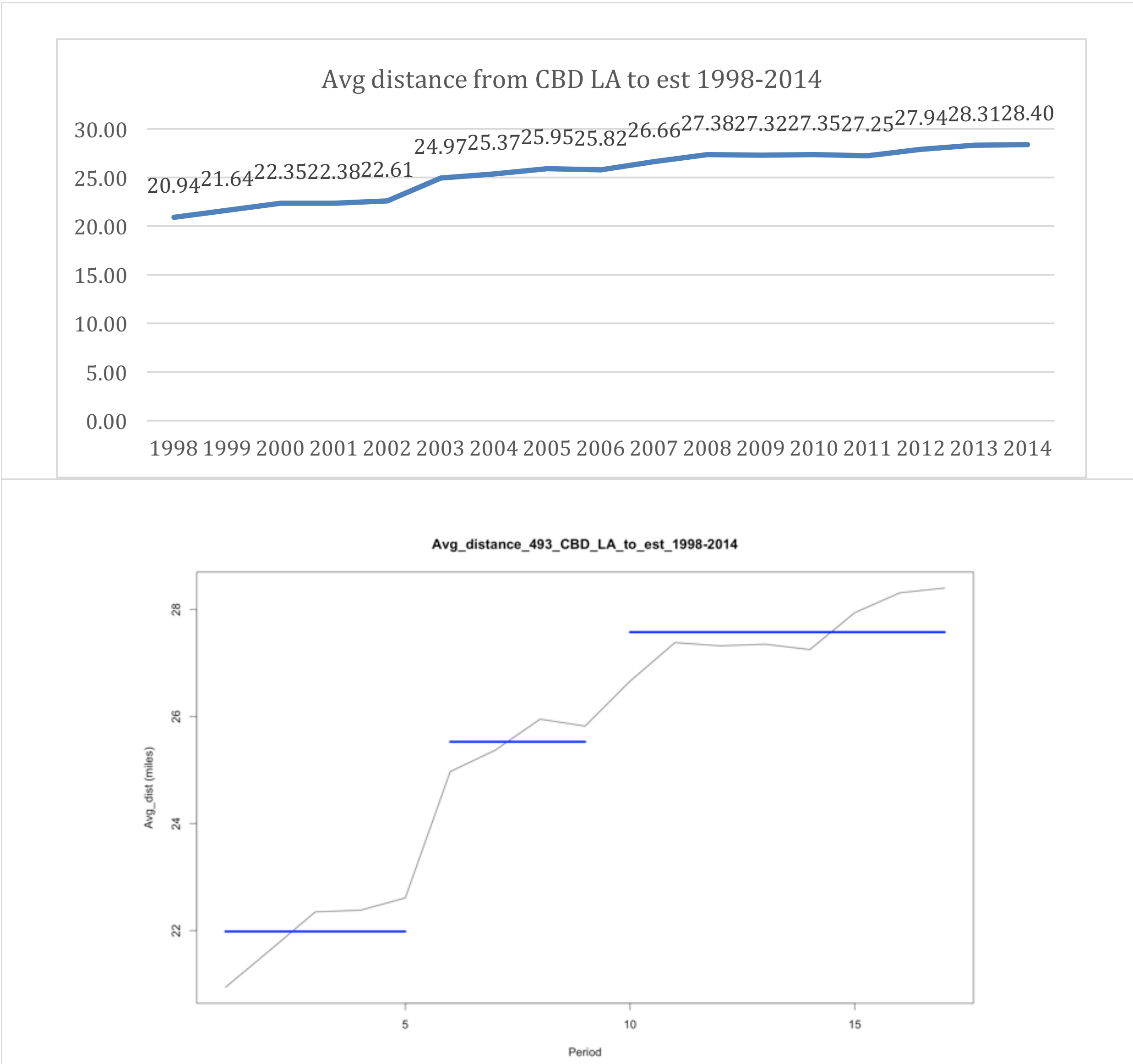
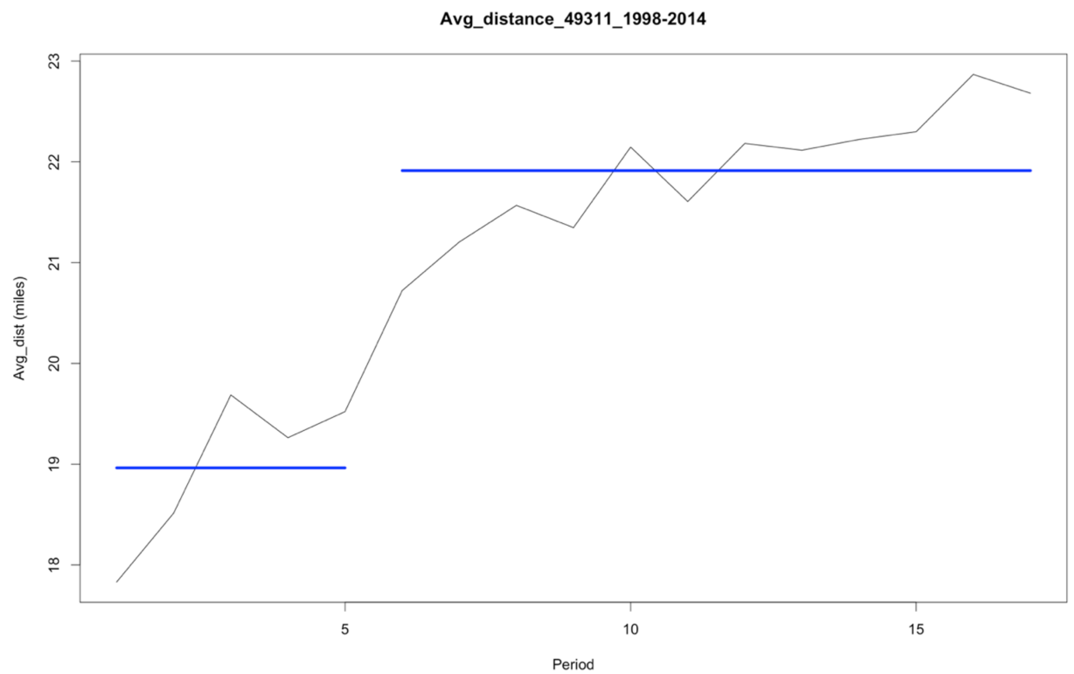
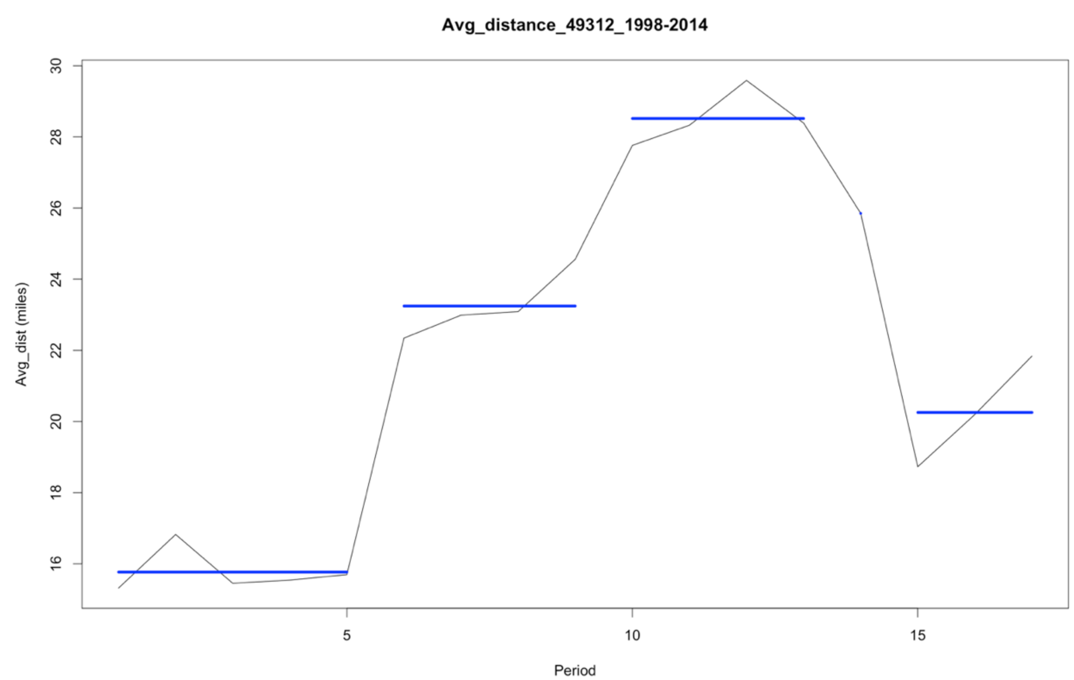


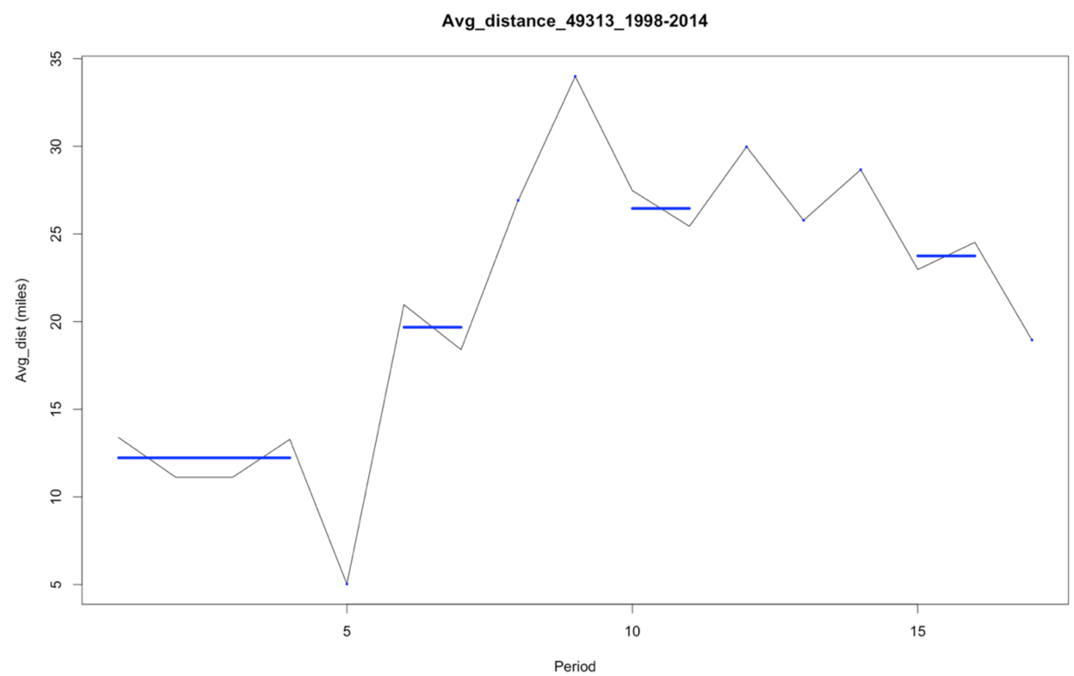
Figure 25. Changepoint Test for 493 Subindustries in 1998-2014



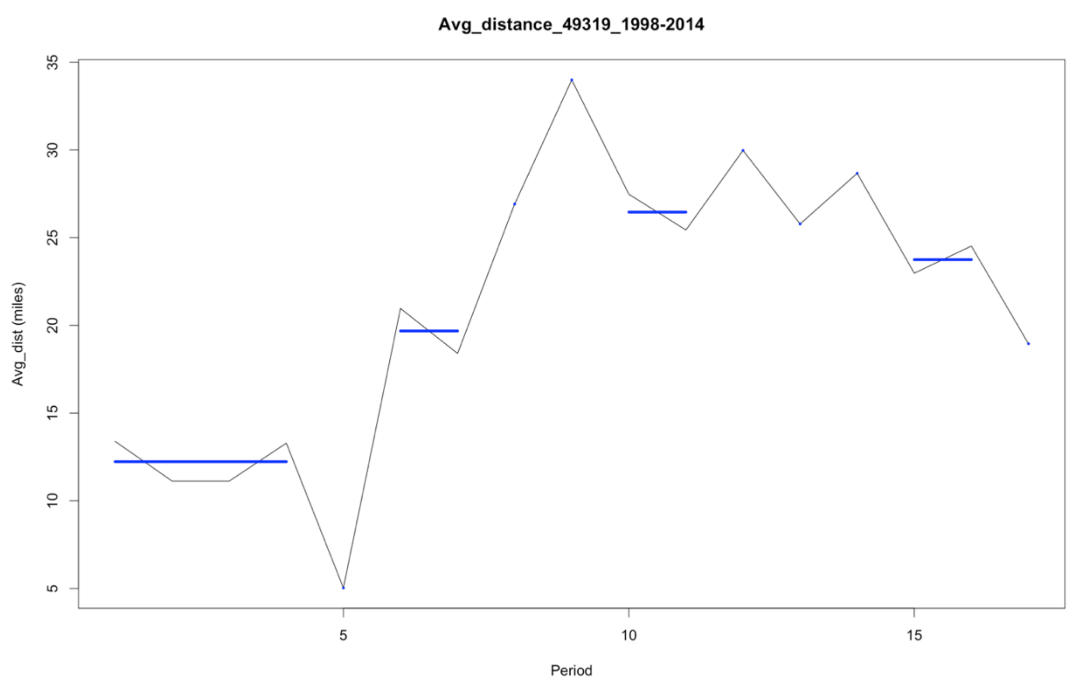
a. 49311 sub industry



b. 49312 sub industry



c. 49313 sub industry



d. 49319 sub industry