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The purpose of this research is to document and analyze the location patterns of warehousing and distribution activity in California. The growth of California's warehousing and distribution (W&D) activities and their spatial patterns is affected by several factors, including population and economic growth, shifting supply chains and distribution practices, scale economies in warehousing, and the state's role in international and domestic trade. The location of W&D activities has implications for freight demand and flows, and thus is a critical element in statewide transportation planning.

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Disclaimer

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Disclosure

Dr. Genevieve Giuliano (Principal Investigator) and Sanggyun Kang participated in this research titled, "Spatial dynamics of warehousing and distribution in California." The research was funded by a grant from Caltrans, the California Department of Transportation, in the amount of $99,500. The research was conducted as part of the METRANS Tier 1 University Transportation Center.

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Abstract

The purpose of this research is to document and analyze the location patterns of warehousing and distribution activity in California. The growth of California's warehousing and distribution (W&D) activities and their spatial patterns is affected by several factors, including population and economic growth, shifting supply chains and distribution practices, scale economies in warehousing, and the state's role in international and domestic trade. The location of W&D activities has implications for freight demand and flows, and thus is a critical element in statewide transportation planning. This research is conducted in two parts.

First, we conduct a descriptive analysis of W&D trends from 2003 – 2013 using Zip Code Business Pattern data. We find that: 1) the W&D industry in California has grown much faster than the transport sector or the economy as a whole; 2) W&D activity is distributed approximately with the population and total employment; the four largest metro areas in California account for about 88% of all jobs and all W&D jobs; 3) at the metropolitan level the relative shares of W&D activity have been stable over the period; 4) there is some evidence of W&D activity moving away from the major metro areas to nearby smaller metro areas; 5) at the sub-metropolitan level we observe significant decentralization of W&D employment for the largest metro areas, suggesting that larger facilities are locating further from the center.

The second part of the research examines possible explanatory factors associated with W&D location trends. We estimate both cross sectional and longitudinal models of location. We find that: 1) the negative binomial specification explains the distribution of W&Ds better than the simple binomial; 2) the correlation between employment density and W&D activity decreased significantly over the decade, whereas the effect of labor force access is consistently significant; 3) W&Ds are more likely to be located in proximity to intermodal terminals and highways and farther from seaports; 4) the signs and significance of regional market attributes – the share of linked industry at the regional level – are consistent across model specifications but vary across the model years and metro areas; 5) the first-order autoregressive model documents that the effect of regional market attributes decreased significantly over the time period. This suggests the responses of the W&D industry to changing market conditions take place quickly. However, the overall pattern of W&D activity appears to be stable.

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Spatial Dynamics of Warehousing and Distribution in California

Introduction

The California economy is one of the largest in the world. With an estimated equivalent gross domestic product of $2.2 trillion, it ranks 7th among the world's economies (Marios and Pei, 2015). California remains the top state for manufacturing by value of total output.[1] California seaports and airports together make California the nation's top international trade gateway, with approximately $550 billion in trade in 2011 (FHWA, 2014). California's large and dynamic economy, together with its role as the nation's major international trade gateway, generates large volumes of freight flows and an active warehousing and distribution sector. This research examines trends in warehousing and distribution (W&D) location in order to develop a better understanding of how these activities may affect the state's transportation system.

Many of the factors that affect the location of W&Ds are those that generally affect all profit-maximizing firms. For W&Ds, the trade-offs are between land costs, transport costs, inventory costs, labor and other inputs. All else equal, firms will select the combination of these factors that minimizes total costs or maximizes profits. Land price plays a major role; firms may trade off transport costs for cheaper land. Location shifts may occur as relative costs change over time. For example, population and economic growth influence land rents as demand for land intensifies. Thus, all else equal, we would expect W&D – a land intensive activity – to shift away from areas with increasing rents and seek new locations in less developed areas. Transport costs also play a significant role. Access to major trade nodes – major highways, port, airport and intermodal terminals – is essential to fulfilling global freight demands.

There are three factors unique to W&Ds that may lead to changes in location patterns. First, the industry itself is changing rapidly. Scale economies, generated by information systems and automation, are increasing demand for very large scale facilities (McKinnon, 2009), which intensifies demand for low land prices and large parcels. Second, structural shifts in the supply chain affect W&Ds. Examples include incorporating secondary processes in distribution, increasing the velocity of supply chains, and omni-channel retail distribution systems (McKinnon, 2009; Napolitano, 2013). Third, the environmental impacts associated with W&Ds affect more people in densely developed areas. Local opposition may act as a push factor for relocation of W&D activity to less developed areas.

Trends in W&Ds are of interest for the following reasons. First, W&Ds are major truck traffic generators. If location patterns are shifting over time, their associated truck travel demand will also shift, affecting the highway system. Understanding how and why these shifts are taking place is essential for metropolitan and statewide planning. Second, factors affecting W&Ds suggest fewer but larger scale operations, located further from population centers. More concentration implies

[1] http://www.nam.org/Data-and-Reports/State-Manufacturing-Data/2014-State-Manufacturing-Data/2014-State-Manufacturing-Data-Table/

greater localized impacts, while decentralized location may imply more truck traffic and truck Vehicle Miles Traveled (VMT). The focus on velocity and highly flexible supply chains may affect mode choice in favor of trucking. Rail transport is slower, less flexible, and reliant on large shipment size, but at the same time more energy efficient. Within the truck mode, these trends may lead to use of smaller trucks and more frequent trips as deliveries become increasingly customized and dispersed. Given California's greenhouse gas reduction goals, it is important to understand the underlying dynamics of truck demand so that appropriate policies can be designed to effectively manage demand.

1.1 Literature review

As cities have de-industrialized, the siting of new W&Ds, as well as the continued operation of existing W&Ds, has grown increasingly complex. Warehouses traditionally clustered around rail terminals, which for historical reasons are typically located near the city center. Warehouses and other industrial land uses have increasingly been pushed to the periphery of cities, due not only to the increasing cost of land, but also to the negative externalities of W&D operations such as noise, emissions, congestion and pavement damage. Increasing warehouse size also contributes to location shifts. W&Ds over 500,000 ft^2, which constituted less than 5% of total new warehouses prior to 1998, reached nearly 25% of new starts by 2006. (Andreoli, Goodchild and Vitasek, 2010)

This trend creates both advantages and disadvantages for the warehousing industry. W&Ds are able to grow larger on former greenfield sites than was possible in inner cities and can engage in 24-hour operation due to less restrictive noise constraints. Furthermore, warehouses are able to cluster and take advantage of economies of scope more readily in industrial parks and "freight villages" (Hesse, 2004; van den Heuval et al, 2013). Finally, an extra-urban location may allow a warehouse to more readily expand its geographic reach as orders destined for external markets can be delivered without encountering urban congestion. The primary disadvantage is that, as congestion worsens, the warehouses become less readily accessible to the city center and to rail or port terminals which are typically too heavily capitalized to be relocated.

There is a small but growing literature on W&D patterns within metropolitan areas. Bowen (2008) conducted a national study of W&D growth in the US from 1998 to 2005, and found that growth was associated with access to major trade nodes. A study of logistics activity in the Netherlands documents increased spatial concentration from 1996 to 2009 (van den Heuval et al, 2013). Of particular interest is decentralization of W&Ds, because it is argued that as W&Ds move further from population and employment centers, delivery trips lengthen, leading to increased truck VMT and associated externalities (Allen, Browne and Cherrett, 2012; Dablanc et al, 2014). W&D industry expansion and decentralization have been documented in two US metropolitan areas, Atlanta and Los Angeles (Dablanc and Ross, 2012; Dablanc, et al., 2014), as well as in the UK (Allen, Browne and Cherrett, 2012). Both US studies used centrography point pattern analysis (a measure of distance from the geographic center). Cidell (2010) used the Gini coefficient and documented W&D facility de-concentration in US metropolitan areas. Dablanc, et al. (2014) documented W&D concentration in Seattle, which they attribute to regional growth management policy. These studies suggest that decentralization may be a phenomenon of large metro areas where major trade nodes and major consumer markets co-locate.

1.2 Results from a previous study of four metro areas in California

In research funded by Caltrans under Task 004-A01 (National Center for Sustainable Transportation; Giuliano, Kang and Yuan, 2015), we conducted an analysis of spatial trends in the logistics industry for the four largest metro areas in California. We addressed the question of decentralization as an indirect way to determine whether changes in W&D patterns may lead to more truck VMT. Because the argument is about truck VMT, care must be taken in how decentralization is measured. For example, if W&D patterns are no different than that of population or all economic activity, it is unlikely that any observed decentralization would imply more truck VMT, all else equal. Also, spatial concentration should make a difference. Even if there is no change in the degree of centralization, W&Ds may become more or less concentrated. Depending on location relative to markets or suppliers, shifts in concentration could also affect truck VMT.

We used the concepts of centralization (distribution relative to the center) and concentration (distribution relative to other W&Ds) to develop a set of spatial measures. We considered both absolute change (e.g. relative to a fixed point) and relative change (e.g. with respect to change in other spatial distributions). We used annual Zip Code Business Pattern (ZBP) data, which gives total number of W&Ds by zip code, to examine changes from 2003 to 2013. TABLE 1 gives summary results for four measures as follows:

1. Absolute decentralization: average distance to the CBD (Central Business District)
2. Relative decentralization: average distance to all employment
3. Absolute concentration: Gini coefficient
4. Relative decentralization: share of W&Ds in the first upper quartile by employment density

The first row in TABLE 1 gives the change in the number of W&D facilities. Sacramento had the greatest percentage increase, followed by Los Angeles. For average distance to the CBD, only Los Angeles shows a significant change. When we consider decentralization in the context of all employment, the change is reduced by more than half. Results on concentration are more mixed, with a large increase in San Diego, modest increase in Los Angeles, and decreases in Sacramento. Changes in the relative concentration of W&Ds in the densest quartile are mixed as well. Possible explanations include metropolitan area size, economic structure, and physical geography. Metropolitan size is associated with higher density and land prices, which in turn pushes land intensive activities to more distant locations. Metro areas that are international trade nodes have more W&D activity and more demand for large scale facilities. Physical geography, such as the San Francisco Bay, imposes constraints on land availability, and pushes activities to more distant locations.

TABLE 1 Changes in the number of W&Ds and four measures of spatial change

Changes over 2003-2013	Los Angeles	San Francisco	Sacramento	San Diego
Number of W&Ds	29%	21%	79%	2%
1. Average distance to the CBD	14%	4%	5%	-5%
2. Average distance to all emp.	7%	1%	-4%	1%
3. Gini coefficient	8%	1%	-6%	32%
4. Share of W&Ds in the densest employment density quartile	-8%	-4%	10%	1%

Part I Trends in W&D in California 2003-2013

2.1 Research Framework

W&D location patterns in metropolitan areas have attracted increasing attention due to concerns of the impacts of decentralization on truck VMT and associated externalities. At the state level, the question is more complex. Rates of population and employment growth as well as industry mix vary across the state. For example, Southern California is the major international gateway, the San Joaquin Valley is an export region, and the San Francisco Bay area is a major technology and manufacturing hub. These roles imply different demands for W&D services. From a state planning perspective, the question is how growth is distributed across the state, and what implications these trends have for freight transport demand.

We analyze the trends in W&D distribution in California in two parts. In Part I, we describe trends over the last decade – change in overall numbers of W&Ds at multiple geographic levels, change in W&D distribution with respect to general employment and population trends, and change in W&D spatial patterns. In Part II, we assess multiple explanatory factors associated with these trends. Several statistical models test the extent to which the factors explain the cross-sectional distribution and its changes over time. Here we specify the research framework of the first part.

Because the state of California is diverse in terms of its development density, we delineate the region into four levels of geography consisting of 14 metropolitan areas and two regions with micropolitan and rural counties. Based on this delineation, we describe the distribution and changes in the number of W&Ds at three different geographic scales – the entire state, four metro levels, and county and ZIP Code. Then, we identify areas of growth or decline and compare trends. In order to evaluate whether W&D spatial trends simply replicate the larger spatial trends of the entire economy, we compare the numbers of W&Ds to the numbers of total establishments and employment. If so, we may conclude that location choice factors are similar, and population and employment growth would be good proxies for predicting future patterns. If not, we are interested in how and why W&D patterns differ, and what implications these may have for truck travel. Furthermore, we analyze the extent of spatial concentration by industry share and location quotient at varying geographic scales. Lastly, we assess the changes in spatial distribution with respect to the central business district (CBD) over time. The CBD is a proxy for the location where the demand for goods is most concentrated in the urban market. Thus, with the changes in the average distance from the CBD to all W&Ds, we can draw implications for truck travel.

2.2 Study Area Delineation

The first task of our study is a descriptive analysis of statewide trends. The state is diverse, with some of the largest and densest metro areas along the coast, vast agricultural areas in the interior, and sparsely populated desert and forest regions. We use categories of urbanization defined by the Office of Management and Budget (OMB) to differentiate parts of the state. Of the fifty-eight counties, 45 are urban counties, which comprise 26 metropolitan statistical areas (MSAs) and 8 micropolitan statistical areas (MiSAs). A MSA consists of one or multiple counties with at least one urban area with more than 50,000 population;a MiSA consists of one or more counties with one urban area with 10,000-50,000 population.[2] Neighboring counties are combined to form an MSA, if the level of social and economic interactions (quantified by commuting ties) is over the threshold OMB designates. Moreover, neighboring MSAs are combined further to form a Combined Statistical Area (CSA), if the level of interactions is significant to merit regional-level studies, yet not as strong as the counties in an MSA. Any counties that are not either MSA or MiSA are rural.

These definitions of metropolitan areas provide a useful means for study area delineation. First, CSAs are suitable for regional studies of commodity distribution and wholesaling (OMB, 2015); thus we use CSAs where they exist. For example, the Greater Los Angeles region CSA includes three MSAs (Los Angeles-Long Beach-Anaheim MSA, Riverside-San Bernardino-Ontario MSA, and Oxnard-Thousand Oaks-Ventura MSA). In this case, we use one CSA as the study unit of the region. Using CSAs, MSAs, MiSAs, and rural areas, as well as population cutoffs, we group all counties as follows:

- Level 1: CSA or MSA with population over 2 million
- Level 2: CSA or MSA with population over 250,000 and less than 2 million
- Level 3: CSA or MSA with population less than 250,000
- Level 4: MiSA or rural counties

TABLE 2 lists the areas by level, and FIGURE 1 maps their location. The four largest metro areas (level 1) account for nearly 85% of the state population. FIGURE 1 also shows the urban areas, which are defined by the U.S. Census Bureau using the density, count, and size thresholds of census tracts and block population.[3] It can be seen that the metropolitan counties include a great deal of non-urban area, and that the vast majority of the State's area is non-urban. That is, the metropolitan population is concentrated in a small share of total land area.

[2] Glossary of Metropolitan-related terms (http://www.census.gov/population/metro/data/glossary.html)
Current list of MSA/MiSA delineations (http://www.census.gov/population/metro/data/metrodef.html)
[3] Urban area criteria (2010) (http://www2.census.gov/geo/pdfs/reference/fedreg/fedregv76n164.pdf)

TABLE 2 Study Area Groups

Level	Full Name	Short Name	Type	Population in 2010 (thousand)
1	Los Angeles-Long Beach, CA CSA	Los Angeles	CSA	17,877
	San Jose-San Francisco-Oakland, CA CSA	San Francisco	CSA	8,154
	San Diego-Carlsbad, CA MSA	San Diego	MSA	3,095
	Sacramento-Roseville, CA CSA	Sacramento	CSA	2,415
2	Fresno-Madera, CA CSA	Fresno	CSA	1,081
	Bakersfield, CA MSA	Bakersfield	MSA	840
	Modesto-Merced, CA CSA	Modesto	CSA	770
	Visalia-Porterville-Hanford, CA CSA	Visalia	CSA	595
	Santa Maria-Santa Barbara, CA MSA	Santa Barbara	MSA	424
	Salinas, CA MSA	Salinas	MSA	415
	San Luis Obispo-Paso Robles-Arroyo Grande, CA MSA	San Luis Obispo	MSA	270
3	Redding-Red Bluff, CA CSA	Redding	CSA	241
	Chico, CA MSA	Chico	MSA	220
	El Centro, CA MSA	El Centro	MSA	175
4	Eureka, Ukiah, Clearlake, Susanville, and Crescent City MiSAs and 12 rural counties in Northern California	Northern rural	MiSA /rural	492
	Sonora MiSA and 7 rural counties in Central California	Central rural	MiSA /rural	191
Total				37,254

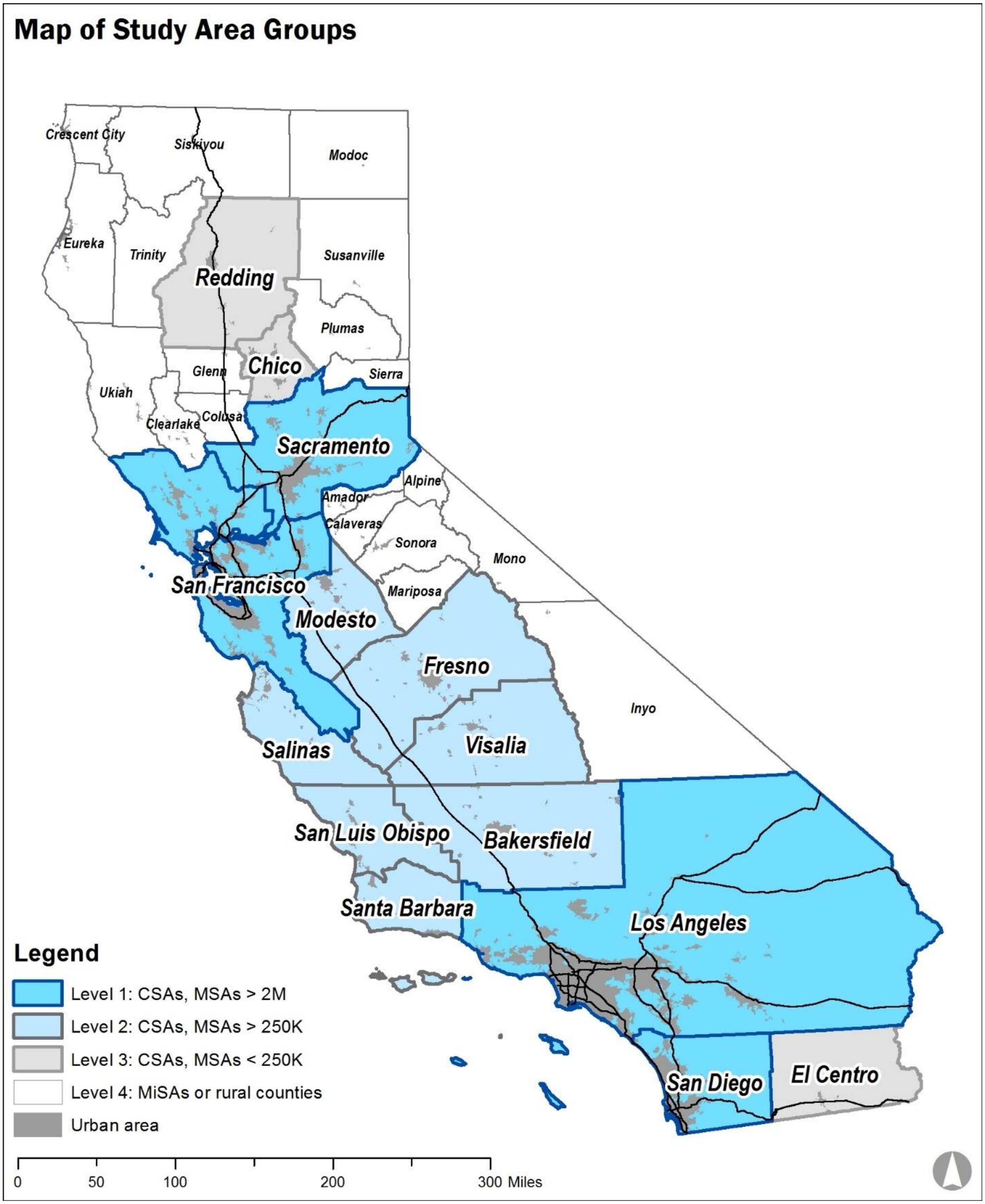

FIGURE 1 Map of study area groups

2.3 Data

The primary data source is the US Census' ZIP Code Business Patterns (ZBP) data. ZBP is based on the Business Register in which records of every known business with an EIN (employer identification number) are maintained. ZBP provides the number of establishments at the 6-digit industry code level. We use NAICS 493 'Warehousing and Storage' to identify W&D establishments. The Census Bureau defines 'establishments' as "a single physical location at which business is conducted, or services or industrial operations are performed."[4] ZBP is structured based on USPS ZIP Codes. Descriptive analyses are based on the centroids of ZIP Codes. ZBP data are reported annually. Because of changes in industry coding that make prior year data not comparable, the earliest year of data we use is 2003. We use 2013, the most recent year of available data, as the end period. This allows us to compare changes over a decade.

2.4 General Trends at the State Level

We present descriptive statistics of W&D trends in California in comparison to the entire economy and the transportation sector. TABLEs 3 and 4 give annual establishments and employment for the entire economy, the transportation two-digit sector (NAICS 48-49), truck transportation (NAICS 484), and warehousing and storage (NAICS 493).[5] The transportation sector accounts for approximately 3.3% of jobs and 2.4% of establishments in California. The W&D sector is much smaller, accounting for just 0.5% of jobs and 0.2% of establishments. Over the entire decade, total jobs and establishments increased by about 3% and 5.6% respectively. For the transportation two-digit sector, jobs were unchanged and establishments increased (12%), suggesting increased numbers of smaller firms. Jobs in the trucking sector declined 12%, while establishments increased slightly. In contrast, the W&D sector far outpaced growth of the other sectors and the general economy, with a 31% increase in jobs and a 24% increase in establishments.

FIGURE 2 illustrates the relative growth patterns of these industry groups. W&D grew rapidly through 2007, declined by about 15%, and has since recovered to its 2007 peak. No other sector has recovered to its 2007 peak. All jobs, as well as the super-sector and trucking fell below 2003 levels during the recession. Trucking has been in decline since 2006.

[4] Census Bureau (http://www.census.gov/econ/cbp/)
[5] CBP excludes 482 Rail transportation and 491 Postal service

TABLE 3 Comparison between the entire economy and transportation sector in California

Year	The entire economy		NAICS 48-49 Transportation		Share of	
	Jobs	Est.	Jobs	Est.	Jobs	Est.
2003	12,991,795	827,472	447,703	19,184	3.45%	2.32%
2004	13,264,918	841,774	448,081	19,586	3.38%	2.33%
2005	13,382,470	860,866	448,607	20,086	3.35%	2.33%
2006	13,834,264	878,128	453,208	20,776	3.28%	2.37%
2007	13,771,650	891,997	460,761	21,553	3.35%	2.42%
2008	13,742,925	879,025	468,916	21,711	3.41%	2.47%
2009	12,833,709	857,831	428,840	21,178	3.34%	2.47%
2010	12,536,402	849,875	414,859	20,876	3.31%	2.46%
2011	12,698,427	849,316	424,729	21,208	3.34%	2.50%
2012	12,952,818	864,913	439,204	21,263	3.39%	2.46%
2013	13,401,863	874,243	445,742	21,397	3.33%	2.45%
Change	3.16%	5.65%	-0.44%	11.54%	-3.48%	5.57%

** Statistics at the state and other levels are slightly different due to those businesses with suppressed location information

TABLE 4 Truck transportation and warehousing: jobs and establishments

Year	NAICS 484 Truck transportation		Share of		NAICS 493 Warehousing and Storage		Share of	
	Jobs	Est.	Jobs	Est.	Jobs	Est.	Jobs	Est.
2003	119,151	9,032	0.92%	1.09%	59,663	1,454	0.46%	0.18%
2004	117,601	9,146	0.89%	1.09%	65,354	1,582	0.49%	0.19%
2005	118,163	9,425	0.88%	1.09%	69,256	1,620	0.52%	0.19%
2006	120,014	9,818	0.87%	1.12%	70,384	1,684	0.51%	0.19%
2007	115,360	10,133	0.84%	1.14%	79,517	1,770	0.58%	0.20%
2008	115,308	9,735	0.84%	1.11%	78,529	1,746	0.57%	0.20%
2009	107,009	9,413	0.83%	1.10%	70,363	1,784	0.55%	0.21%
2010	102,042	9,161	0.81%	1.08%	68,317	1,773	0.54%	0.21%
2011	106,248	9,300	0.84%	1.09%	70,934	1,735	0.56%	0.20%
2012	103,904	9,295	0.80%	1.07%	71,875	1,711	0.55%	0.20%
2013	105,264	9,304	0.79%	1.06%	78,319	1,804	0.58%	0.21%
Change	-11.65%	3.01%	-14.36%	-2.50%	31.27%	24.07%	27.25%	17.43%

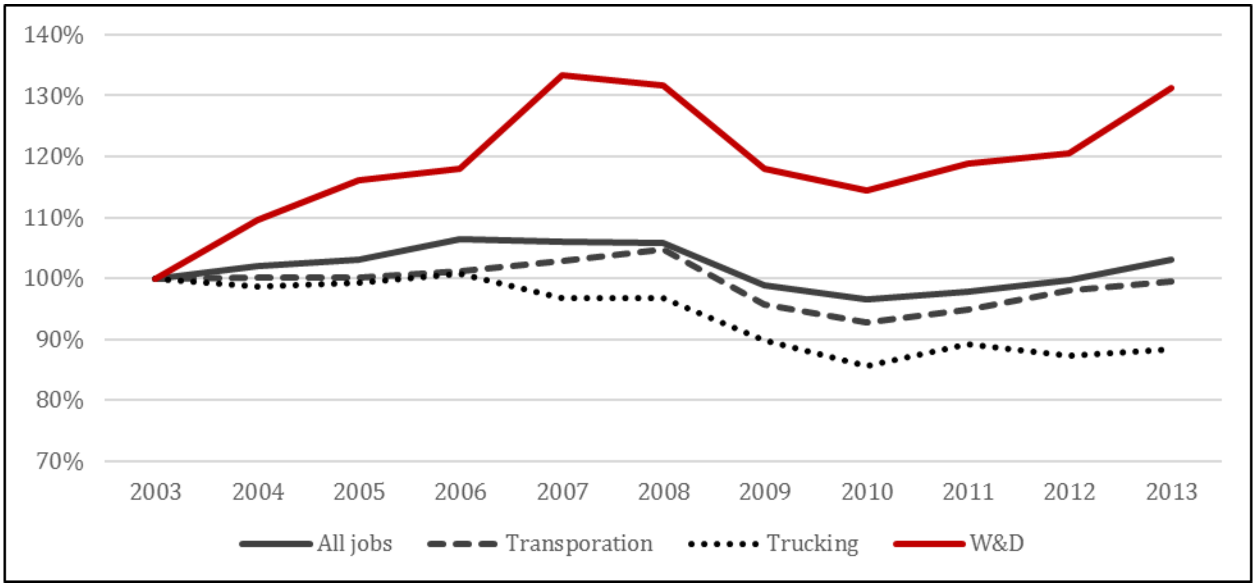

FIGURE 2 Trends in the relative job growth of the entire economy and sub-sectors of transportation in California

2.5 Trends at the Four Metropolitan Levels

2.5.1 Distribution and Change

TABLES 5 and 6 give establishments and jobs by four metro levels, for the entire economy, two-digit transportation sector, and W&D sector. Comparing across all rows, economic activity is approximately distributed as the population. Level 1 metro areas account for slightly more jobs than their population share, and the other levels account for slightly less. With respect to establishments, the distribution of the two-digit transportation sector is slightly more weighted towards the lower level groups than total establishments or W&D establishments. Shares within each sector change very little between 2003 and 2013. There is substantial variation within each level (not shown). For example, the Los Angeles region accounts for about 60% of all Level 1 establishments and 65% of W&D establishments in 2013. The San Francisco region accounts for 23% of all businesses and 20% of all W&D. Detailed statistics at the metro level are available in Appendix A.

TABLE 5 Total establishments, 2003 – 2013, by county group level

Level	The entire economy				Transportation				W&D				Population
	2003		2013		2003		2013		2003		2013		2010
	N	Share	N	Share	N	Share	N	Share	N	Share	N	Share	Share
1	673,582	86.5%	723,433	87.5%	15,186	82.1%	17,461	83.9%	1,196	86.0%	1,541	87.3%	84.7%
2	75,206	9.7%	76,568	9.3%	2,390	12.9%	2,519	12.1%	152	10.9%	175	9.9%	11.8%
3	12,776	1.6%	12,085	1.5%	476	2.6%	432	2.1%	24	1.7%	30	1.7%	1.7%
4	17,063	2.2%	14,962	1.8%	449	2.4%	388	1.9%	19	1.4%	19	1.1%	1.8%
Total	778,627		827,048		18,501		20,800		1,391		1,765		

TABLE 6 Total jobs, 2003 – 2013, by county group level

Level	The entire economy (thousand)				Transportation				W&D			
	2003		2013		2003		2013		2003		2013	
	N	Share	N	Share	N	Share	N	Share	N	Share	N	Share
1	10,797	88.8%	10,918	88.9%	384,395	89.0%	394,873	89.1%	49,405	89.6%	68,174	87.4%
2	1,043	8.6%	1,072	8.7%	36,459	8.4%	39,233	8.9%	5,104	9.3%	8,376	10.7%
3	155	1.3%	147	1.2%	7,579	1.8%	5,588	1.3%	429	0.8%	1,018	1.3%
4	161	1.3%	142	1.2%	3,349	0.8%	3,300	0.7%	202	0.4%	396	0.5%
Total	12,156		12,278		431,782		442,994		55,140		77,964	

Growth patterns are shown in TABLE 7. There is a general trend of economic growth in the larger metro areas and decline in the smaller areas (levels 3 and 4). The same pattern of positive growth for levels 1 and 2 and negative growth for levels 3 and 4 is observed for the two-digit transportation sector. The pattern is quite different for W&D: positive growth is observed in all but one cell for both establishments and jobs. The very large increase in jobs in level 3 is due to a particularly big change in Redding. The numbers in levels 3 and 4 are quite small and thus are less reliable. Also, other counties in the group (Chico and El Centro) had W&D job losses. Because levels 3 and 4 together account for less than 3% of W&D jobs, possible data problems should not affect our results. Detailed statistics at the metro level are available in Appendix B.

TABLE 7 Changes in establishments and jobs by metro level

Level	All businesses		Transportation		W&D	
	Est.	Jobs	Est.	Jobs	Est.	Jobs
1	7.4%	1.1%	15.0%	2.7%	28.8%	38.0%
2	1.8%	2.7%	5.4%	7.6%	15.1%	64.1%
3	-5.4%	-4.8%	-9.2%	-26.3%	25.0%	137.5%
4	-12.3%	-11.9%	-13.6%	-1.5%	0.0%	96.2%
Total	6.2%	1.0%	12.4%	2.6%	26.9%	41.4%

2.5.2 Concentration of the Warehousing Sector by Location Quotient

The Location Quotient (LQ) quantifies the spatial concentration of an industry in a region (Miller et al., 1991). LQ is the ratio of two shares: the share of employment in industry (i) in metro area (j) relative to total employment in metro area (j); and the share of employment in industry (i) in California relative to total California employment. It is calculated as follows:

$$LQ = \frac{(Emp_i/Emp)}{(EMP_i/EMP)} \qquad (1)$$

Where,
Emp_i = N of employment in industry (i) in metro area (j)
Emp = N of all employment in metro area (j)
EMP_i = N of employment in industry (i) in California
EMP = N of all employment in California

We present LQs at the four metro levels in TABLE 8. LQs of Level 1 are very close to one, because Level 1 accounts for approximately 87% the entire economy of California. For Level 2, the transportation sector is proportionately distributed, but the relative share of W&D increases. For Level 3, the transportation sector LQ declines, but the W&D LQ increases. All LQs are below one in Level 4, reflecting the smaller share of employment in these areas. FIGURE 3 maps the LQ in 2013 by MSA/MiSA/rural county. The highest relative concentration is in Bakersfield, Visalia, Modesto, and Redding. Detailed statistics at the metro level are available in Appendix C.

TABLE 8 LQs of transportation and W&D sectors in 2003 and 2013

Level	Transportation			W&D		
	2003	2013	% change	2003	2013	% change
1	1.00	1.00	0.0%	1.01	0.98	-2.5%
2	0.98	1.01	3.1%	1.08	1.23	14.1%
3	1.38	1.05	-23.7%	0.61	1.09	78.3%
4	0.59	0.64	10.1%	0.28	0.44	59.1%
Total	1.00	1.00		1.00	1.00	

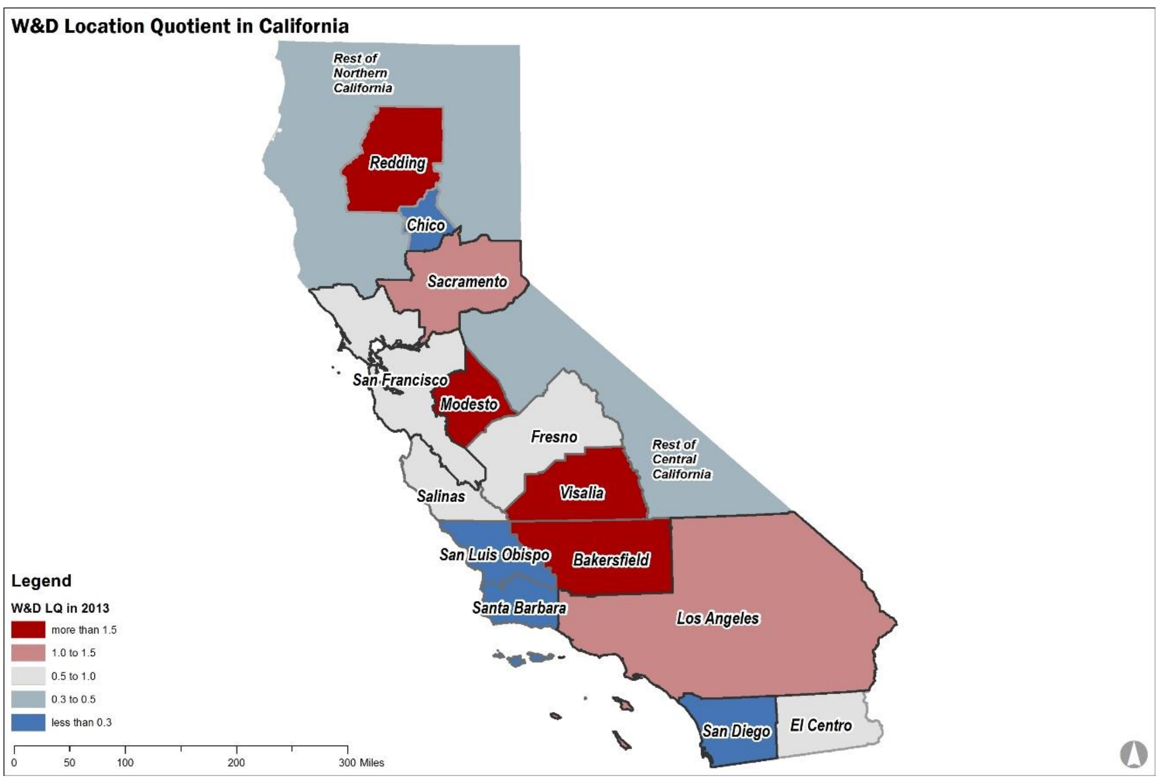

FIGURE 3 LQs of the W&D sector in 2013

2.6 Trends at the Sub-Metropolitan Level

2.6.1 Gain and Loss at the County-level

We present the gains and losses of W&Ds at the sub-metropolitan level. We first analyze distribution and trends at the county level and further explore them by each metro area at the ZIP Code level. We describe where W&D growth and decline have occurred.

The county level gains and losses in the number of W&D establishments are presented in FIGURE 4. Over the ten-year period, the number of W&Ds increased the most in the Los Angeles CSA; the Bakersfield, Visalia, and Salinas MSAs, and the outer counties of the Sacramento and San Francisco CSAs. The largest reductions occurred in the Fresno MSA and in one county of the San Francisco MSA. Counties with significant gains of W&Ds are generally near Los Angeles, San Francisco, and Sacramento where major freight infrastructure is located (See Part II). An important question for the state is whether W&D activity is moving from the major metro areas to outlying areas in response to land constraints, congestion, or other problems. FIGURE 4 lends some support for this possibility.

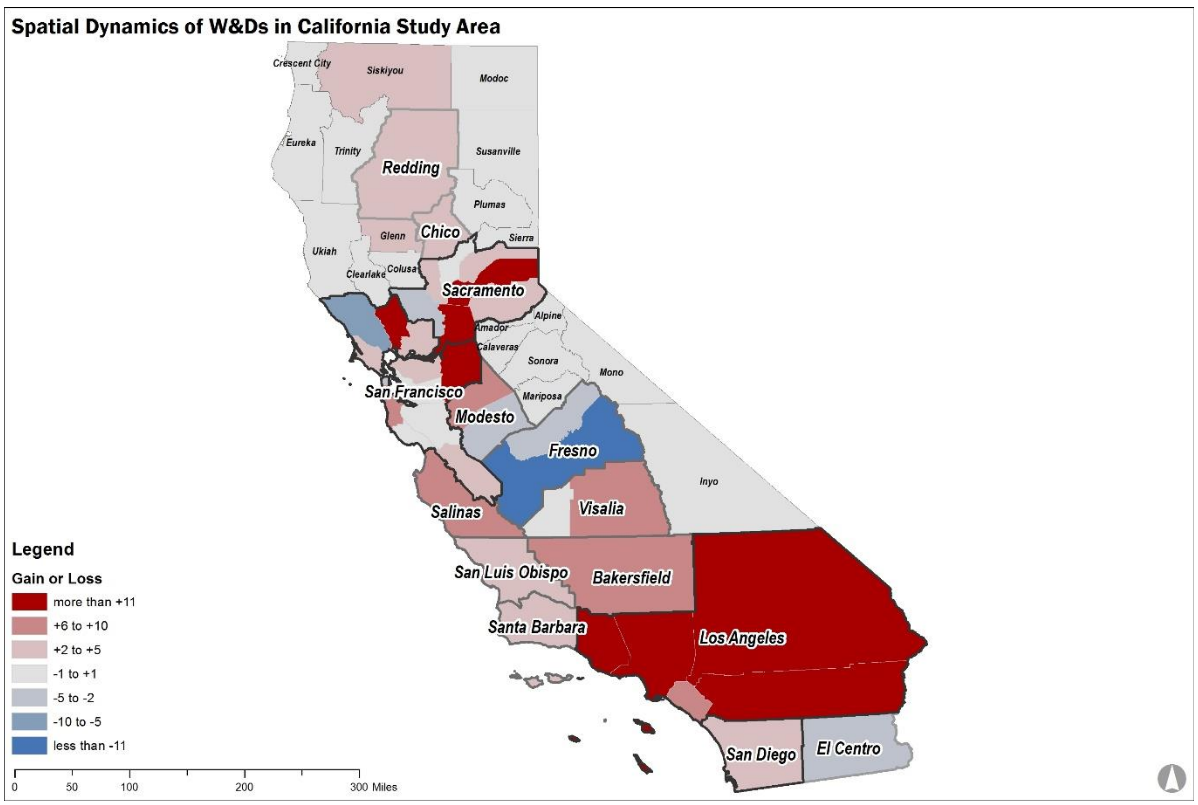

FIGURE 4 Gains and Losses of W&D establishments by county between 2003 and 2013

2.6.2 Gain and Loss at the ZIP Code-level

We now move to the ZIP Code level analysis. We present four sets of maps for the places in which W&D activity is present. Each set consists of two maps. The first map shows a cross-sectional view of the number of W&Ds by ZIP Code in 2003 and 2013. The location and number of W&D are presented at the centroid of the ZIP Code with a symbol. Solid orange dots represent W&Ds in 2003, and black circles represent W&Ds in 2013. The size of these symbols varies with respect to the number of W&Ds in the ZIP Code. The second map shows the difference in the number of W&Ds over the decade. Gains are in red circles, and losses in blue. We maintain the symbol size consistent across metro areas, so that the level of W&D activity is comparable. Note that the map scale differs across the figures.

FIGURE 5 and FIGURE 6 present W&D distribution in Los Angeles. The hot spots of W&D activities are port areas, industrial areas near central and downtown Los Angeles, the Inland Empire-Ontario area, and Moreno Valley. These locations, which are in proximity to the ports, rail-to-truck intermodal terminals, and Ontario airport, are also where the most gains occurred. In San Francisco, W&Ds are clustered around the narrow corridor of the bay area, due to physical constraints – the bay and hilly terrain. Gains occurred in Vallejo and Napa. In particular, gains in Stockton are significant, which is quite distant from the urban core of San Francisco. In Sacramento, many ZIP Codes throughout the central areas – adjacent to highways I-5, SR-99 and SR-50 – have gained W&Ds. The trend continues down to the northern part of Modesto. In San Diego, both W&D location and gains have been limited to areas near the coast and border. Lastly, FIGURE 11 and FIGURE 12 document significant gains in Visalia and losses in Fresno. However, as discussed, far fewer W&Ds are present in these areas.

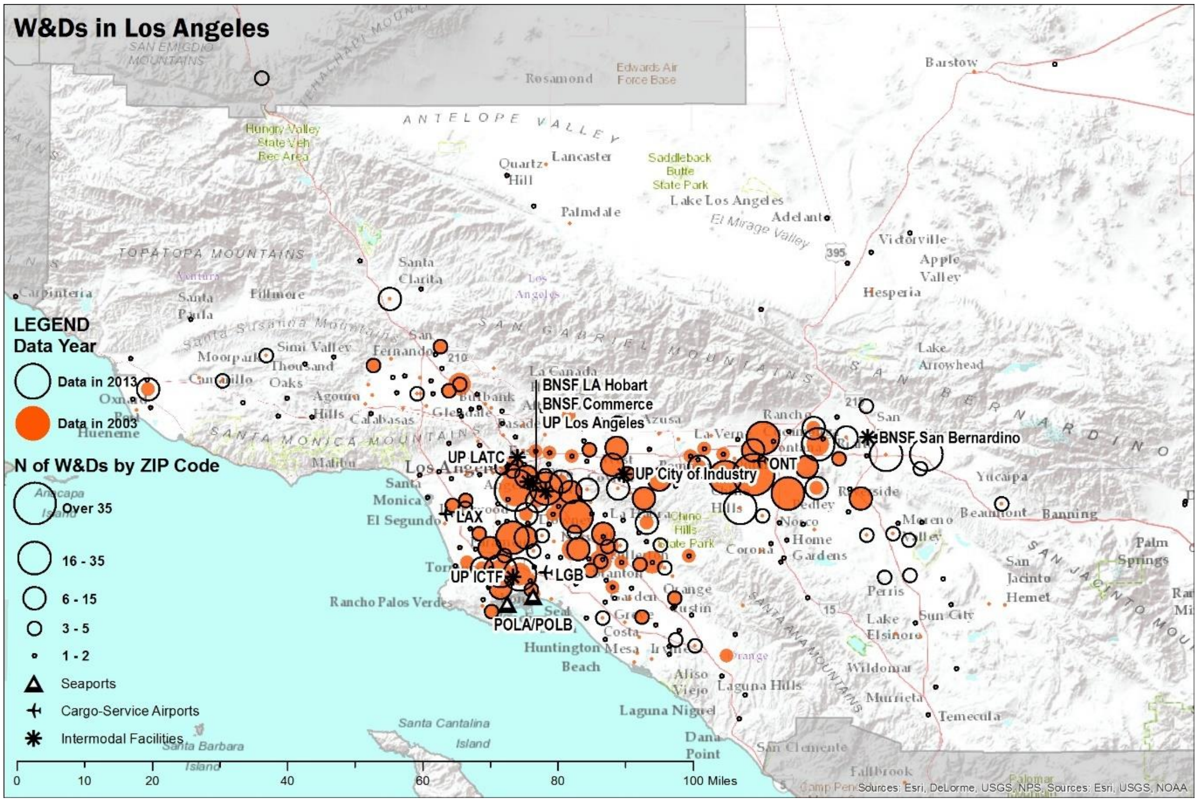

FIGURE 5 Distribution of W&Ds in 2003 and 2013 in Los Angeles

FIGURE 6 Gain and loss of W&Ds in Los Angeles

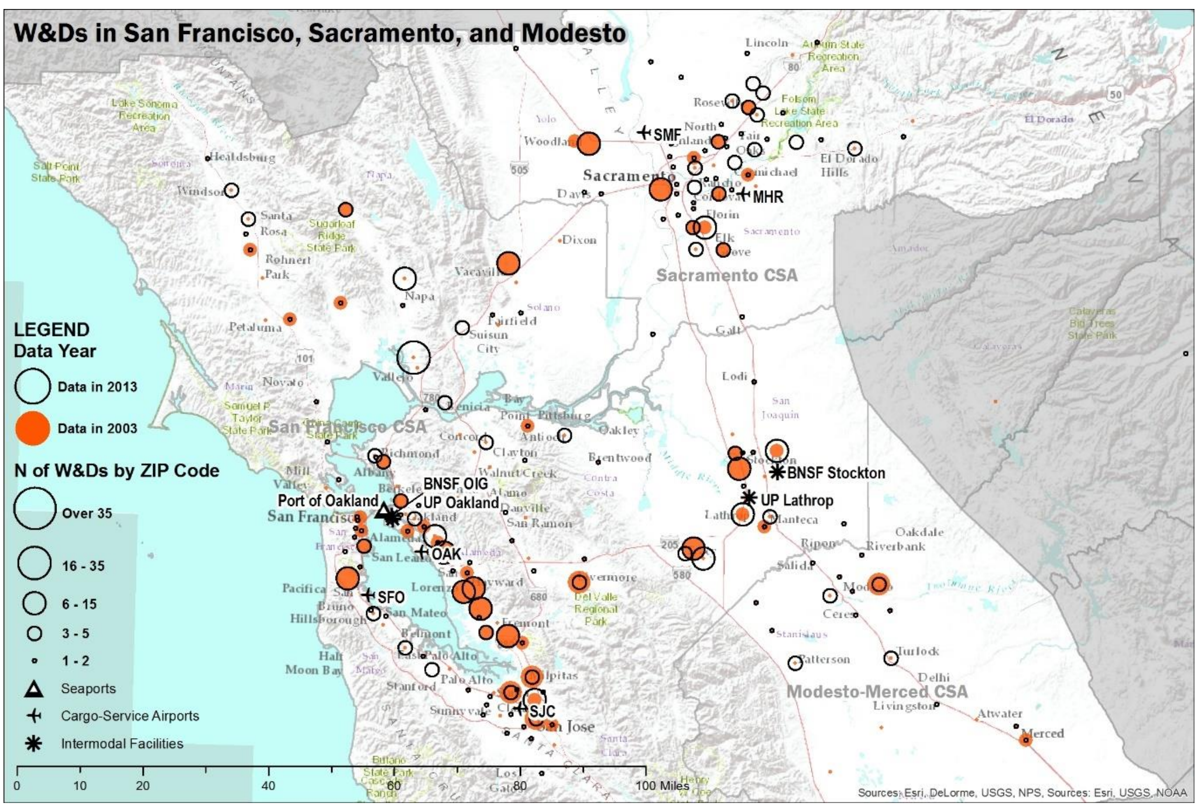

FIGURE 7 Distribution of W&Ds in 2003 and 2013 in San Francisco, Sacramento and Modesto

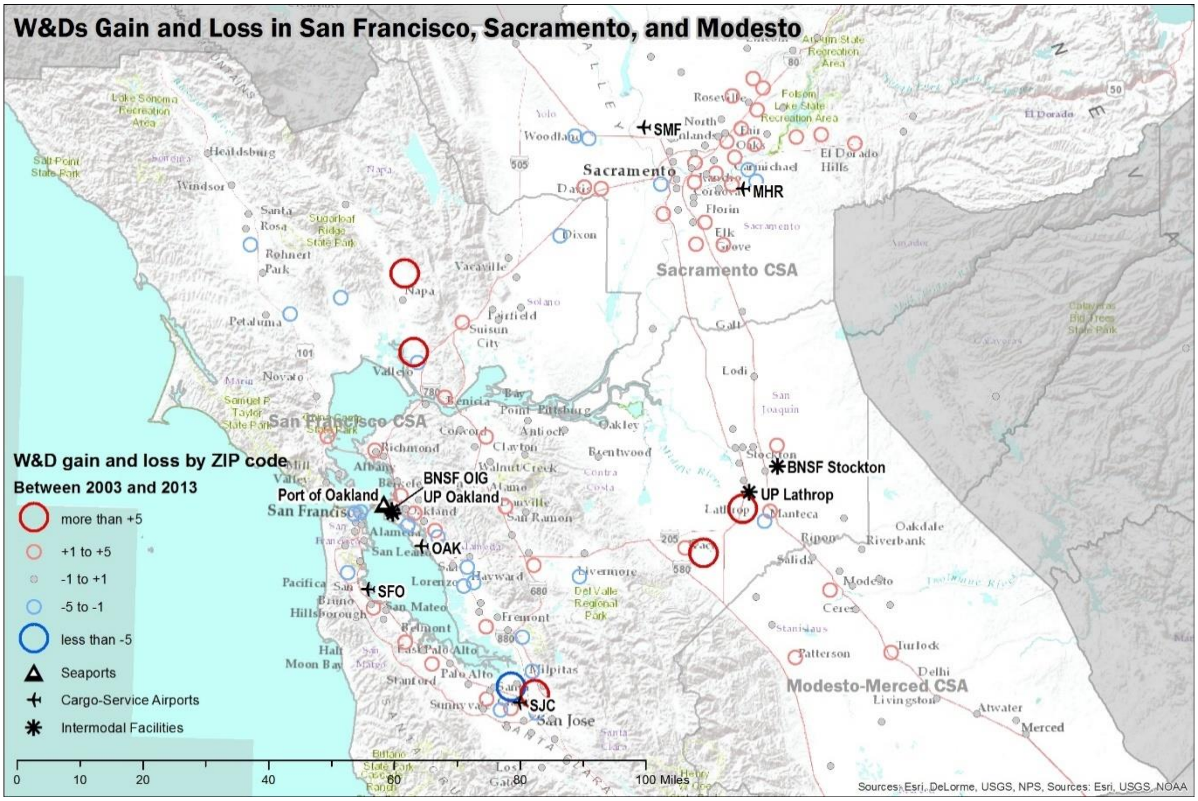

FIGURE 8 Gain and loss of W&Ds in San Francisco, Sacramento and Modesto

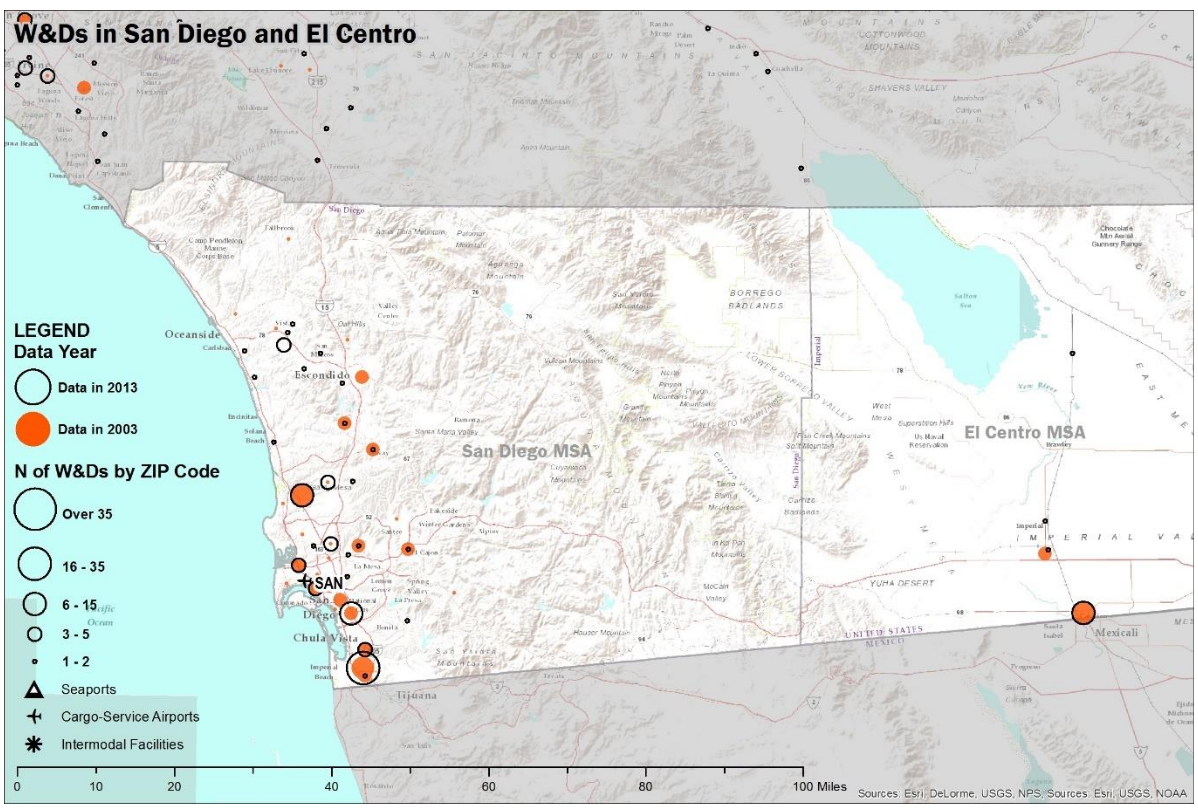

FIGURE 9 Distribution of W&Ds in 2003 and 2013 in San Diego and El Centro

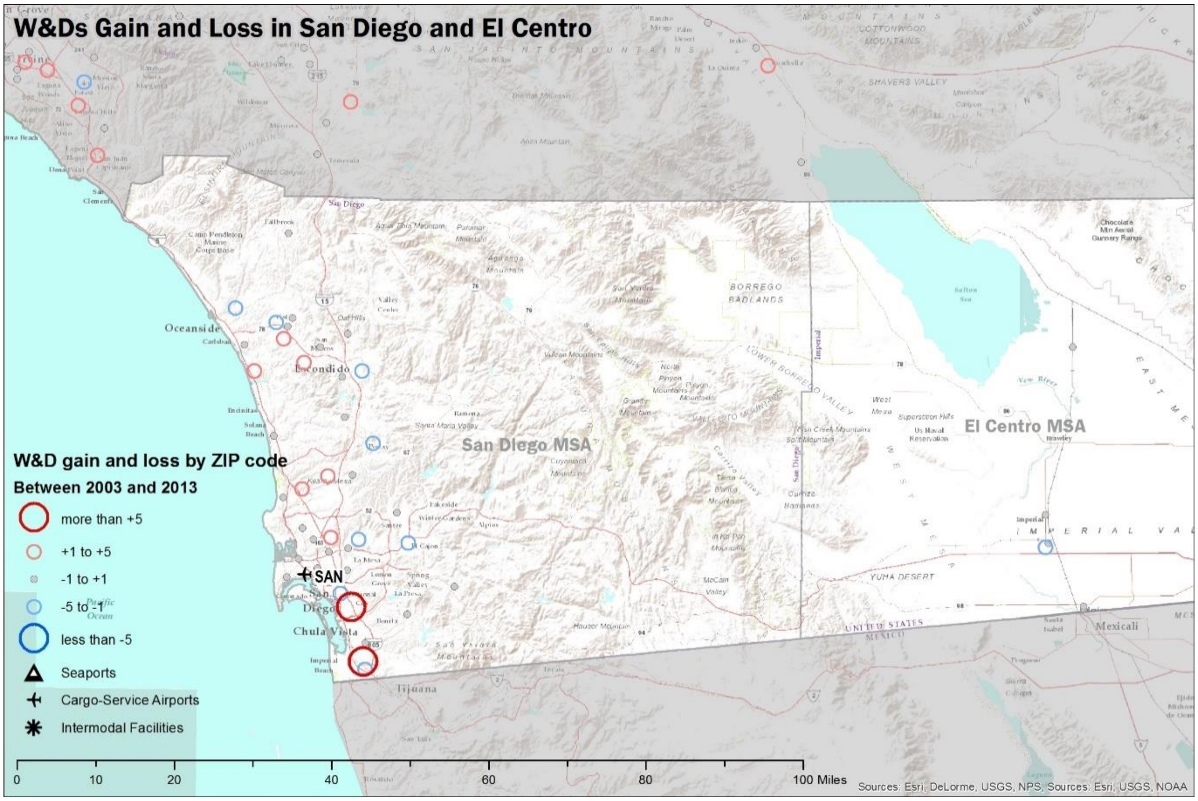

FIGURE 10 Gain and loss of W&Ds in San Diego and El Centro

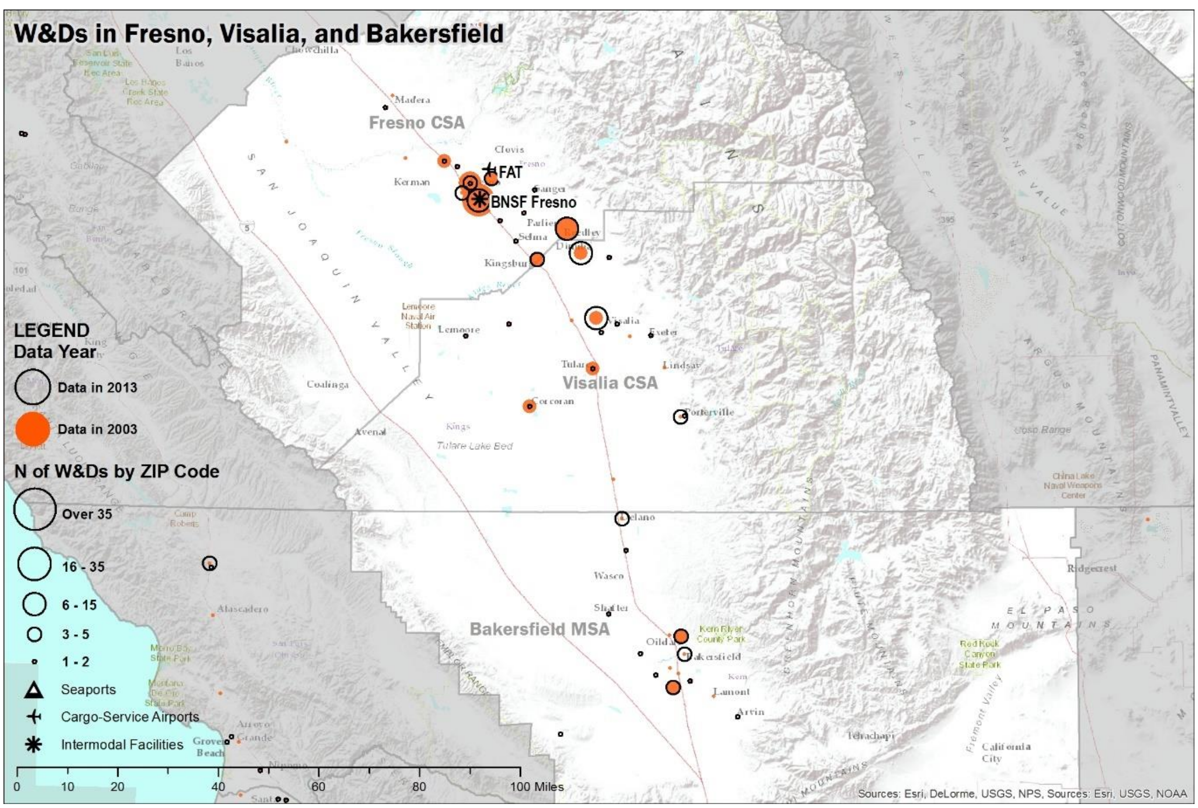

FIGURE 11 Distribution of W&Ds in 2003 and 2013 in Fresno, Visalia, and Bakersfield

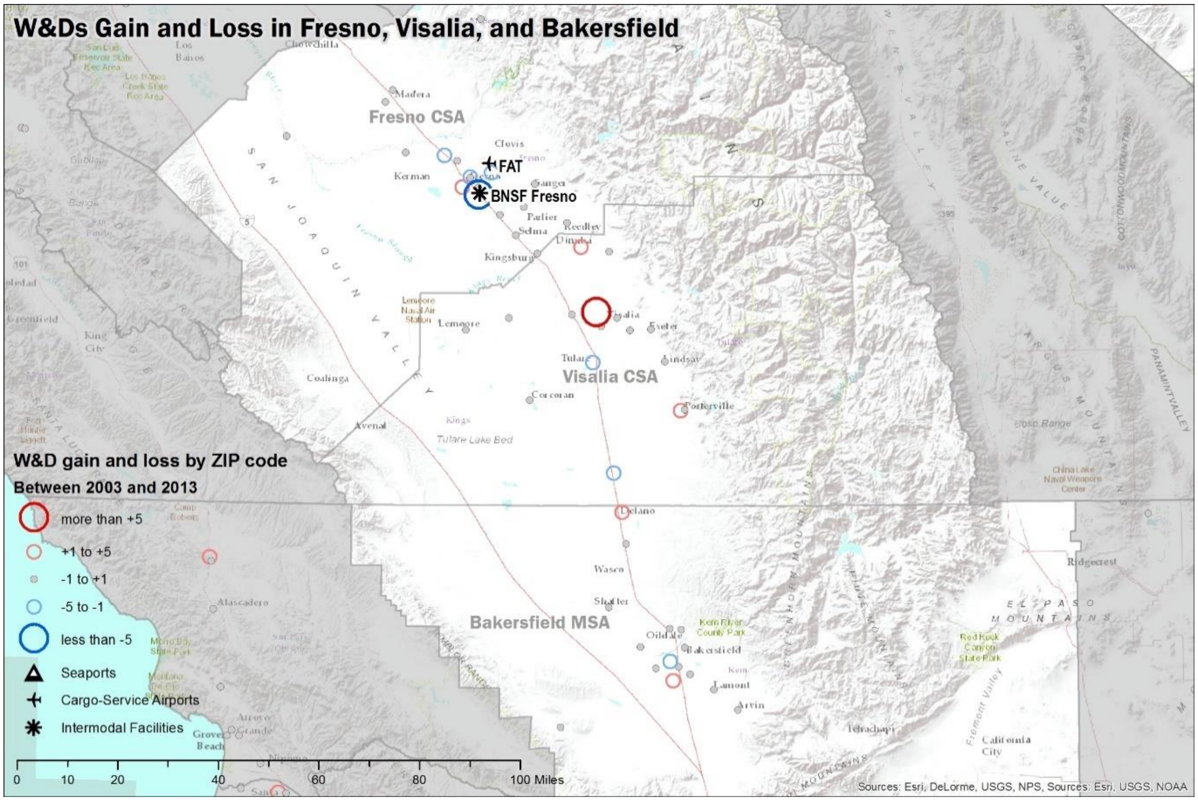

FIGURE 12 Gain and loss of W&Ds in Fresno, Visalia, and Bakersfield

2.6.3 Changes in W&D Distribution with respect to the Urban Center

Lastly we quantify the changes in W&D distribution patterns with a spatial measure. Giuliano, Kang and Yuan (2015) defined and tested multiple spatial measures to quantify changes in spatial patterns over time. The main discussion of the changes in W&D location has been about W&Ds' movement from the urban center to the outskirts (Aljohani and Thompson, 2016). Therefore, we use average distance from the central business district (CBD) to all W&Ds as our measure of change in spatial distribution. We calculate distance with respect to both establishments and employment. We define the CBD as the centroid of the ZIP Code with the highest employment density of a metro area, and we use Euclidean distance. We test whether changes from 2003 to 2013 are statistically significant via Welch's t-tests. Average distance to the CBD is calculated as follows:

$$W\&D\ distribution\ by\ average\ distance\ to\ the\ CBD = \frac{\sum_{j=1}^{N} d_j \times e_j}{E} \quad (2)$$

Where,

d_j = distance from the CBD to ZIP Code (j) (n; j = 1, 2, …, N)

e_j = number of W&D establishments or employment in ZIP Code (j)

E = sum of e_j

We show results only for the four largest metro areas (the Level 1 areas). The smaller metro areas have small numbers of W&Ds, hence small shifts (given that they are measured as ZIP code centroids) can lead to very large percentage changes. TABLE 9 presents results. A significant change in average distance with respect to establishments is observed for Los Angeles only: a 3.5-mile increase in distance from the CBD. When calculated with respect to employment, average distance increases significantly for all four metro areas. The 11-mile increase in Los Angeles is more than threefold more than the change in distance with respect to establishments. This is consistent with large W&Ds being built in the urban peripheries where land is cheaper and more available (Aljohani and Thompson, 2016). The average distance is the greatest for San Francisco and shortest for Sacramento and San Diego. In Giuliano, Kang, and Yuan (2016), the authors surmised that "the geography of San Francisco imposes more constraints on W&D location relative to the other metro areas" (pp. 23). Likewise, they noted that "the shorter average distances for Sacramento and San Diego are consistent with their smaller population size, and likely greater availability of land closer to the CBD than in the much larger CSAs" (pp. 23).

TABLE 9 Changes in average distance to the CBD between 2003 and 2013

Metro areas		Los Angeles	San Francisco*	Sacramento	San Diego
N of ZIP Codes with at least one W&D (in 2003/2013)		(218/239)	(87/91)	(33/59)	(33/27)
Average distance to the CBD Between 2003-2013	% change, W&D Establishment	14.2%	3.8%	4.6%	-4.6%
	2003-2013 (mile)	25.1 – 28.6	33.8 – 35.1	14.3 – 15.0	13.5 – 12.8
	% change, W&D Employment	43.0%	8.3%	4.6%	21.0%
	2003-2013 (mile)	25.3 – 36.1	41.4 – 44.8	13.2 – 13.8	8.6 – 10.4

*San Francisco excludes Santa Clara County

2.7 Conclusions

Our descriptive analysis leads to the following observations: 1) the W&D industry in California has grown much faster than the transport sector or the economy as a whole; 2) W&D activity is distributed approximately with the population and total employment; the four largest metro areas in California account for about 88% of all jobs and all W&D jobs; 3) at the metropolitan level the relative shares of W&D activity have been stable over the period; 4) there is some evidence of W&D activity moving away from the major metro areas to nearby smaller metro areas; 5) at the sub-metropolitan level we observe significant decentralization of W&D employment for the Level 1 metro areas, suggesting that larger facilities are locating further from the center. We conclude that W&D patterns across the state have remained stable over the 2003 -2013 decade, but within the largest metro areas, W&D activity location is shifting in response to land prices, possible development constraints, congestion, and other factors. Part II examines factors that may explain W&D location in California.

Part II Understanding Trends

The second part of our research addresses the question of how to explain the observed spatial patterns. As described in Part I, we use ZIP Code level data, 2003 and 2013, which gives numbers of establishments and employees by industry sector by ZIP Code. The ten-year period allows us to examine location changes over time. Because of the 2007 recession, we do not consider the intervening years.

3.1 Research Framework

Given that W&Ds are part of a profit maximizing supply chain, it follows that W&Ds, like other actors, will seek "productivity enhancing location attributes" (Sivitanidou, 1996, pp. 1262).[6] We assume that the observed W&D locations are a best proxy for optimal locations. Thus, we seek to explain why particular locations are attractive. Per the industrial location literature, important factors include land price, input costs (labor), transport costs, labor force access, market access and transportation access (Arauzo-Carod, et al. 2010). The general cross section model is:

$$W_i = f(L_i, M_i, A_i) \quad (3)$$

Where
W_i = Number of W&Ds in (i)
L_i = vector of local market attributes;
M_i = vector of regional market attributes;
A_i = vector of transport access measures;

We define the local market as the ZIP code. Factors that would affect location at the ZIP code level include land availability and price, as well as labor force access. Population or employment density serve as proxies for land price, per the standard urban economics approach (Anas and Arnott, 1998). Density also serves as a proxy to land constraints. Labor force access is measured as the inverse-distance weighted population within 10 miles of the ZIP code centroid.[7]

The regional market is the CSA or MiSA for the rural parts of the state. Locations in metro areas that have more related industries or potential customers should be preferred. Regional market attributes include access to suppliers and linked industries (manufacturing, wholesale, and transportation), as well as to customers. Access to customers can be proxied by the regional population. There are two ways to measure regional market effects. The first is to use regional dummy variables, which would capture the differences between regions, but not differences in

[6] W&Ds may or may not be built or owned by the firms that use them, but the principle holds in both cases. Firms that supply W&Ds would maximize profits by locating in places that are optimal for tenants.
[7] The average commute length is about 10 miles. See APPENDIX D for details on calculation of labor force access.

relative location within regions. The regional dummies should work for the smaller metro areas (there is little difference in relative location in a small metro area), but would not capture the potential importance of relative location in the largest metro areas. The second is to measure access with respect to the ZIP Code centroid (for example a distance weighted measure of access to linked industries with respect to each ZIP code) which would measure relative access within the region. However, our preliminary analysis revealed that all access variables are highly correlated with one another. Thus including all of them would lead to biased results. We therefore use a regional measure of the share of linked industry employment relative to all employment and an interaction variable to capture region-level effects.

The third group of variables measures transportation access. These include distance to nearest airport, intermodal terminal, port and distance to nearest highways. We use the Euclidean distance from the centroid of a ZIP Code.

It is possible that the relative importance of these factors changes over time. As a metro area grows, density and land prices increase. Thus, W&D location may shift to lower density locations, trading off labor force or intermodal access for lower land price. Even without metropolitan growth, if scale economies increase demand for larger facilities, a similar shift to lower density locations could occur. If supply chains are increasingly national in scope, then attributes of the regional market may become less important. This suggests that the coefficients on our independent variables are a function of the time period. If we observe changes in the coefficients, we have (indirect) evidence that external factors are affecting location choice. We test by estimating cross sectional models for 2003 and 2013 and formally testing for differences in coefficients between the time periods.

We have no priors regarding the temporal structure of independent variable effects. In our cross section estimations, we are assuming that effects are contemporaneous. However, it is possible that effects are lagged. Once W&Ds are built they remain in the stock for a long time, and markets may not be able to respond to shifts in demand immediately, given the length of the development process. We therefore also estimate a time series model.

3.2 Modeling approach

Our dependent variable is the number of W&Ds in a ZIP Code. There are, of course, many ZIP codes with no W&Ds; of the 1,644 ZIP codes in California, 998 do not have W&Ds in either 2003 or 2013. Thus the dependent variable is truncated at zero. For those with at least one W&D, the numbers are generally low. The average number of W&Ds per ZIP code is 3.09 in 2003 and 3.53 in 2013, and the median is 2 in both years. Thus, we cannot use the conventional OLS model.

3.2.1 Cross Section Models

We use two model forms for the cross section estimations. The first is a simple binomial logit model that estimates the probability (p) of a ZIP Code having at least one W&D:

The outcome variable (y) takes either 1 or 0 where, $y = \begin{cases} 1 \; with\; probability\; p \\ 0 \; with\; probability\; 1-p \end{cases}$

Then, the conditional probability (p) at location (i):

$$p_i \equiv Pr(y_i = 1 \mid X) = \Lambda(X'\beta) = \frac{e^{X'\beta}}{1+e^{X'\beta}} \qquad (4)^{8}$$

Where,
y_i= outcome variable at location (i)
X = vector of location factors with its systematic components (L_i, M_i, A_i)
$\Lambda(\cdot)$ = logit model with a cumulative distribution function
β = vector of parameters to estimate by maximum likelihood

Model 2 is a count data model. Count data models have been used extensively to examine location choices over a period of time (Arauzo-Carod, et al., 2010). Count data models estimate the effect of location characteristics on the conditional expectation of the number of firms established at that location, controlling for all other factors. We assume that the observed W&D locations are a best proxy for optimal locations. Thus we apply the same framework: the conditional expectation of the number of existing W&Ds at any time-period is a function of variation in location characteristics. This applies to both new and existing W&Ds. Existing W&Ds continuously make decisions to operate or close down. If not profitable to operate, the business would close down or relocate, exiting the economic census for that time period.

The general starting point of the count data model is the Poisson model where *equidispersion* is assumed; that is, the conditional mean (*$E(Y) = \mu$; e.g. vector of expected counts of W&Ds*) equals the conditional variance ($Var(Y) = \mu$). However, in applied studies, this assumption is usually violated. For example, the distribution of our dependent variable (count of W&Ds by ZIP Code) is skewed towards zero, since the majority of ZIP codes do not have W&Ds. To account for this unobserved heterogeneity, we use the negative binomial (NB) model.[9] The NB model replaces μ with μν, where ν is a random variable: $E(\nu) = 1$ and $Var(\nu) = \sigma^2$. Thus, the mean is preserved ($E(y) = \mu$), but the variance increases to ($Var(y) = \mu(1+ \mu\, \sigma^2)$). In this case, the variance ($Var(y)$) exceeds the mean ($E(y) = \mu$), hence is characterized by *overdispersion*. In the NB model, in particular, $\nu \sim$ Gamma (1, α), where α is the variance parameter. This NB model is denoted by NB (μ, α), and its probability mass function is:

$$Pr(Y = y|\mu, \alpha) = \frac{\Gamma(\alpha^{-1}+y)}{\Gamma(\alpha^{-1})\Gamma(y+1)}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu}\right)^{\alpha^{-1}}\left(\frac{\mu}{\mu+\alpha^{-1}}\right)^{y} \qquad (5)^{10}$$

Where,
y = count of W&Ds by ZIP Codes, which takes zero or positive integers

[8] Cameron and Trivedi (2009)
[9] There are various forms of the negative binomial. Since we have no priors on the most appropriate specification, we use the most general form.
[10] Cameron and Trivedi (2009)

α = the variance parameter (as $\alpha \longrightarrow 0$, the NB model reduces to the Poisson)
$\Gamma(\cdot)$ = Gamma integral "that specializes to a factorial for an integer argument"[11]
μ is parameterized as $e^{X'\beta}$ where X consists of systematic components (L_i, M_i, A_i), and β is estimated by maximum likelihood

3.2.2 Time series model

To test whether there is a lagged effect on W&D location, we estimate a first-order autoregressive model:

$$W_{i,t2} = f(L_{i,t1}, M_{i,t1}, A_{i,t1}) \qquad (6)$$

All terms are as defined as in equation (*3*). This model tests whether W&D locations in 2013 are a function of location characteristics in 2003. As with the cross-section models, we estimate both binary and a negative binomial models (Models 3 and 4). Note that in this formulation we cannot test for differences in effect across time periods, because we have only two time periods. Variables included in our models are listed in TABLE 10.

TABLE 10 Description of variables

Variables	Spatial Unit	Description
Dependent variable ($W_i^{t}, W_i^{t_2}$)		
Binary	ZIP Code	At least one W&D = 1, otherwise = 0
Count	ZIP Code	N of W&D est.; zero & positive integer values
Local market attributes (L_i)		
Population density	ZIP Code	Population/mile^2
Labor force access	ZIP Code	Sum of the population within 10 miles with an inverse distance weight
Regional market attributes (M_j)		
Share of linked industries	CSA/MSA/MiSA	Share of linked Industry employment in region total employment
Transport access measures (A_i)		
Distance to airport	ZIP Code	Miles to the nearest airport from centroid
Distance to seaport	ZIP Code	Miles to the nearest seaport from centroid
Distance to intermodal	ZIP Code	Miles to the nearest intermodal terminal from centroid
Distance to highway	ZIP Code	Miles to the nearest highway from centroid

[11] Cameron and Trivedi (2009), pp. 569

3.3 Data

3.3.1 Dependent Variable – binary likelihoods and counts of W&Ds

As noted above, the dependent variable is highly skewed, as the majority of ZIP codes do not have W&Ds. FIGURE 13 gives the cumulative frequency distribution including ZIP Codes with zero W&Ds for both 2003 and 2013. In each year, the majority of ZIP Codes did not have a W&D: 71.6% in 2003 and 69% in 2013. It is hard to distinguish in this figure, but the 2013 curve is slightly more spread-out than the 2003. TABLE 11 gives the number of ZIP Codes that have at least one W&D in 2003, 2013, and both years. It can be seen that even though the majority (61%) did not have a W&D in either year, there is still a fair amount of change in whether a ZIP Code had at least one W&D. Eight percent of all ZIP codes had a W&D in 2003 but not in 2013, and 11% had a W&D in 2013 but not 2003. Only 20% had at least one W&D in both years. The number of ZIP Codes across metro levels and metro areas is available in Appendix E.

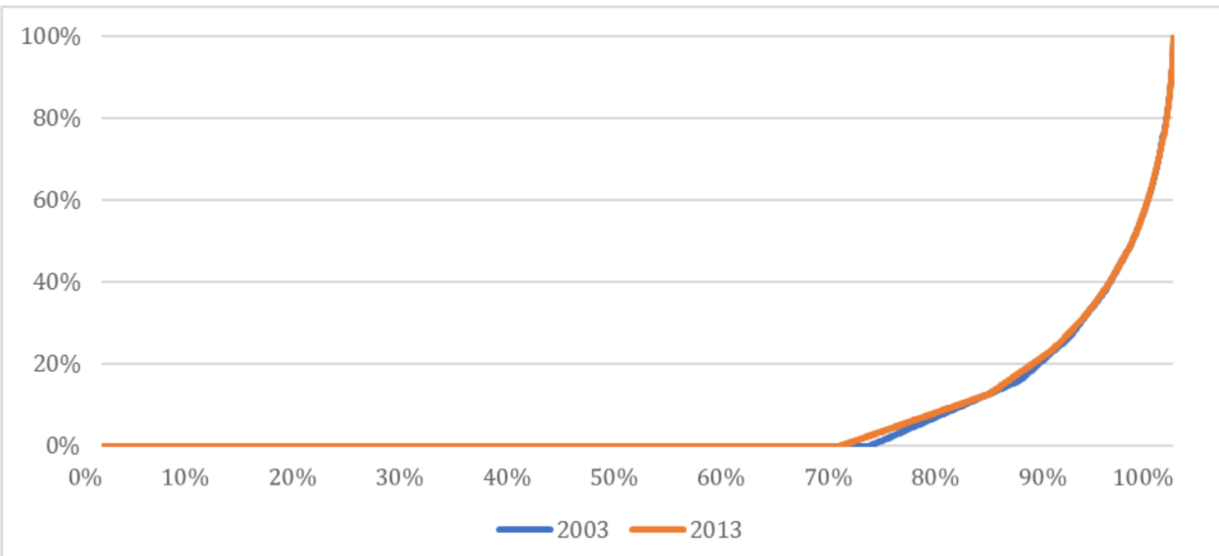

FIGURE 13 Cumulative distribution of W&Ds by ZIP Code, including zero, in 2003 and 2013

TABLE 11 ZIP Codes with at least one W&Ds

	No W&Ds in 2003	Yes, in 2003	Sum
No W&Ds in 2013	998 (61%)	135 (8%)	1,133 (69%)
Yes, in 2013	180 (11%)	331 (20%)	511 (31%)
Sum	1,178 (72%)	466 (28%)	1,644 (100%)

3.3.2 Explanatory Variables

3.3.2.1 Local market

We use employment density and labor force access by ZIP Code as zone-specific local market attributes. Summary statistics are given in TABLE 12. The mean values of 2003 and 2013 are not significantly different for either variable. Employment density has extremely large variation; this is due to the spatial concentration of employment. Labor force access variation, while large, is much less extreme, reflecting the relatively smoother spatial distribution of the population. The distribution of these variables is also skewed (the median is much smaller than the mean). Therefore, we use natural log forms of the variables.

TABLE 12 Summary statistics of population and employment density by ZIP Code

Variables	Mean	Median	SD	Min	Max
Employment Density 2003	2,458	184	17,009	0	527,901
Employment Density 2013	2,579	231	18,562	0	553,752
Labor force access 2003	109,850	49,833	138,071	0	628,324
Labor force access 2013	115,071	58,401	139,459	0	626,678

(People/mi^2)

3.3.2.2 Regional Market Attributes

Our measure for regional market attractiveness is the employment share of linked industry sectors – manufacturing, wholesaling, and transportation – relative to all employment in the region. Our data source is the Longitudinal Employer-Household Dynamics (LEHD) datasets published by the US Census Bureau.[12] TABLE 13 shows that the linked industry share declines across all metro areas from 2003 to 2013, likely due to industrial restructuring (decline of manufacturing and increase of technical and professional services). The group averages by level show that the shares are correlated with metro size. The only outlier is Modesto, with a 2013 share greater than that of Los Angeles.

[12] https://lehd.ces.census.gov/. We use LEHD because in the CBP data employment at the two-digit sector level is suppressed for many counties due to small numbers. Two-digit counts are given for all counties in LEHD.

TABLE 13 Regional share of linked industries in 2003 and 2013

Level	2003	2013	Metro area	2003	2013
1	19.4%	16.4%	Los Angeles	21.6%	18.0%
			San Francisco	18.5%	15.9%
			San Diego	14.5%	13.1%
			Sacramento	12.5%	9.7%
2	15.4%	13.4%	Fresno	15.7%	13.8%
			Bakersfield	17.5%	11.1%
			Modesto	20.4%	19.8%
			Visalia	14.9%	14.6%
			Santa Barbara	12.4%	11.1%
			Salinas	9.9%	8.4%
			San Luis Obispo	11.9%	11.2%
3	12.3%	10.2%	Redding	14.1%	11.9%
			Chico	10.6%	8.7%
			El Centro	11.7%	10.0%
4	10.7%	8.8%	Rest of Nor-Cal	12.0%	9.5%
			Rest of Cen-Cal	7.2%	7.0%

3.3.2.3 Transportation Access Measures

As transportation access measures, we use distance from the centroid of a ZIP Code to the closest major freight infrastructure – airport, seaport, intermodal terminal, and highways. For airports, we use the top 10 airports based on cargo volume.[13] For seaports, we use the Los Angeles/Long Beach and Oakland seaports, which together account for 75% of all seaport tonnage in California.[14] We use all the rail-truck intermodal terminals of the two Class 1 railroads, UP and BNSF.[15] For distance to the nearest highway, we use all interstate and state highways.[16] All access measures are based on the ZIP code centroids.

TABLE 14 presents summary statistics of the transport access measures. Average distances to airport, seaport and intermodal terminal are quite large, and all have large standard deviations. All are skewed by long tails due to the long distance of smaller metro and rural areas to major freight facilities. In contrast, almost all ZIP codes are close to a major highway. Because of the skewed distribution of these variables, we use the natural log form in our analysis. FIGUREs 14 and 15 map the state's access facilities used in our analysis. The differences in accessibility are obvious; facilities are concentrated in the greater Los Angeles and San Francisco regions, consistent with their dominant role in California's goods movement industry.

TABLE 14 Summary statistics of transportation access measures by ZIP Code (mile)

Variables	Mean	Median	SD	Min	Max

[13] Data source: Federal Aviation Administration annual enplanements and cargo tonnage, all airports, 2013
[14] Data source: https://www.marad.dot.gov/resources/data-statistics/
[15] Data source: https://www.up.com; http://www.bnsf.com/
[16] Data source: US Bureau of Census TIGER/Line files

Distance to airport	45.3	26.7	48.1	0.2	262.1
Distance to seaport	81.5	67.1	64.1	0.6	306.0
Distance to intermodal	57.6	39.3	58.4	0.4	302.2
Distance to highway	1.3	0.6	2.2	0.0	24.2

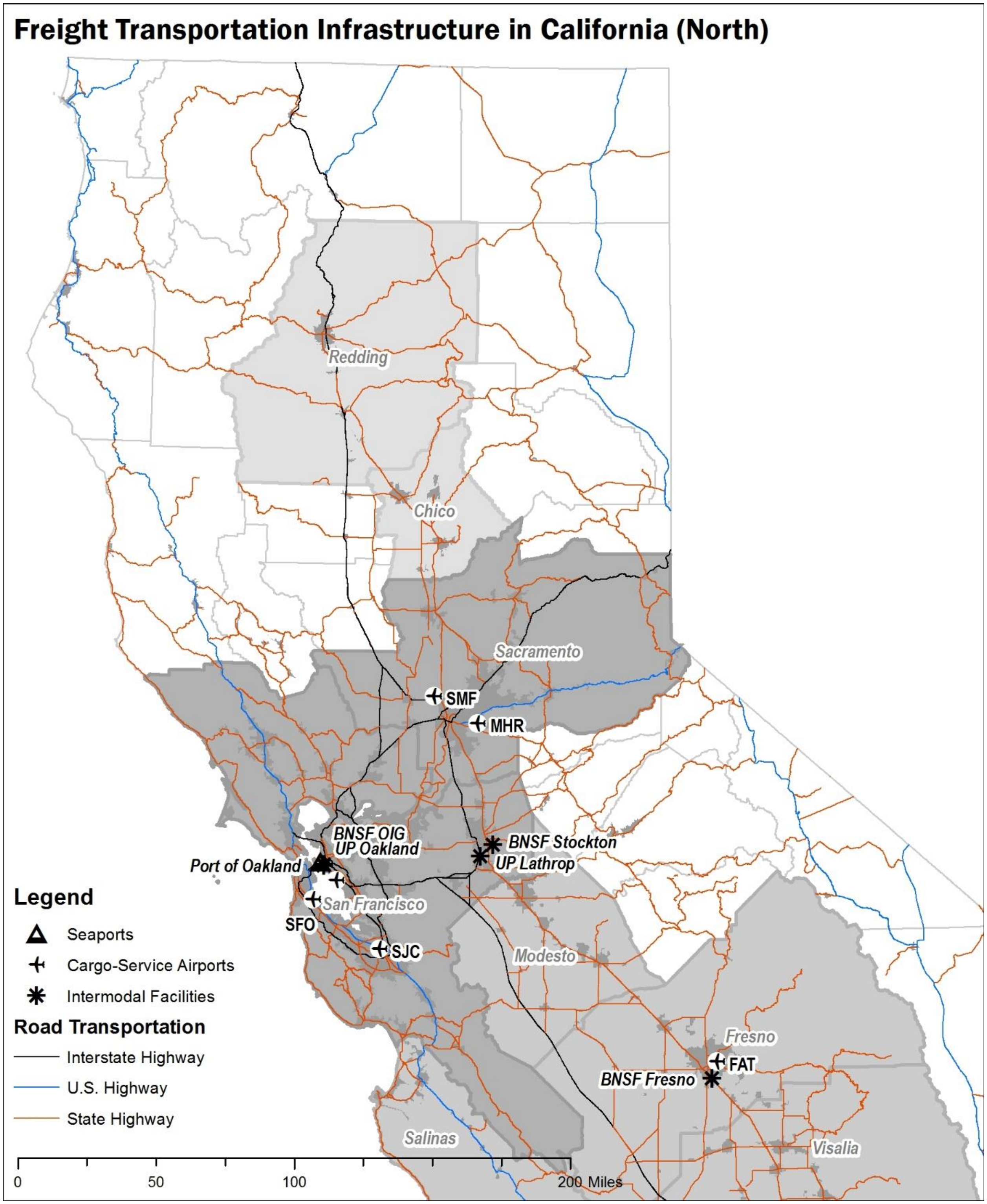

FIGURE 14 Freight infrastructure in California (North)

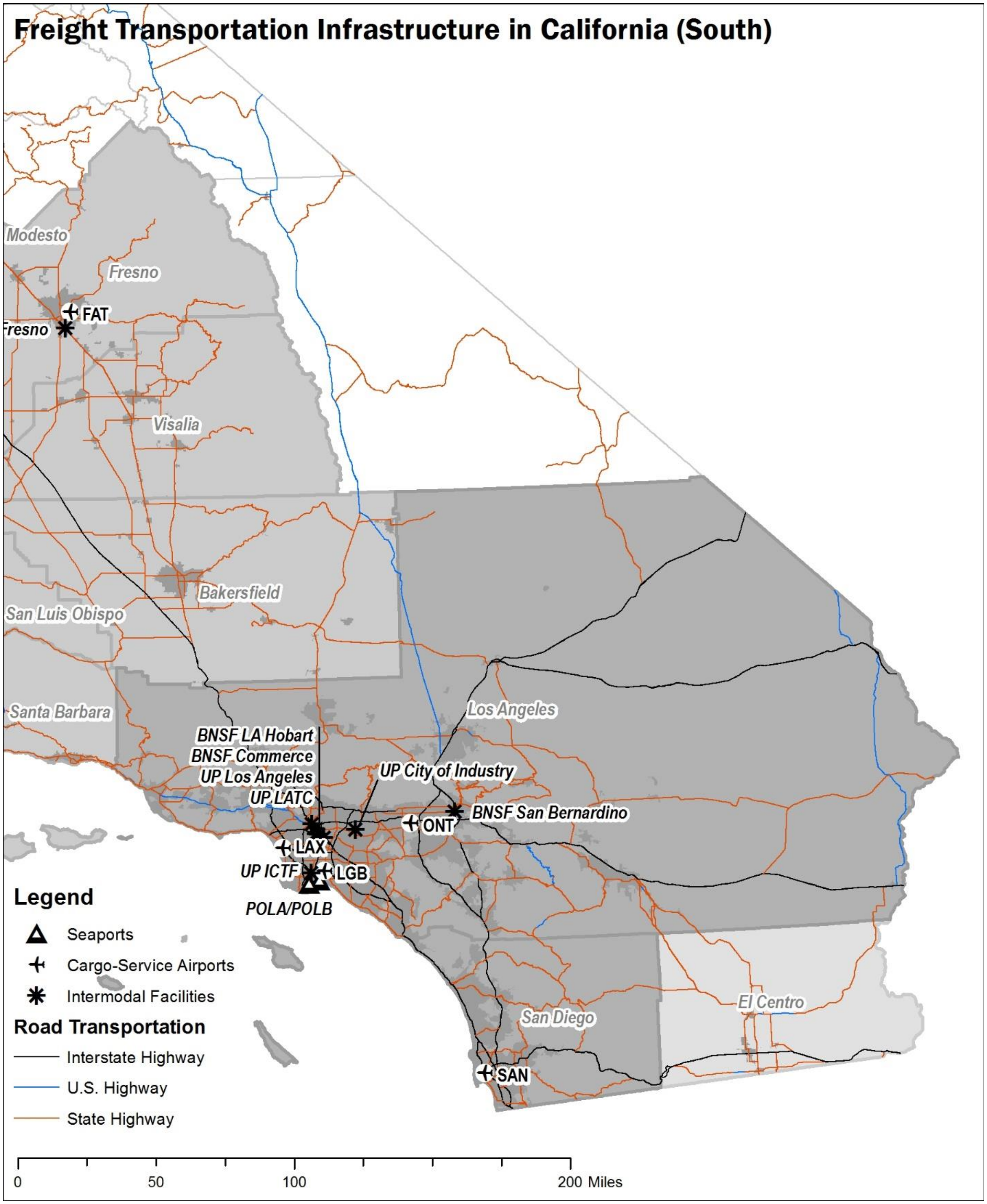

FIGURE 15 Freight infrastructure in California (South)

3.3.2.4 Distribution of W&Ds with respect to the distance to freight infrastructure

We present the count and share of W&Ds in proximity to the select freight infrastructure in 2003 and 2013. We delineate arbitrary thresholds of five miles for seaports, airports and intermodal terminals and one-mile for highways to get a sense of how close W&Ds are to major facilities. Results are presented in TABLE 15-18. For each table, only the metro areas that have at least one seaport, airport, or intermodal terminal are listed. Highways are common to all areas, and we provide results across our metro levels. It can be seen that the share of W&Ds near seaports and airports declines in all metro areas; over time, W&Ds are moving further away, consistent with the analysis presented in Part 1. In contrast, there is a slight increase in share located close to intermodal terminals. Given the strong economic linkages of W&D and intermodal transport, this makes sense. Note however the big difference in magnitude of the share across the three metro areas. Finally, the vast majority of W&D are located within one mile of a highway. This trend is stronger in Levels 3 and 4. W&Ds in these areas are likely oriented to local exports, for which access to the state highway system is critical.

TABLE 15 Share of W&Ds within 5 miles from the nearest seaport by metro area

Metro areas	5 miles from seaports			
	2003		2013	
	N	Share	N	Share
Los Angeles	42	5.4%	45	4.5%
San Francisco	14	5.4%	12	3.9%

TABLE 16 Share of W&Ds within 5 miles from the nearest airport by metro area

Metro areas	5 miles from airports			
	2003		2013	
	N	Share	N	Share
Los Angeles	157	20.3%	189	18.9%
San Francisco	36	14.0%	40	12.9%
San Diego	15	17.9%	9	10.5%
Sacramento	8	10.0%	8	5.6%
Fresno	11	21.2%	7	18.4%

TABLE 17 Share of W&Ds within 5 miles from the nearest intermodal terminal by metro area

Metro areas	5 miles from intermodal terminals			
	2003		2013	
	N	Share	N	Share
Los Angeles	214	27.6%	282	28.2%
San Francisco	36	14.0%	52	16.7%
Fresno	27	51.9%	21	55.3%

TABLE 18 Share of W&Ds within 1 mile from highways by metro area level

Level	1 mile from highways			
	2003		2013	
	N	Share	N	Share
1	846	70.7%	1,050	68.1%
2	125	82.2%	142	81.1%
3	20	83.3%	26	86.7%
4	17	89.5%	16	84.2%
Total	1,008	72.5%	1,234	69.9%

3.4 Results

In this section we present model results. We begin with the cross section models.

3.4.1 Model 1: Binary logit

We start with the simplest model, testing whether the presence of at least one W&D is related to local, regional, or transport access characteristics. We use two versions of the regional variables, one based on our metro area levels (Model 1a, TABLE 19), and the other on each metro area (Model 1b, TABLE 20). Each table gives the two cross-section regressions and the tests for differences in coefficients. We conducted stepwise estimations to test the significance of each group of variables; with the exception of the linked industry share variable, each group is significant in both time periods. See Appendix F for details.

Starting with local area characteristics, the coefficients for employment density and labor force access are positive and significant in most cases, as expected. Access variable coefficients are generally significant in Model 1a, but often with the wrong sign. In Model 1b, none of the access coefficients are significant for 2003; three are significant for 2013. The positive coefficients for distance to airport are consistent with the spatial distribution of W&Ds. Most of the State's major airports are located in densely developed areas. In addition, not all warehouses are oriented to international trade. Both of the seaport complexes are also located in the core of metro areas. Distance to intermodal and to highway have the expected signs.

We interpret the linked industry share coefficient in combination with metro area level interaction variables, since the linked industry share coefficient alone is not significant. In Model 1a, Level 4 is the base. It makes sense that all interaction coefficients are positive. The size of effect varies across metro area levels. The combined effect is not significant in Level 1 ($7.534 - 7.790 \cong 0$) and in Level 2 ($8.929 - 7.790 \cong 0$), whereas, in Level 3, it is positive and significant. In Model 1b, MiSAs and rural counties in Level 4 are the base. There is a fair amount of variation in metro area interaction coefficients. Relative to Level 4 in 2013, the combined effect is significantly smaller in Los Angeles, San Francisco, San Diego, Fresno, and Modesto.

Our last test is whether the influence of local market, regional market, or transport access characteristics changes from 2003 to 2013. The last column of each table gives the results of testing for significant differences in the value of the coefficients. It can be seen that there are many significant differences. In local market attributes, as expected, the effect of employment density (land rent and local market demand) decreased. As W&Ds have decentralized to the urban periphery, the variation in employment density within chosen locations would decrease. The influence of labor force access increased, which is consistent with the recent literature that automation in W&D technology requires skilled rather than the unskilled labor (Jacubicek and Woudsma, 2011). It also makes sense that as location choice shifts away from more developed areas, labor force access would become a more important consideration.

The changes in transportation access variables are mixed. The share of linked industry with metro area dummies changed significantly over time (Model 1b), whereas the variation was not captured in Model 1a in Level 1. The increase was most pronounced in Sacramento, Salinas, Chico, and El Centro.

TABLE 19 Model 1a with metro area level variables

Dependent variables	Binary likelihood of W&D (Logit)				Hypothesis test
Independent variables	2003		2013		H_0: $\beta_{j,M1-1} = \beta_{j,M1-2}$
	Coefficient	Sig.	Coefficient	Sig.	If rejected w/ sig.
Employment density	0.248	*	0.142	*	* / ⇘
Labor force access	0.262		0.378	*	* / ⇗
Distance to airport	0.202	*	0.278	*	
Distance to seaport	0.339	*	0.366	*	
Distance to intermodal	-0.173	*	-0.296	*	* / ⇘
Distance to highway	-0.409	*	-0.349	*	
Share of linked industry	0.117		-7.790	*	Combined coefficient
Share * Level dummies					(Share + interaction)
Level 1	1.180		7.534	*	
Level 2	4.379	*	8.929	*	* / ⇘
Level 3	4.599	*	17.048	*	* / ⇗
Level 4 (base)	-		-		
Constant	-6.527	*	-6.716	*	
N	1644		1644		
Log Likelihood	-827.3		-865.5		

P (* <0.1)

TABLE 20 Model 1b with metro-area variables

Dependent variables	Binary likelihood of W&D (Logit)				Hypothesis test
Independent variables	In 2003		In 2013		$H_0: \beta_{j,M3-1} = \beta_{j,M3-2}$
	Coefficient	Sig.	Coefficient	Sig.	If rejected w/ sig.
Employment density	0.262	*	0.167	*	* / ⇘
Labor force access	0.262	*	0.386	*	* / ⇗
Distance to airport	0.219		0.163		
Distance to seaport	0.314		0.455	*	* / ⇗
Distance to intermodal	-0.180		-0.264	*	
Distance to highway	-0.389		-0.334	*	
Share of linked industry	4.429	*	18.778	*	Combined coefficient
Share * Metro area dummies					(Share + interaction)
Los Angeles	-1.633		-7.356	*	* / ⇗
San Francisco	-1.079		-5.606	*	* / ⇗
San Diego	0.234		-6.765	*	* / ⇗
Sacramento	2.093		13.439	*	* / ⇗
Fresno	0.768		-8.447	*	* / ⇗
Bakersfield	2.199	*	6.118	*	* / ⇗
Modesto	2.763	*	-5.124	*	* / ⇗
Visalia	8.414	*	0.944		* / ⇗
Santa Barbara	2.180		4.231	*	* / ⇗
Salinas	2.478		12.792	*	* / ⇗
San Luis Obispo	1.757		-2.281		* / ⇗
Redding	-0.606		6.170	*	* / ⇗
Chico	6.084	*	18.852	*	* / ⇗
El Centro	10.859	*	17.561	*	* / ⇗
Level 4 MiSA and rural (base)	-		-		
Constant	-6.957	*	-9.242	*	
N	1644		1644		
Log Likelihood	-822.7		-848.8		

P (* <0.1)

3.4.2 Model 2: Negative Binomial

The negative binomial model estimates the probability of a specific integer number of W&Ds in each ZIP code. As noted above, we use the negative binomial form because of the truncated and skewed distribution of the dependent variable. We again estimate two versions, one with our metro level category interaction dummies (Model 2a, TABLE 21), and one with metropolitan interaction dummies (Model 2b, TABLE 22). Each table gives the two cross-section regressions and the tests for differences in coefficients. Again we conducted stepwise estimations to test the significance of each group of variables; each group is significant in both time periods, except for the share of linked industry. See Appendix F for details.

In the count models the coefficients for employment density and labor force access are positive as expected and mostly significant. It is notable that the coefficient for employment density decreases over time but increases for labor force access. This is consistent with W&D decentralization; as W&Ds locate in less developed areas, labor force access becomes more important. Among the transport access variables, all but distance to seaport have the theoretically expected signs and are mostly significant. The binary model cannot distinguish between ZIP Codes with many W&Ds and those with just a few. The difference in airport access coefficients may be due to more W&Ds being located in the largest metro area where there are multiple airports. The effect of share of linked industry is consistent with the previous models; it is significant only with the location interaction dummy variables. All but one of the interaction dummy coefficients are significant in Model 2b. Effects are smaller in Los Angeles, San Francisco, San Diego, Fresno, Modesto, and Visalia where we documented W&D expansion in the previous chapters, and larger in Salinas, Chico, and El Centro.

TABLE 21 Model 2a with metro area level variables

Dependent variable	Count of W&Ds (Negative binomial)				Hypothesis test
Independent variables	In 2003		In 2013		$H_0: \beta_{j,M3-1} = \beta_{j,M3-2}$
	Coefficient	Sig.	Coefficient	Sig.	If rejected w/ sig.
Employment density	0.232	*	0.121	*	* / ⇘
Labor force access	0.210		0.308	*	* / ⇗
Distance to airport	-0.291	*	-0.206		
Distance to seaport	0.470	*	0.522	*	
Distance to intermodal	-0.293	*	-0.409	*	
Distance to highway	-0.449	*	-0.360	*	
Share of linked industry	1.874	*	-1.081		Combined coefficient
Share * Level dummies					(Share + interaction)
Level 1	-1.765		1.595		
Level 2	0.363		2.409	*	* / ⇗
Level 3	5.020	*	9.815	*	* / ⇗
Level 4 (base)	-		-		
Constant	-3.718	*	-4.046	*	
Log Alpha	1.142	*	1.217	*	
N	1644		1644		
Log Likelihood	-827.3		-865.5		

P (* <0.1)

TABLE 22 Model 2b with metro area variables

Dependent variables	Count of W&Ds (Negative binomial)				Hypothesis test
Independent variables	In 2003		In 2013		$H_0: \beta_{j,M4-1} = \beta_{j,M4-2}$
	Coefficient	Sig.	Coefficient	Sig.	If rejected w/ sig.
Employment density	0.230	*	0.117	*	* / ⇘
Labor force access	0.209		0.301	*	* / ⇗
Distance to airport	-0.378		-0.361		
Distance to seaport	0.593	*	0.761	*	* / ⇗
Distance to intermodal	-0.376	*	-0.550	*	* / ⇘
Distance to highway	-0.354		-0.256		
Share of linked industry	19.406	*	53.762	*	Combined coefficient
Share * Metro area dummies					(Share + interaction)
Los Angeles	-11.240	*	-27.262	*	* / ⇗
San Francisco	-8.685	*	-22.424	*	* / ⇗
San Diego	-8.769	*	-20.111	*	* / ⇗
Sacramento	-6.186	*	-2.991		* / ⇗
Fresno	-11.456	*	-31.677	*	* / ⇗
Bakersfield	-5.467	*	-2.930	*	* / ⇗
Modesto	-7.465	*	-28.029	*	* / ⇗
Visalia	-2.682	*	-19.691	*	* / ⇗
Santa Barbara	-1.642		-6.801	*	* / ⇗
Salinas	3.862	*	12.015	*	* / ⇗
San Luis Obispo	-3.782		-9.570	*	* / ⇗
Redding	-6.953	*	-6.747	*	* / ⇗
Chico	1.870		9.663	*	* / ⇗
El Centro	13.126	*	9.937	*	* / ⇗
Level 4 MiSA and rural (base)	-		-		
Constant	-5.472	*	-8.741	*	
Log Alpha	1.107	*	1.162	*	
N	1644		1644		
Log Likelihood	-1659.0		-1858.4		

P (* <0.1)

3.4.3 Models 3 and 4: first-order autoregressive models

We present the results of first-order autoregressive models in TABLEs 23-24. In this case our dependent variable is number of W&Ds in 2013, and our independent variables are as of 2003. As noted earlier, the employment density, labor force access, and transport access variables do not change much between the two time periods. Thus results should be quite similar to the cross-section results.

Results are mostly consistent with the cross-section models. Employment density and labor force access coefficients are positive and mostly significant. Transport access variable coefficients are also mostly consistent. Only the airport access variable coefficients are not significant. When we use metropolitan area specific interaction dummies, the significance level of intermodal and highway access coefficients tends to drop. The linked industry share variable coefficient of Model 3a and 4a with metro level dummies is similar to Models 1 and 2 in that regional market effects are pronounced in Level 2 and 3. When metro-area dummies are used (Model 3b and 4b), the coefficient significance decreases, but the models consistently pick up the metro areas with significant variations of the regional market effect from the base (Level 4 metro areas). For example, Model 3b captured Sacramento, Salinas, Chico, and El Centro – consistent with Model 1b. Model 4b captured Los Angeles (-), San Diego (-), Fresno (-), Salinas (+), and El Centro (+). The consistency of the cross-section and lagged models suggests that the underlying dynamics of W&D location have not changed much over the 2003-2013 period.

TABLE 23 Model 3a with metro area level variables

Dependent variables	Binary likelihood of W&Ds (Logit)	
Independent variables	In 2013	
	Coefficient	Sig.
Employment density	0.127	*
Labor force access	0.352	*
Distance to airport	0.238	
Distance to seaport	0.374	*
Distance to intermodal	-0.270	*
Distance to highway	-0.349	*
Share of linked industry	-4.743	*
Share * Level dummies		
Level 1	6.444	*
Level 2	7.727	*
Level 3	14.248	*
Level 4 (base)	-	
Constant	-6.644	*
N	1644	
Log Likelihood	-872.6	

P (* <0.1)

TABLE 24 Model 3b with metro area variables

Dependent variables	Binary likelihood of W&Ds (Logit)	
Independent variables	In 2013	
	Coefficient	Sig.
Employment density	0.144	*
Labor force access	0.37	*
Distance to airport	0.135	
Distance to seaport	0.453	*
Distance to intermodal	-0.269	*
Distance to highway	-0.342	*
Share of linked industry	10.084	
Share * Metro area dummies		
Los Angeles	-2.539	
San Francisco	-1.227	
San Diego	-2.078	
Sacramento	11.110	*
Fresno	-3.996	
Bakersfield	3.289	
Modesto	0.912	
Visalia	6.031	
Santa Barbara	6.580	
Salinas	11.560	*
San Luis Obispo	1.662	
Redding	7.209	
Chico	16.035	*
El Centro	17.079	*
Level 4 MiSA and rural (base)	-	
Constant	-8.323	*
N		
Log Likelihood	1644	

P (* <0.1)

TABLE 25 Model 4a with metro area level variables

Dependent variables	Count of W&Ds (Negative binomial)	
Independent variables	In 2013	
	Coefficient	Sig.
Employment density	0.096	*
Labor force access	0.298	*
Distance to airport	-0.241	
Distance to seaport	0.540	*
Distance to intermodal	-0.384	*
Distance to highway	-0.379	*
Share of linked industry	0.939	
Share * Level dummies		
Level 1	1.521	
Level 2	2.260	*
Level 3	8.357	*
Level 4 (base)	-	
Constant	-4.150	*
Log Alpha	1.229	*
N	1644	
Log Likelihood	-1878.8	

P (* <0.1)

TABLE 26 Model 4b with metro area variables

Dependent variables	Count of W&Ds (Negative binomial)	
Independent variables	In 2013	
	Coefficient	Sig.
Employment density	0.085	*
Labor force access	0.297	*
Distance to airport	-0.385	*
Distance to seaport	0.767	*
Distance to intermodal	-0.560	*
Distance to highway	-0.275	*
Share of linked industry	28.459	*
Share * Metro area dummies		
Los Angeles	-13.393	*
San Francisco	-9.869	
San Diego	-8.277	*
Sacramento	-1.579	
Fresno	-19.339	*
Bakersfield	-5.174	
Modesto	-11.275	
Visalia	-5.620	
Santa Barbara	0.767	
Salinas	10.903	*
San Luis Obispo	0.063	
Redding	-0.275	
Chico	8.574	
El Centro	12.462	*
Level 4 MiSA and rural (base)	-	
Constant	-6.825	*
Log Alpha	1.173	*
N	1644	
Log Likelihood	-1863.1	

P (* <0.1)

3.5 Summary of Results

We evaluate the binary likelihood (logit) and count (NB) of W&Ds at the ZIP Code level using local market, transport access, regional market, and regional dummy variables with cross-sectional and first-order autoregressive models. We summarize our results as follows. First, regarding model specifications, the NB specification performs better than the simple binomial. The NB model better reflects the variation in the dependent variable (e.g. the differences in the total number of W&D across ZIP codes). Second, the correlation between employment density and W&D activity decreased significantly over the decade, whereas the effect of labor force access is consistently significant throughout the period. W&Ds have decentralized to the urban peripheries where land is cheap and more available, yet still prioritize access to labor pools. Third, W&D are more likely to be located in proximity to intermodal terminals and highways and farther from seaports. The effect of airports varies across model specifications. Proximity to intermodal terminals reflects strong inter-industry linkages. Access to major highways is always important, and particularly so in small metro and rural areas. Fourth, the signs and significance of regional market attributes – the share of linked industry at the regional level – are consistent across model specifications but vary across the model years and metro areas. W&D locations in the largest metro areas (Level 1) are relatively less influenced by regional effects, perhaps because the two largest metros account for such a large share of all ZIP codes. Lastly, the first-order autoregressive model suggests that the influence of our explanatory variables is rather consistent over time. It is notable that local market variables barely changed. The correlation between 2003 and 2013 is 0.989 for employment density and 0.999 for labor force access. In addition, the location of transportation infrastructure is fixed. Thus the most likely source of lagged influence is the unique circumstances of specific metro areas. Given that far fewer of the interaction dummy coefficients are significant compared to the differences observed in the cross-section models, we surmise that a 10-year lag has little influence. That is, responses to changing market conditions take place much more quickly.

Conclusions

The purpose of this research has been to document and analyze the location patterns of warehousing and distribution activity in California. Although the warehousing sector constitutes less than 1% of all jobs in the state, it is a critical part of the state's freight sector. The warehousing sector has grown much faster than the transportation sector or the economy as a whole. The growth of California's warehousing and distribution (W&D) activities and their spatial patterns are being affected by several factors, including population and economic growth, shifting supply chains and distribution practices, scale economies in warehousing, and the state's role in international and domestic trade. The location of W&D activities has implications for freight demand and flows, and thus is a critical element in statewide transportation planning.

We conducted our research in two parts. First, we conducted a descriptive analysis of W&D trends from 2003 – 2013 using Zip Code Business Pattern data. We find that: 1) W&D activity is distributed approximately with the population and total employment; the four largest metro areas in California account for about 88% of all jobs and all W&D jobs; 2) at the metropolitan level the relative shares of W&D activity have been stable over the period; 3) there is some evidence of W&D activity moving away from the major metro areas to nearby smaller metro areas; 4) at the sub-metropolitan level we observe significant decentralization of W&D employment for the four largest metro areas, suggesting that larger facilities are locating further from the center.

The second part of the research examines possible explanatory factors associated with W&D location trends. We test the effects of local factors (employment density and labor force access), regional factors (linked industry share), and transportation access factors. We examine changes between 2003 and 2013 in two ways. First, we estimate cross-sectional models and test for differences between coefficients. Second, we estimate a time series model and test coefficients directly. Our findings may be summarized as follows: 1) there is some churning in W&D location over the period; while about 30% of ZIP codes have at least one W&D in 2003 or 2013, only 20% had at least one in both 2003 and 2013; 2) local access variables have the expected effect, but the effect of employment density declines and the effect of labor force access increases, consistent with decentralization trends at the sub-metropolitan level; 3) the effect of access varies by transport facility; W&Ds tend to locate away from seaports and airports, but closer to intermodal terminals and highways; 4) linked industry share is significant only jointly with metro level interaction dummy variables and tends to be of greater magnitude for mid-size metro areas.

Our research leads to the following more general observations. First, warehouse location patterns overall are quite stable. W&D location is largely a function of the population and employment distribution. Just as California's population and jobs are concentrated in a few very large metro areas, so is W&D activity. This makes sense; large metro areas are the hubs for international and domestic trade, have large and diverse labor pools, have the largest shares of linked industries and total economic activity, and have the richest supply of transport facilities. These are in effect "sunk resources" that would be very difficult to relocate or replicate elsewhere. Therefore, we see no reason why these general patterns should change in the future.

However, we also observe some hints of spillover effects from Los Angeles and San Francisco. We observed decentralization of W&D employment within these metro areas. Is land scarcity and other factors pushing large W&Ds even further away? For example, is the growth in Bakersfield and in the San Joaquin Valley east of San Francisco spillover growth? More detailed research on the specific function of new facilities would be required to answer this question.

Second, explanatory factors associated with W&D location are consistent with the industry location literature. Employment density, our proxy for land price and land scarcity is consistently significant, as is our measure of labor force access. Although W&Ds locate further from seaports and airports, this is largely a function of the geography of California's big metro areas. All but one have seaports and airports located in the urban core. Our findings are consistent with the literature for intermodal terminals and highway access. The presence of linked industries (transportation, manufacturing, and wholesale trade) has mixed effects, but seems to be more important for midsize metro areas. Effects may be masked in the largest metro areas by the diversity of their economies, or there may be more W&D activity associated with local distribution. At the other end of the spectrum, facilities in the smallest areas may be oriented to specific sectors such as agriculture. More detailed data on the function of W&Ds and local commodity flows would be required to gain a better understanding of the role of industry linkages in location choice.

Finally, our model results also provide evidence for our first point. The overall pattern of W&D activity appears to be quite stable. Absent major external shocks (say a very large increase in transport costs), W&Ds will remain concentrated in the largest metro areas, and those in less populated areas will continue to cluster around high access nodes of the highway network.

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Appendix

A. The distribution of W&D, transportation and all businesses in 2003 and 2013

TABLE 27 N of Establishments: W&D, Transportation, and All Businesses in 2003

Lv.	Location	W&D est.		Transportation est.		All businesses	
		2003	share	2003	share	2003	share
1	Los Angeles	775	55.7%	9,057	49.0%	391,926	50.3%
	San Francisco	257	18.5%	3,642	19.7%	160,528	20.6%
	San Diego	84	6.0%	1,430	7.7%	72,242	9.3%
	Sacramento	80	5.8%	1,057	5.7%	48,886	6.3%
	Subtotal	1,196	86.0%	15,186	82.1%	673,582	86.5%
2	Fresno	56	4.0%	630	3.4%	17,570	2.3%
	Bakersfield	18	1.3%	387	2.1%	11,190	1.4%
	Modesto	24	1.7%	430	2.3%	11,757	1.5%
	Visalia	25	1.8%	360	1.9%	7,509	1.0%
	Santa Barbara	9	0.6%	207	1.1%	11,039	1.4%
	Salinas	15	1.1%	232	1.3%	8,603	1.1%
	San Luis Obispo	5	0.4%	144	0.8%	7,538	1.0%
	Subtotal	152	10.9%	2,390	12.9%	75,206	9.7%
3	Redding	3	0.2%	181	1.0%	5,651	0.7%
	Chico	5	0.4%	108	0.6%	4,805	0.6%
	El Centro	16	1.2%	187	1.0%	2,320	0.3%
	Subtotal	24	1.7%	476	2.6%	12,776	1.6%
4	Rest of Nor-Cal	15	1.1%	343	1.9%	11,990	1.5%
	Rest of Cen-Cal	4	0.3%	106	0.6%	5,073	0.7%
	Subtotal	19	1.4%	449	2.4%	17,063	2.2%
	Total	1,391	100%	18,501	100%	778,627	100%

TABLE 28 N of Establishments: W&D, Transportation, and All Businesses in 2013

Lv.	Location	W&D est.		Transportation est.		All businesses	
		2013	share	2013	share	2013	share
1	Los Angeles	1,001	56.7%	10,882	52.3%	430,076	52.0%
	San Francisco	311	17.6%	3,800	18.3%	164,051	19.8%
	San Diego	86	4.9%	1,573	7.6%	78,373	9.5%
	Sacramento	143	8.1%	1,206	5.8%	50,933	6.2%
	Subtotal	1,541	87.3%	17,461	83.9%	723,433	87.5%
2	Fresno	41	2.3%	711	3.4%	17,918	2.2%
	Bakersfield	28	1.6%	437	2.1%	12,324	1.5%
	Modesto	30	1.7%	432	2.1%	11,388	1.4%
	Visalia	34	1.9%	361	1.7%	7,608	0.9%
	Santa Barbara	12	0.7%	207	1.0%	11,199	1.4%
	Salinas	22	1.2%	249	1.2%	8,255	1.0%
	San Luis Obispo	8	0.5%	122	0.6%	7,876	1.0%
	Subtotal	175	9.9%	2,519	12.1%	76,568	9.3%
3	Redding	10	0.6%	156	0.8%	5,052	0.6%
	Chico	7	0.4%	104	0.5%	4,633	0.6%
	El Centro	13	0.7%	172	0.8%	2,400	0.3%
	Subtotal	30	1.7%	432	2.1%	12,085	1.5%
4	Rest of Nor-Cal	16	0.9%	297	1.4%	10,527	1.3%

	Rest of Cen-Cal	3	0.2%	91	0.4%	4,435	0.5%
	Subtotal	19	1.1%	388	1.9%	14,962	1.8%
	Total	1,765	100%	20,800	100%	827,048	100%

TABLE 29 N of Jobs: W&D, Transportation, and All Jobs in 2003

Lv.	Location	W&D jobs		Transport jobs		All jobs (thousand)	
		2003	share	2003	share	2003	share
1	Los Angeles	34,329	62.3%	241,648	56.0%	6,375.9	52.4%
	San Francisco	9,694	17.6%	95,541	22.1%	2,518.4	20.7%
	San Diego	1,674	3.0%	23,779	5.5%	1,151.4	9.5%
	Sacramento	3,708	6.7%	23,426	5.4%	751.8	6.2%
	Subtotal	49,405	89.6%	384,395	89.0%	10,797	88.8%
2	Fresno	1,953	3.5%	10,683	2.5%	256.8	2.1%
	Bakersfield	1,299	2.4%	6,348	1.5%	161.7	1.3%
	Modesto	439	0.8%	5,294	1.2%	173.7	1.4%
	Visalia	947	1.7%	7,315	1.7%	112.5	0.9%
	Santa Barbara	114	0.2%	2,492	0.6%	146.7	1.2%
	Salinas	169	0.3%	2,373	0.5%	108.3	0.9%
	San Luis Obispo	184	0.3%	1,952	0.5%	83.4	0.7%
	Subtotal	5,104	9.3%	36,459	8.4%	1,043	8.6%
3	Redding	13	0.0%	4,629	1.1%	69.5	0.6%
	Chico	224	0.4%	1,456	0.3%	57.6	0.5%
	El Centro	192	0.3%	1,494	0.3%	27.5	0.2%
	Subtotal	429	0.8%	7,579	1.8%	155	1.3%
4	Rest of Nor-Cal	145	0.3%	2,728	0.6%	110.6	0.9%
	Rest of Cen-Cal	56	0.1%	621	0.1%	50.3	0.4%
	Subtotal	202	0.4%	3,349	0.8%	161	1.3%
	Total	55,139	100%	431,782	100%	12,156	100%

TABLE 30 N of Jobs: W&D, Transportation, and All Jobs in 2013

Lv.	Location	W&D jobs		Transport jobs		All jobs (thousand)	
		2013	share	2013	share	2013	share
1	Los Angeles	49,208	63.1%	256,560	57.9%	6,494.7	52.9%
	San Francisco	11,615	14.9%	91,936	20.8%	2,502.1	20.4%
	San Diego	1,746	2.2%	21,866	4.9%	1,195.6	9.7%
	Sacramento	5,606	7.2%	24,511	5.5%	725.5	5.9%
	Subtotal	68,174	87.4%	394,873	89.1%	10,918	88.9%
2	Fresno	901	1.2%	10,299	2.3%	268.9	2.2%
	Bakersfield	2,057	2.6%	8,239	1.9%	197.7	1.6%
	Modesto	2,179	2.8%	6,937	1.6%	169.1	1.4%
	Visalia	2,637	3.4%	6,600	1.5%	111.2	0.9%
	Santa Barbara	72	0.1%	2,560	0.6%	140.6	1.1%
	Salinas	425	0.5%	2,726	0.6%	98.7	0.8%
	San Luis Obispo	103	0.1%	1,873	0.4%	85.4	0.7%
	Subtotal	8,376	10.7%	39,233	8.9%	1,072	8.7%
3	Redding	855	1.1%	2,715	0.6%	58.6	0.5%
	Chico	59	0.1%	1,131	0.3%	57.3	0.5%
	El Centro	105	0.1%	1,743	0.4%	31.3	0.3%
	Subtotal	1,018	1.3%	5,588	1.3%	147	1.2%
4	Rest of Nor-Cal	284	0.4%	2,694	0.6%	97.2	0.8%
	Rest of Cen-Cal	112	0.1%	606	0.1%	44.6	0.4%
	Subtotal	396	0.5%	3,300	0.7%	142	1.2%

Total	77,964	100%	442,994	100%	12,278	100%

B. The changes in W&D, transportation and all businesses between 2003 and 2013

TABLE 31 Changes in N of Establishments between 2003 and 2013

Lv.	Location	W&D est.		Transportation est.		All businesses	
		N change	% change	N change	% change	N change	% change
1	Los Angeles	226	29.2%	1,825	20.2%	38,150	9.7%
	San Francisco	54	21.0%	158	4.3%	3,523	2.2%
	San Diego	2	2.4%	143	10.0%	6,131	8.5%
	Sacramento	63	78.8%	149	14.1%	2,047	4.2%
	Subtotal	345	28.8%	2,275	15.0%	49,851	7.4%
2	Fresno	-15	-26.8%	81	12.9%	348	2.0%
	Bakersfield	10	55.6%	50	12.9%	1,134	10.1%
	Modesto	6	25.0%	2	0.5%	-369	-3.1%
	Visalia	9	36.0%	1	0.3%	99	1.3%
	Santa Barbara	3	33.3%	0	0.0%	160	1.4%
	Salinas	7	46.7%	17	7.3%	-348	-4.0%
	San Luis Obispo	3	60.0%	-22	-15.3%	338	4.5%
	Subtotal	23	15.1%	129	5.4%	1,362	1.8%
3	Redding	7	233.3%	-25	-13.8%	-599	-10.6%
	Chico	2	40.0%	-4	-3.7%	-172	-3.6%
	El Centro	-3	-18.8%	-15	-8.0%	80	3.4%
	Subtotal	6	25.0%	-44	-9.2%	-691	-5.4%
4	Rest of Nor-Cal	1	6.7%	-46	-13.4%	-1,463	-12.2%
	Rest of Cen-Cal	-1	-25.0%	-15	-14.2%	-638	-12.6%
	Subtotal	0	0.0%	-61	-13.6%	-2,101	-12.3%
	Total	374	26.9%	2,299	12.4%	48,421	6.2%

TABLE 32 Changes in N of Employment between 2003 and 2013

Lv.	Location	W&D jobs		Transportation jobs		All jobs (thousand)	
		N change	% change	N change	% change	N change	% change
1	Los Angeles	14,879	43.3%	14,911	6.2%	118.8	1.9%
	San Francisco	1,921	19.8%	-3,606	-3.8%	-16.3	-0.6%
	San Diego	71	4.3%	-1,913	-8.0%	44.1	3.8%
	Sacramento	1,898	51.2%	1,085	4.6%	-26.3	-3.5%
	Subtotal	18,769	38.0%	10,478	2.7%	120.3	1.1%
2	Fresno	-1,052	-53.9%	-385	-3.6%	12.2	4.7%
	Bakersfield	758	58.4%	1,891	29.8%	36.0	22.3%
	Modesto	1,741	396.8%	1,642	31.0%	-4.6	-2.6%
	Visalia	1,691	178.6%	-716	-9.8%	-1.3	-1.2%
	Santa Barbara	-41	-36.3%	68	2.7%	-6.1	-4.2%
	Salinas	256	151.6%	352	14.9%	-9.6	-8.8%
	San Luis Obispo	-81	-44.0%	-79	-4.0%	2.0	2.3%
	Subtotal	3,272	64.1%	2,775	7.6%	28.5	2.7%
3	Redding	841	6373.5%	-1,914	-41.4%	-10.9	-15.7%
	Chico	-165	-73.8%	-325	-22.3%	-0.3	-0.6%
	El Centro	-87	-45.3%	249	16.6%	3.8	13.8%
	Subtotal	589	137.5%	-1,991	-26.3%	-7.5	-4.8%
4	Rest of Nor-Cal	138	95.0%	-34	-1.3%	-13.3	-12.1%
	Rest of Cen-Cal	56	99.3%	-15	-2.4%	-5.8	-11.5%
	Subtotal	194	96.2%	-49	-1.5%	-19.1	-11.9%
	Total	22,825	41.4%	11,213	2.6%	122.2	1.0%

C. Location Quotient at the metro level in 2003 and 2013

TABLE 33 Location Quotient at the metro level in 2003 and 2013

Lv.	Location	Transportation			W&D		
		2003	2013	% change	2003	2013	% change
1	Los Angeles	1.07	1.09	2.6%	1.19	1.19	0.5%
	San Francisco	1.07	1.02	-4.6%	0.85	0.73	-13.9%
	San Diego	0.58	0.51	-12.8%	0.32	0.23	-28.3%
	Sacramento	0.88	0.94	6.7%	1.09	1.22	11.9%
	subtotal	1.00	1.00	0.0%	1.01	0.98	-2.5%
2	Fresno	1.17	1.06	-9.4%	1.68	0.53	-68.5%
	Bakersfield	1.11	1.15	4.5%	1.77	1.64	-7.5%
	Modesto	0.86	1.14	32.5%	0.56	2.03	264.5%
	Visalia	1.83	1.65	-10.1%	1.85	3.74	101.4%
	Santa Barbara	0.48	0.50	5.6%	0.17	0.08	-52.5%
	Salinas	0.62	0.77	24.0%	0.34	0.68	97.1%
	San Luis Obispo	0.66	0.61	-7.7%	0.49	0.19	-60.9%
	subtotal	0.98	1.01	3.1%	1.08	1.23	14.1%
3	Redding	1.88	1.29	-31.5%	0.04	2.30	5388.5%
	Chico	0.71	0.55	-23.1%	0.86	0.16	-81.2%
	El Centro	1.53	1.54	0.9%	1.54	0.53	-65.7%
	subtotal	1.38	1.05	-23.7%	0.61	1.09	78.3%
4	Rest of Nor-Cal	0.69	0.77	10.6%	0.29	0.46	58.5%
	Rest of Cen-Cal	0.35	0.38	8.5%	0.25	0.40	60.8%
	subtotal	0.59	0.64	10.1%	0.28	0.44	59.1%
	Total	1.00	1.00		1.00	1.00	

D. The mathematical formula of labor force access

$Labor\ force\ access, L_i = \sum_{j=1}^{n} POP_j \times d_{ij}^{-1}$ where,

POP_j = population in census tract (j);

d_{ij} = (1 + distance between ZIP Code (i) and census tract (j)); (d < 10 miles)

E. N of ZIP Code by metro level and metro area

TABLE 34 The number and share of ZIP Codes by metro level and metro area

Level	N/ share	Metro Area	N	Share
1	1138	Los Angeles	552	33.6%
	69.2%	San Francisco	332	20.2%
		San Diego	106	6.4%
		Sacramento	148	9.0%
2	243	Fresno	62	3.8%
	14.8%	Bakersfield	46	2.8%
		Modesto	37	2.3%
		Visalia	32	1.9%
		Santa Barbara	22	1.3%
		Salinas	24	1.5%
		San Luis Obispo	20	1.2%
3	54	Redding	30	1.8%
	3.3%	Chico	14	0.9%
		El Centro	10	0.6%
4	209	Rest of Nor-Cal	155	9.4%
	12.7%	Rest of Cen-Cal	54	3.3%
Sum			1,644	100.0%

F. Results of stepwise regression analyses

TABLE 35 Stepwise results of Model 1a

Dependent variables	Binary likelihood of W&D (Logistic)							
Independent variables	Step 1 In 2003		Step 2 In 2003		Step 3 In 2003		Step 4 In 2003	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Employment density	0.222	***	0.243	***	0.243	***	0.248	**
Labor force access	0.169	***	0.279	***	0.283	*	0.262	
Distance to airport			0.232	**	0.237	*	0.202	***
Distance to seaport			0.440	***	0.435	**	0.339	***
Distance to intermodal			-0.219	**	-0.225	**	-0.173	***
Distance to highway			-0.427	***	-0.426		-0.409	***
Share of linked industry					-0.408		0.117	
Share * Level dummies								
Level 1							1.180	
Level 2							4.379	***
Level 3							4.599	***
Level 4 (base)							-	
Constant	-3.920	***	-6.701	***	-6.637	***	-6.527	***
N	1644		1644		1644		1644	
Log Likelihood	-849.4		-830.4		-830.4		-827.3	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

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

TABLE 36 Stepwise results of Model 1b

Dependent variables	Binary likelihood of W&D (Logistic)							
Independent variables	Step 1 In 2013 Coefficient	Sig.	Step 2 In 2013 Coefficient	Sig.	Step 3 In 2013 Coefficient	Sig.	Step 4 In 2013 Coefficient	Sig.
Employment density	0.112	***	0.140	***	0.132	**	0.142	*
Labor force access	0.282	***	0.392	***	0.436	***	0.378	**
Distance to airport			0.198	**	0.25		0.278	**
Distance to seaport			0.429	***	0.387	**	0.366	***
Distance to intermodal			-0.173	**	-0.25		-0.296	***
Distance to highway			-0.340	**	-0.336	**	-0.349	**
Share of linked industry					-5.426		-7.790	***
Share * Level dummies								
Level 1							7.534	***
Level 2							8.929	***
Level 3							17.048	***
Level 4 (base)							-	
Constant	-4.392	***	-7.262	***	-6.634	***	-6.716	***
N	1644		1644		1644		1644	
Log Likelihood	-892.8		-875.4		-873.1		-865.5	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

P (* <0.1; ** <0.05; *** <0.01)

TABLE 37 Stepwise results of Model 2a

Dependent variables	Count of W&Ds (Negative binomial)							
Independent variables	Step 1 In 2003 Coefficient	Sig.	Step 2 In 2003 Coefficient	Sig.	Step 3 In 2003 Coefficient	Sig.	Step 4 In 2003 Coefficient	Sig.
Employment density	0.230	***	0.230	***	0.23	***	0.232	***
Labor force access	0.253	***	0.210	***	0.209		0.210	
Distance to airport			-0.222	***	-0.223		-0.291	***
Distance to seaport			0.527	***	0.528	***	0.470	***
Distance to intermodal			-0.327	***	-0.325	***	-0.293	***
Distance to highway			-0.452	***	-0.452		-0.449	***
Share of linked industry					0.098		1.874	*
Share * Level dummies								
Level 1							-1.765	
Level 2							0.363	
Level 3							5.020	**
Level 4 (base)							-	
Constant	-4.333	***	-3.927	***	-3.946	*	-3.718	**
Log Alpha	1.237	***	1.156	***	1.156	***	1.142	***
N	1644		1644		1644		1644	
Log Likelihood	-1694.4		-1671.5		-1671.5		-1667.8	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

P (* <0.1; ** <0.05; *** <0.01)

TABLE 38 Stepwise results of Model 2b

Dependent variables	Count of W&Ds (Negative binomial)							
Independent variables	Step 1 In 2013		Step 2 In 2013		Step 3 In 2013		Step 4 In 2013	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Employment density	0.109	**	0.115	**	0.115	*	0.121	***
Labor force access	0.390	***	0.331	***	0.336	**	0.308	**
Distance to airport			-0.184	**	-0.18		-0.206	
Distance to seaport			0.543	***	0.537	***	0.522	***
Distance to intermodal			-0.373	***	-0.39	***	-0.409	**
Distance to highway			-0.366	***	-0.364	*	-0.360	***
Share of linked industry					-1.078		-1.081	
Share * Level dummies								
Level 1							1.595	
Level 2							2.409	**
Level 3							9.815	***
Level 4 (base)							-	
Constant	-4.889	***	-4.413	***	-4.24	**	-4.046	**
Log Alpha	1.298	***	1.227	***	1.227	***	1.217	***
N	1644		1644		1644		1644	
Log Likelihood	-1897.7		-1876.9		-1876.8		-1874.1	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

P (* <0.1; ** <0.05; *** <0.01)

TABLE 39 Stepwise results of Model 3a

Dependent variables	Binary likelihood of W&D (Logistic)							
Independent variables	Step 1 In 2003 Coefficient	Sig.	Step 2 In 2003 Coefficient	Sig.	Step 3 In 2003 Coefficient	Sig.	Step 3 In 2003 Coefficient	Sig.
Employment density	0.222	***	0.243	***	0.243	***	0.262	***
Labor force access	0.169	***	0.279	***	0.283	*	0.262	*
Distance to airport			0.232	**	0.237	*	0.219	
Distance to seaport			0.440	***	0.435	**	0.314	
Distance to intermodal			-0.219	**	-0.225	**	-0.180	
Distance to highway			-0.427	***	-0.426		-0.389	
Share of linked industry					-0.408		4.429	**
Share * Metro dummies								
Los Angeles							-1.633	
San Francisco							-1.079	
San Diego							0.234	
Sacramento							2.093	
Fresno							0.768	
Bakersfield							2.199	***
Modesto							2.763	***
Visalia							8.414	***
Santa Barbara							2.180	
Salinas							2.478	
San Luis Obispo							1.757	
Redding							-0.606	
Chico							6.084	***
El Centro							10.859	***
Level 4 MiSA and rural (base)							-	
Constant	-3.920	***	-6.701	***	-6.637	***	-6.957	***
N	1644		1644		1644		1644	
Log Likelihood	-849.4		-830.4		-830.4		-822.7	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

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

TABLE 40 Stepwise results of Model 3b

Dependent variables	Binary likelihood of W&D (Logistic)							
Independent variables	Step 1 In 2013 Coefficient	Sig.	Step 2 In 2013 Coefficient	Sig.	Step 3 In 2013 Coefficient	Sig.	Step 4 In 2013 Coefficient	Sig.
Employment density	0.112	***	0.140	***	0.132	**	0.167	***
Labor force access	0.282	***	0.392	***	0.436	***	0.386	***
Distance to airport			0.198	**	0.25		0.163	
Distance to seaport			0.429	***	0.387	**	0.455	*
Distance to intermodal			-0.173	**	-0.25		-0.264	*
Distance to highway			-0.340	**	-0.336	**	-0.334	**
Share of linked industry					-5.426		18.778	***
Share * Metro dummies								
Los Angeles							-7.356	***
San Francisco							-5.606	***
San Diego							-6.765	***
Sacramento							13.439	***
Fresno							-8.447	**
Bakersfield							6.118	***
Modesto							-5.124	**
Visalia							0.944	
Santa Barbara							4.231	*
Salinas							12.792	***
San Luis Obispo							-2.281	
Redding							6.170	***
Chico							18.852	***
El Centro							17.561	***
Level 4 MiSA and rural (base)							-	
Constant	-4.392	***	-7.262	***	-6.634	***	-9.242	***
N	1644		1644		1644		1644	
Log Likelihood	-892.8		-875.4		-873.1		-848.8	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

P (* <0.1; ** <0.05; *** <0.01)

TABLE 41 Stepwise results of Model 4a

Dependent variables	Count of W&Ds (Negative binomial)							
Independent variables	Step 1 In 2003 Coefficient	Sig.	Step 2 In 2003 Coefficient	Sig.	Step 3 In 2003 Coefficient	Sig.	Step 4 In 2003 Coefficient	Sig.
Employment density	0.230	***	0.230	***	0.23	***	0.230	***
Labor force access	0.253	***	0.210	***	0.209		0.209	
Distance to airport			-0.222	***	-0.223		-0.378	
Distance to seaport			0.527	***	0.528	***	0.593	***
Distance to intermodal			-0.327	***	-0.325	***	-0.376	***
Distance to highway			-0.452	***	-0.452		-0.354	
Share of linked industry					0.098		19.406	***
Share * Metro dummies								
Los Angeles							-11.240	***
San Francisco							-8.685	***
San Diego							-8.769	***
Sacramento							-6.186	**
Fresno							-11.456	***
Bakersfield							-5.467	***
Modesto							-7.465	***
Visalia							-2.682	***
Santa Barbara							-1.642	
Salinas							3.862	*
San Luis Obispo							-3.782	
Redding							-6.953	***
Chico							1.870	
El Centro							13.126	***
Level 4 MiSA and rural (base)							-	
Constant	-4.333	***	-3.927	***	-3.946	*	-5.472	***
Log Alpha	1.237	***	1.156	***	1.156	***	1.107	***
N	1644		1644		1644		1644	
Log Likelihood	-1694.4		-1671.5		-1671.5		-1659.0	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

P (* <0.1; ** <0.05; *** <0.01)

TABLE 42 Stepwise results of Model 4b

Dependent variables	Count of W&Ds (Negative binomial)							
Independent variables	Step 1 In 2013 Coefficient	Sig.	Step 2 In 2013 Coefficient	Sig.	Step 3 In 2013 Coefficient	Sig.	Step 4 In 2013 Coefficient	Sig.
Employment density	0.109	**	0.115	**	0.115	*	0.117	*
Labor force access	0.390	***	0.331	***	0.336	**	0.301	**
Distance to airport			-0.184	**	-0.18		-0.361	
Distance to seaport			0.543	***	0.537	***	0.761	***
Distance to intermodal			-0.373	***	-0.39	***	-0.550	***
Distance to highway			-0.366	***	-0.364	*	-0.256	
Share of linked industry					-1.078		53.762	***
Share * Metro dummies								
Los Angeles							-27.262	***
San Francisco							-22.424	***
San Diego							-20.111	***
Sacramento							-2.991	
Fresno							-31.677	***
Bakersfield							-2.930	*
Modesto							-28.029	***
Visalia							-19.691	***
Santa Barbara							-6.801	**
Salinas							12.015	***
San Luis Obispo							-9.570	***
Redding							-6.747	***
Chico							9.663	***
El Centro							9.937	***
Level 4 MiSA and rural (base)							-	
Constant	-4.889	***	-4.413	***	-4.24	**	-8.741	***
Log Alpha	1.298	***	1.227	***	1.227	***	1.162	***
N	1644		1644		1644		1644	
Log Likelihood	-1897.7		-1876.9		-1876.8		-1858.4	
Hypothesis test	Pr. > Chi2		Pr. > Chi2		Pr. > Chi2		Pr. > Chi2	
H0: Coefficients of added variables are jointly zero	***		***				***	

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