Location of warehouses and environmental justice: Evidence from four metros in California

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ABSTRACT

Warehousing activities generate substantial externalities that affect surrounding neighborhoods. Using data for four major metropolitan areas in California, Los Angeles, San Francisco, San Diego and Sacramento, this study tests the relationship between the spatial distribution of warehouses and disadvantaged neighborhoods. The results show that warehouses are disproportionately located in minority neighborhoods, regardless of the urban contexts. The four metros are diversified in the roles of global trade, land availability, and development stage of the warehousing industry. However, the consistent spatial patterns across these metros suggest that the environmental justice problem in warehousing location is a common concern. Local governments should monitor and evaluate the rapid spatial expansion of warehousing facilities and make efforts to mitigate subsequent environmental impacts that are disproportionately located in disadvantaged communities.

INTRODUCTION

The dramatic growth of the warehousing industry within major metropolitan areas in the last decade has attracted attention from academia, local governments and the public. New warehouses and distribution centers (W&Ds) have been expanding into suburban neighborhoods, where large parcels of land are available, transport access is high and local policies are flexible. These facilities bring about not only jobs and tax revenues, but also environmental externalities including truck emissions and pavement damage. Given the nature of warehousing activities, several questions have been raised by researchers who are interested in the environmental implications of logistics expansion. First, what is the attitude of local residents towards the warehousing facilities? Are these facilities locally undesirable? Second, are warehousing related environmental impacts evenly distributed? Third, do the spatial distribution patterns of warehousing facilities vary across metropolitan areas which have different roles in the global supply chain? To answer these questions, researchers introduced the concept of environmental justice (EJ), which helps explain why warehouses and distribution centers are likely to be disproportionately located in disadvantaged neighborhoods.

Since the 1970s, environmental justice has been a popular topic in the field of land use planning, and public agencies such as the Environmental Protection Agency (EPA) have developed policies to evaluate and monitor the spatial distribution of locally undesirable land uses (LULUs). A list of traditional LULUs includes toxic facilities, heavy manufacturers, and contaminated sites. Warehouses and distribution centers have never received as much attention, because the recognition of warehousing related externalities is inadequate. Neither local planners nor environmental advocates are fully aware of whether and how W&Ds could be environmentally threatening. However, an increasing number of cases show that local residents have started to be concerned about environmental impacts and have organized against massive warehousing development in their communities. The gap between real-world problems and academic understanding suggests a need for more research on the theoretical mechanisms and empirical evidence of the EJ problem in warehousing location.

This paper examines the spatial relationship between warehousing facilities and disadvantaged neighborhoods using data from four major metropolitan areas in California. In the literature review section, we discuss how the location choice of warehouses is affected by various factors, and how the environmental justice problem may arise in the siting process of warehouses. We present the research approach, results and conclusions in the later sections.

LITERATURE REVIEW

Several significant changes have taken place in the warehousing industry during the last decade. First, warehousing facilities are increasingly specialized in new services including transshipping, packaging, labeling, inventory management and so forth (Akman and Baynal, 2014). They serve a wide range of customers ranging from retail businesses, wholesalers, manufacturers, to importers, and exporters. They also cooperate with Third-party (3PL) logistics providers, trucking and freight forwarders. The role of warehousing in the global and local supply chains is getting more sophisticated and important. Second, warehousing facilities serve more geographically dispersed markets (Hesse and Rodrigue, 2004) and respond to demand from regional markets and resources (Hesse, 2007). Therefore they do not have to remain in close vicinity of local customers. Third, in spite of increased congestion, warehousing facilities make more frequent deliveries as retail businesses become more dependent on warehousing services (Hesse and Rodrigue, 2004). For instance, grocery stores and restaurants in the CBDs reduce their inventory to save rent costs, but require more frequent and time stringent deliveries. Fourth, technological advances such as automated warehousing systems and warehousing robots are increasingly adopted. As the sizes of warehousing facilities increase, so do the sizes of land parcels they consume (Andreoli, Goodchild and Vitasek, 2010). Finally, in spite of the case that warehousing facilities increasingly rely on automated equipment, they still need a large number of low-or-medium-skilled workers.

The environment in which warehousing facilities operate is changing considerably as well. First, transportation access has improved over the past decades (Giuliano, 2004). Convenient access to freeways and railroads is available in many locations in the major metropolitan areas. Second, land is getting more and more expensive, and industries that could afford high land rent occupy the land in the city cores. The warehousing industry becomes less competitive in obtaining space in those areas (Giuliano et al., 2016).

Sociopolitical factors are equally important in the location of warehouses. First, local public policies including zoning ordinances and industrial incentives can encourage or discourage warehousing development (Dablanc and Rakotonarivo, 2010; Christensen Associates et al., 2012; Dablanc, 2013). Second, attitudes of local residents towards warehousing development are increasingly significant. Local residents may persuade local authorities not to approve projects that have high potential environmental hazards (Newman, 2012; Esquivel, 2015).

Given all these changing factors, warehouses are more likely to be located in places with: 1) cheap land and large parcels; 2) ready transport access; 3) good regional connections; 4) low-wage labor; 5) favorable sociopolitical environment.

Warehousing facilities and truck activities generate various impacts on local communities including land use and landscape changes, air pollution (Dablanc, 2013), noise, pavement damage (Dong et al, 2014; Cidell, 2015), and traffic safety threats. The impacts are growing as a result of the massive expansion of the logistics industry. The spatial distribution of these impacts is nonetheless uneven due to two dynamics: the firm location choice of the warehousing facilities, and the housing location choice of disadvantaged populations. According to the literature of environmental justice, three explanations can help us understand the uneven distribution pattern of warehouses (Mohai and Saha, 2007; Mohai et al., 2009). First, warehousing developers prefer places with cheap land and low-wage labor, while those places are usually where poor or minority people are concentrated. Second, disadvantaged populations are less empowered to prevent the development of undesirable land uses in their backyards, and the spatial disparities in political power give warehousing developers incentives to site facilities in those neighborhoods. Third, public policies and the housing market have been less friendly to poor and minority residents, making their housing choices more difficult and restrained. The three explanations may work jointly or independently in different contexts.

RESEARCH APPROACH

The spatial distribution of warehouses is expected to be associated with transport access, industrial connections, land rent, and population characteristics. To answer whether the environmental justice problem exists in warehousing location, this study aims to test the hypothesis that warehousing activities are disproportionately located in disadvantaged neighborhoods. While the results may be subject to the contexts from which data are collected, we examine whether spatial patterns vary across metropolitan areas with different sizes and levels of freight demand. We expect the spatial inequity of warehousing related impacts to be consistent across metro areas.

This study focuses on the status quo; it will investigate the current spatial relationship between warehousing facilities and disadvantaged neighborhoods. We assume that warehousing location is dependent on various characteristics of the neighborhood itself, all else equal. In the conceptual model (see the equation below), the dependent variable measures the spatial distribution of warehousing activities in each neighborhood. The primary independent variables of interest are population characteristics, including race and socioeconomic status of residents in the geographic unit. Control variables include transport access, industrial connections, population and employment densities and other economic attributes of the neighborhood.

$$Y_i = f(PC_i, CV_i)$$

where Y = warehousing location, PC = population characteristics variables, and CV = control variables.

The dependent variable, warehousing location, is measured as warehouse activity intensity in a neighborhood. Population characteristics include percentage of minority population and median household income. The minority population is defined as all non-white people including African Americans, Asians, Hispanics and so forth. These two indicators can help identify different types of neighborhoods, especially disadvantaged neighborhoods. Transport access contains a vector of indicators measuring the accessibility of a certain neighborhood to freeway ramps and major freight generators such as airports, seaports, intermodal terminals and ports of entry. Variables including population density, and employment densities in manufacturing, wholesale and retail industries provide proxies for land use and industry mix patterns. The patterns imply the preference of local authorities over different land use types, which can be highly related to the location choice of warehousing facilities. The model also includes density of residents working in the transportation, warehousing and utilities industries, and median housing rents. These two variables are reasonable proxies for labor and land costs for warehousing operation.

DATA

We use the four largest metropolitan areas in California: Los Angeles (LA) Combined Statistical Area (CSA), San Francisco (SF) CSA, Sacramento CSA, and San Diego (SD) Metropolitan Statistical Area (MSA). The four regions vary in population and employment sizes, industry mix patterns and geographic constraints. The demand for freight movement and logistics services differs between these regions as well, because each region plays its unique role in the global supply chain. The Los Angeles and San Francisco regions function as international trade hubs, production centers and major consumption markets. Large volumes of commodities from overseas, especially from East Asia flow into the two regions through seaports and airports. Those imports are either consumed locally or transshipped to other regions in the US. San Diego also receives a considerable amount of imports, particularly through its border with Mexico. Its local market is smaller than LA and SF. Sacramento is another type of metro which has little international trade volume and is primarily specialized in local production and consumption. Table 1 displays key statistics on economic sizes of the four regions.

TABLE 1 Statistics on economic sizes of the Los Angeles, San Francisco, Sacramento and San Diego regions in 2015 (commodity flow data is in 2012)

	Los Angeles CSA	**San Francisco CSA**	**Sacramento CSA**	**San Diego MSA**
Gross Domestic Product[1] (million dollars)	1,119,674	758,951	124,587	220,573
Population size[2]	18,388,091	8,493,558	2,488,779	3,223,096
Employment size[3]	7,830,378	4,154,975	964,351	1,366,899
Commodity Flow size[4] (million dollars)	1,007,523	421,043	74,932	128,374

Although the four regions have different levels of freight demand, all regions but San Diego have experienced a significant expansion of the logistics industry. During 2003-2013, the number of warehousing and distribution establishments increased by 29%, 21%, 79% and 2% in LA CSA, SF CSA, Sacramento CSA and SD MSA respectively (Giuliano, Kang and Yuan, 2016). A detailed database of warehousing buildings is provided by the CoStar Realty Information Inc. The up-to-date database contains information including but not limited to location, rentable built-up area and year built, from which we know how large the facilities are and when they were built. Facilities in the Warehousing and Storage Industry (based on CoStar's definition, four relevant subcategories are included: warehouses, distribution centers, intermodal warehouses and refrigerated warehouses) with rentable built-up area of at least 30,000 sq. ft. are identified as "warehousing facilities" in this study. Under this definition, self-storage units or mini warehouses are excluded. According to the CoStar data, older warehouses and distribution centers were built mainly in the city centers and along the major freight corridors such as the I-5, and I-880 (see Figures 1-4). In the past two decades, a large proportion of new warehousing facilities were located in the periphery of the regions and a small proportion of them were still concentrated in the old warehousing clusters.

Population data is from the 2010-2014 American Community Survey 5-Year Estimates, and employment data is from the 2014 Longitudinal Employer-Household Dynamics Workplace Area Characteristics. The two data sets offer the most recent socioeconomic and demographic indicator estimates. Federal Aviation Administration (FAA) and National Geospatial-Intelligence Agency (NGA) offer locations of freight generators in this region (see Figures 5-8). We chose census tract as the geographic unit for analysis. There are 3636, 1538, 511 and 588 census tracts in the Los Angeles, San Francisco, Sacramento and San Diego models respectively. These samples do not include the census tracts with population and employment density below the one-tailed 1.96 standard deviation of the mean of the natural log form of the variables (Giuliano et al., 2015).

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[1] U. S. Bureau of Economic Analysis. Gross Domestic Product by Metropolitan Area, 2015
[2] U.S. Census Bureau. 2011-2015 American Community Survey 5-Year Estimates
[3] U.S. Census Bureau. 2015 Q4 End of Quarter Employment Counts, Quarterly Workforce Indicators (QWI)
[4] Freight Analysis Framework. 2012 Total Flows (including domestic, export and import flows) in terms of commodity values entering FAF Zones.

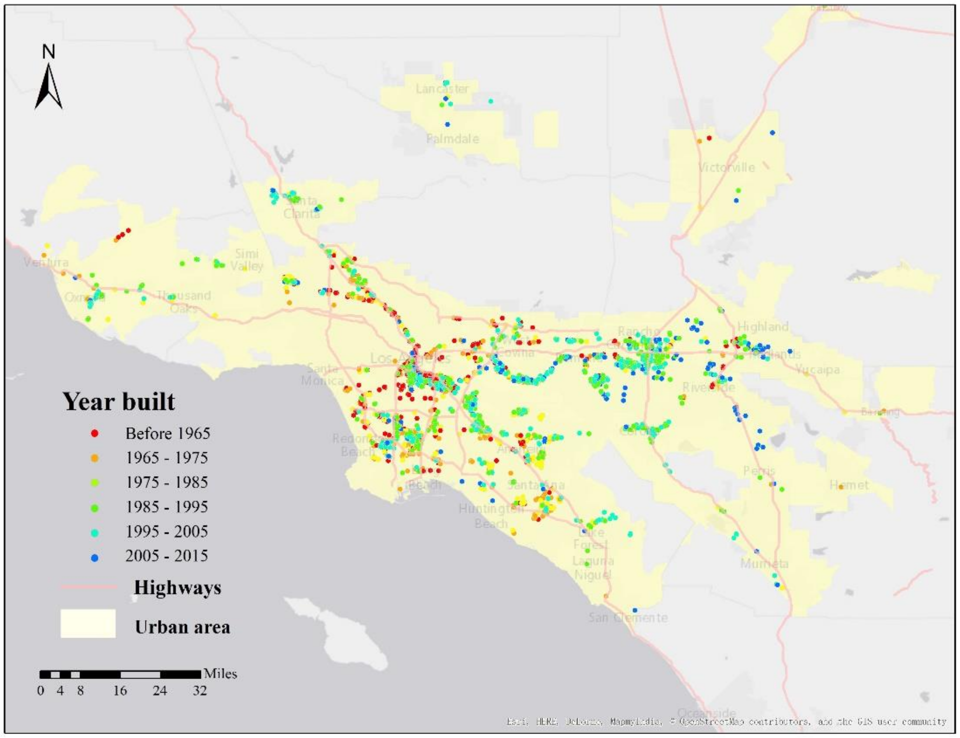

FIGURE 1 The year built of warehousing facilities in the Los Angeles region

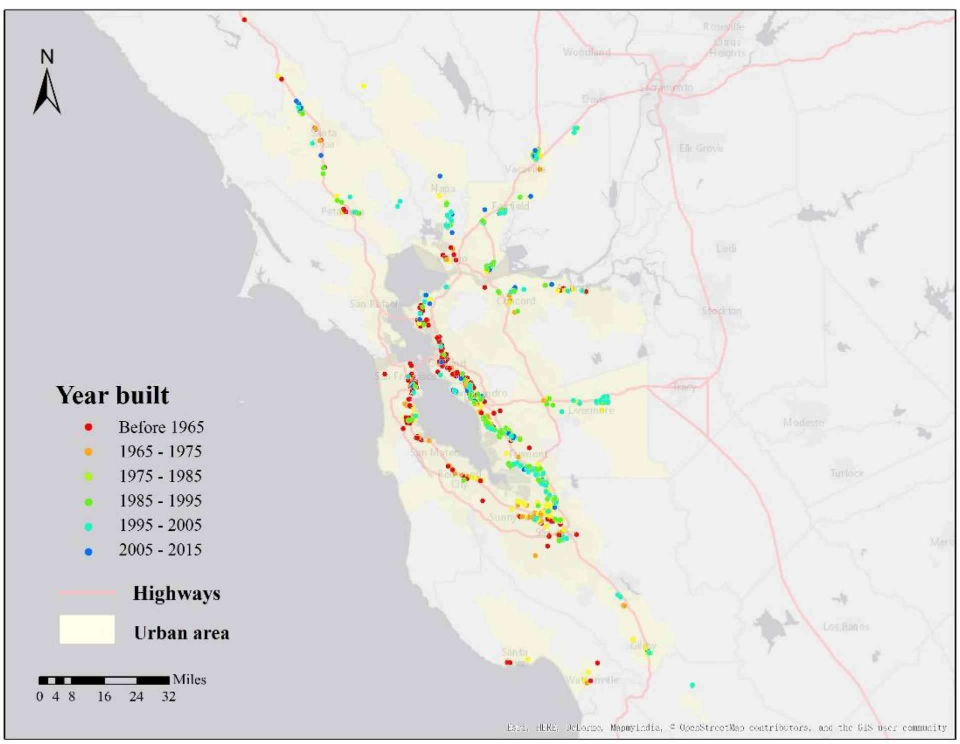

FIGURE 2 The year built of warehousing facilities in the San Francisco region

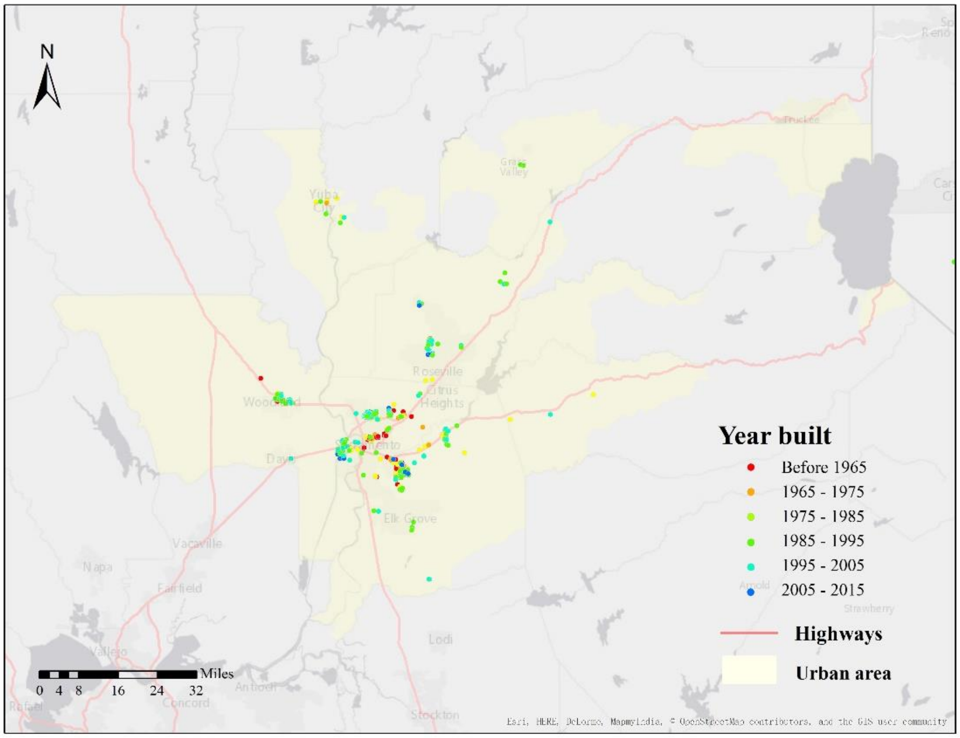

FIGURE 3 The year built of warehousing facilities in the Sacramento region

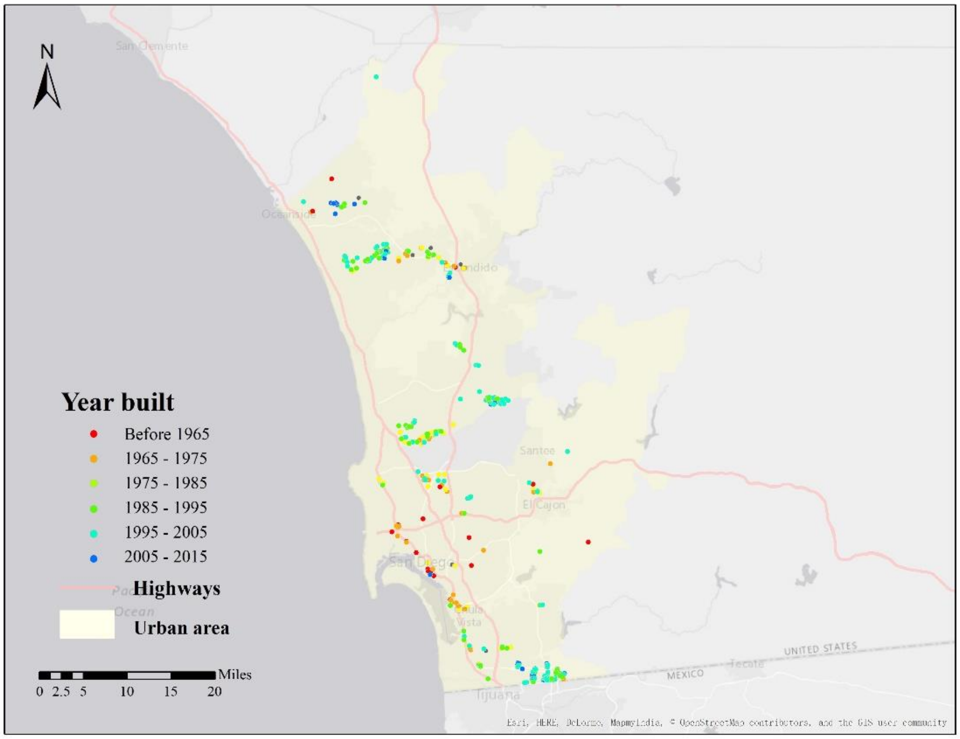

FIGURE 4 The year built of warehousing facilities in the San Diego region

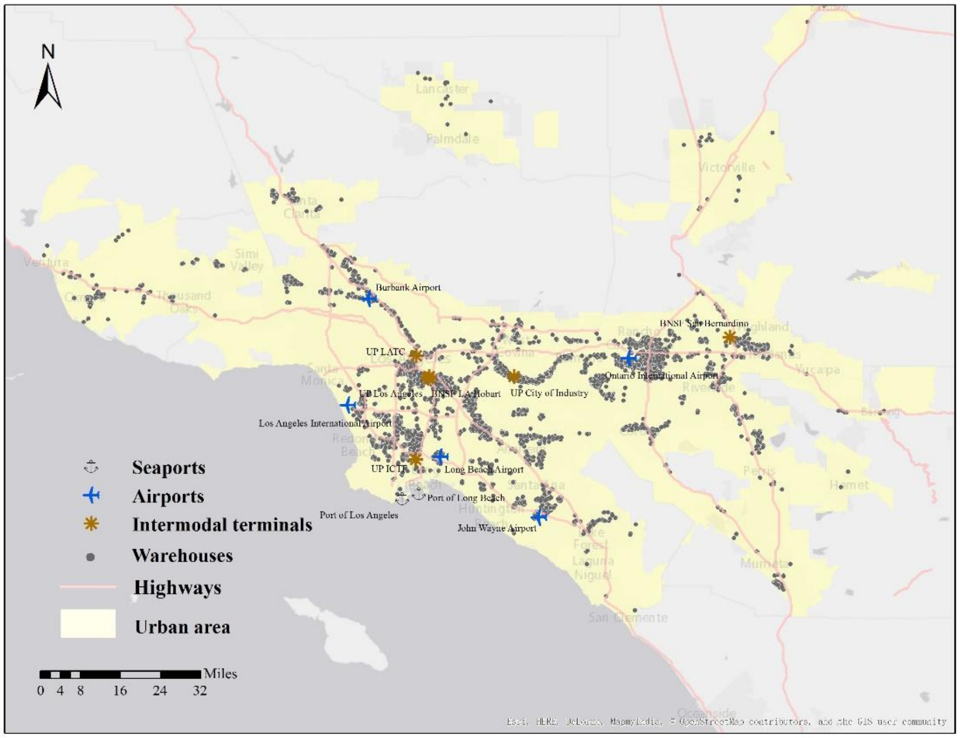

FIGURE 5 Distribution of warehouses and freight generators in the Los Angeles region

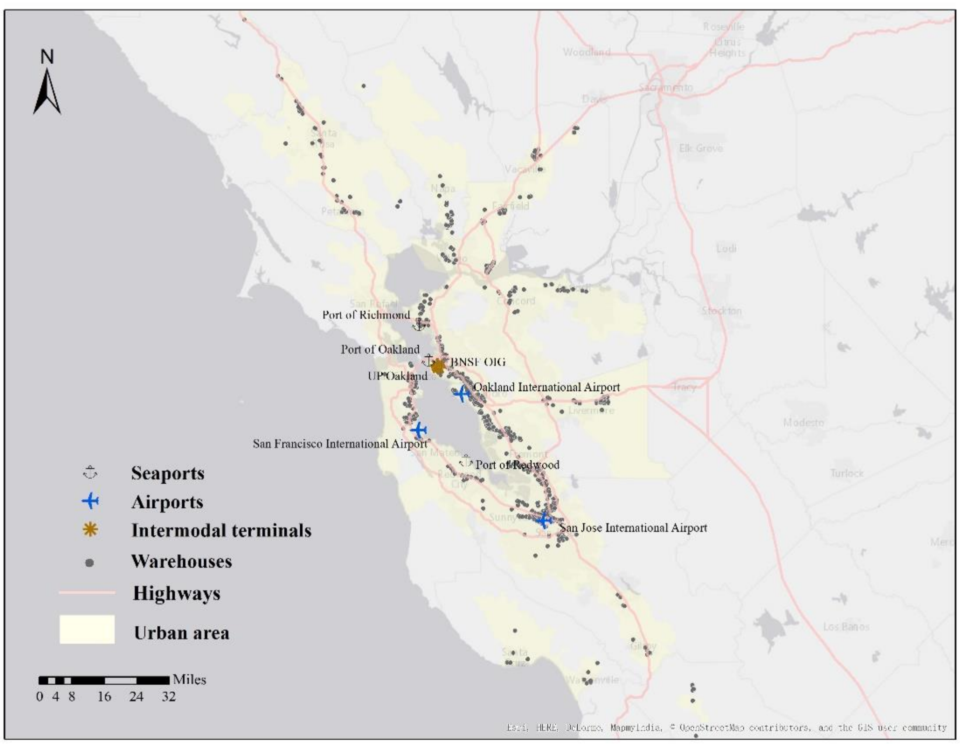

FIGURE 6 Distribution of warehouses and freight generators in the San Francisco region

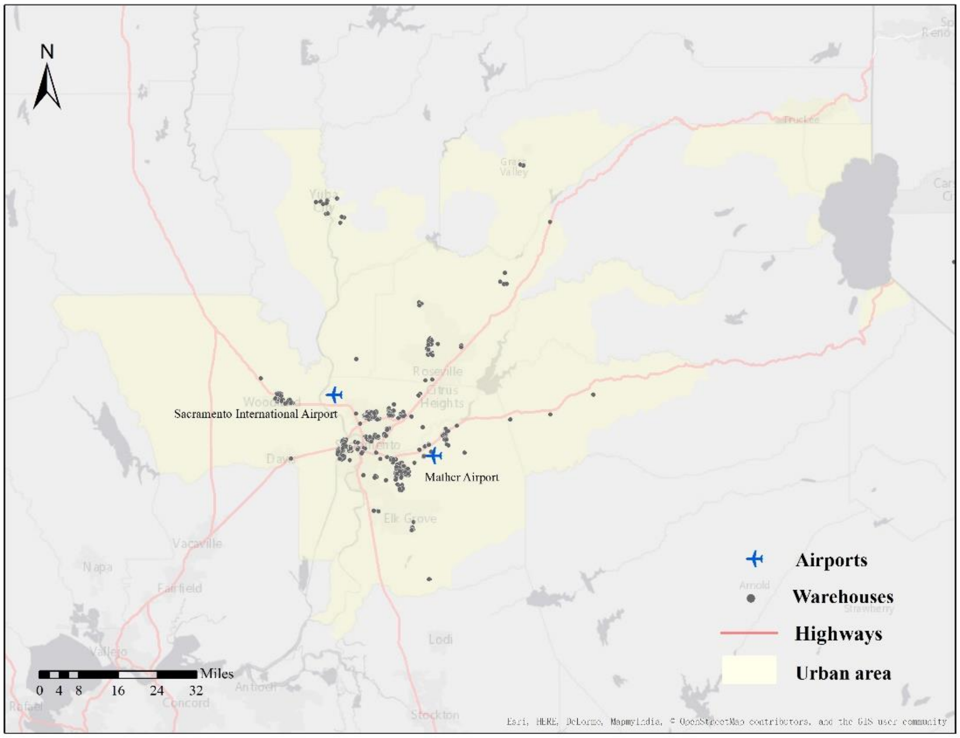

FIGURE 7 Distribution of warehouses and freight generators in the Sacramento region

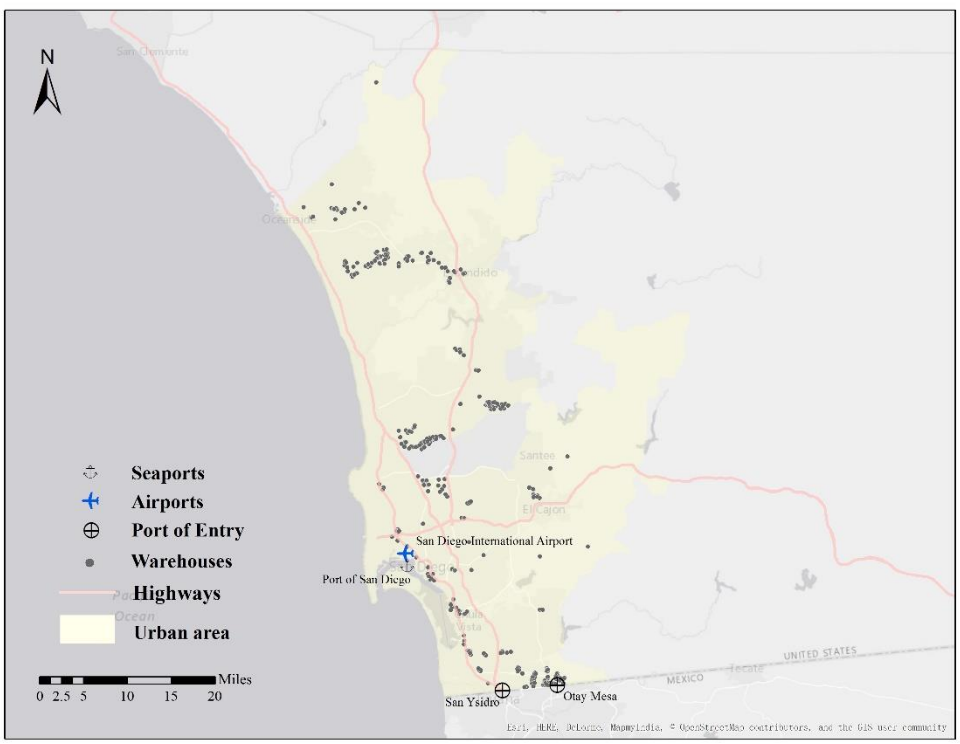

FIGURE 8 Distribution of warehouses and freight generators in the San Diego region

Household income and percentage of minorities are the two major independent variables of interest, and they are highly correlated. Low-income neighborhoods are very likely to be neighborhoods with high percentages of minorities. In order to disentangle the spatial covariation of these two indicators, we divide all census tracts into groups by minority dominance and household income levels. If a census tract has more than 50% of minority residents, it is categorized into the minority-dominant group; otherwise, it belongs to the white-dominant group. If a census tract has household income that is one standard deviation below (or above) the overall mean, it is categorized into the low (or high)-income group; all the other census tracts fall into the medium-income group. The intersection of these two categorization standards creates six groups: high-income minority, medium-income minority, low-income minority, high-income white, medium-income white, and low-income white. Given that the low-income white group contains less than 1% of the observations, we combine the medium-income white and low-income white together to generate the reference group. The following analysis will test whether the other four groups of census tracts would differ from the reference group with regard to warehousing distribution patterns.

Variables for access to major freight generators are measured as distances to the nearest facility. Sacramento and San Diego do not have intermodal terminals, Sacramento is the only region that owns no seaport, and San Diego is the only region that has international land ports of entry. Note that in the San Diego MSA, the only seaport, Port of San Diego and the only airport, San Diego International Airport, are co-located. Due to multicollinearity (Corr. = 0.98), the variable distance to nearest seaport is dropped in the San Diego model. Similarly, in the SF model, distance to nearest intermodal terminal is dropped due to high correlation (Corr. = 0.85) with distance to nearest seaport. To normalize the distribution of variable values, we use the natural log forms of all independent variables except for percentages and dummy variables.

Table 2 shows the descriptive statistics of variables in the models. The average distances to nearest freeway ramp in the Los Angeles region and Sacramento region are about 2 km, while those for the other two regions are slightly more than 1 km. The differences suggest that in San Francisco and San Diego regions, the freeway route location is more restrained by topographical conditions, so the urban areas on average have shorter distances to freeways. The San Francisco region has the highest median housing rent, and the Sacramento region has the lowest. The average percentage of minority neighborhoods in Sacramento, 37%, is much lower than those in LA (71%) and SF (60%), suggesting a wide difference in demographics in these regions.

TABLE 2 Descriptive statistics of variables

Variables	Definition (Unit)	Los Angeles (N.=3636)		San Francisco (N.=1588)		Sacramento (N.=511)		San Diego (N.=588)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Density$_{wh}$	Warehousing density in a census tract (in terms of rentable building area) (sqft/km^2)	42,297	176,394	23,656	108,006	17,327	77,236	8,985	36,867
kmHwy	Distance to nearest freeway ramp (km)	2.17	2.93	1.21	1.16	2.07	1.74	1.15	0.94
kmSea	Distance to nearest seaport (km)	23.79	23.78	27.86	19.62	/	/	24.67	16.99
kmair	Distance to nearest airport (km)	53.02	34.43	26.13	22.47	25.57	24.15	24.11	16.28
kmint	Distance to nearest intermodal terminal (km)	25.17	23.37	40.00	26.50	/	/	/	/
Kmpoe	Distance to nearest port of entry (km)	/	/	/	/	/	/	37.67	22.40
Popdensity	Population density (person/km^2)	4146	3778	3974	4697	1637	1190	2856	2246
Manuden	Employment density in Manufacturing industry (job/km^2)	64.33	207.38	58.89	302.70	18.59	77.57	34.39	177.95
Wholeden	Employment density in Wholesale industry (job/km^2)	47.20	155.25	42.79	224.73	12.89	30.20	21.49	49.72
Retailden	Employment density in Retail industry (job/km^2)	138.52	328.71	159.86	491.25	64.01	118.10	95.05	162.87
WHresidensity	Density of residents in Transportation, warehousing and utility industry (person/km^2)	95.11	101.36	79.46	104.27	32.04	32.34	49.25	56.24
Medrent	Median housing rents (dollars)	1555	546	1842	581	1358	445	1624	514
HighincMinor	Whether the census tract is high-income and minority-dominant	0.03	0.17	0.04	0.21	0.04	0.18	0.03	0.16
MedincMinor	Whether the census tract is medium-income and minority-dominant	0.56	0.50	0.43	0.50	0.21	0.41	0.32	0.47
LowincMinor	Whether the census tract is low-income and minority-dominant	0.12	0.32	0.13	0.33	0.12	0.32	0.13	0.34
HighincWhite	Whether the census tract is high-income and white-dominant	0.12	0.32	0.10	0.30	0.12	0.33	0.13	0.34

RESULTS

According to the existing environmental justice literature, compared to the reference group, neighborhoods with lower household income levels and higher percentages of minorities are expected to have higher probabilities of containing warehousing facilities, all else equal. Figures 9-12 present an overview of the spatial relationship between warehousing facilities and two types of neighborhoods in the four regions. The figures show the majority of warehouses are located in minority neighborhoods, especially medium-income minority ones. This pattern is consistent across four regions, although the spatial distribution of minority neighborhoods is highly subject to the unique urban structure of each region.

The independent variable, warehousing activity intensity, is calculated as aggregate warehousing square footage divided by the square kilometer of each census tract's area. We use the OLS Regression method in the models. The regression results (see Table 3) show that out of four neighborhood groups, the medium-income minority group has significantly higher warehousing activity intensity than the reference group, in all four regions. Except in San Diego, warehousing activity intensity is also found to be higher in the low-income minority neighborhoods than medium-or-low-income white ones. But the coefficients for medium-income minority and low-income minority are only statistically different in San Francisco. In San Diego, the high-income minority neighborhoods marginally have higher warehousing concentration than the reference group. These findings confirm that warehousing activities are more concentrated in minority neighborhoods, but not necessarily in low-income ones. The spatial disparities in warehousing location are generally consistent in the four Californian metros.

The results on transport access variables are mixed across the regions. Access to freeway is only significant in LA, while access to seaport is not significant in any of the regions. Access to airport is significant in all metros but San Diego. As the only metro with port of entry, San Diego sees a marginally significant relationship between warehousing activity intensity and access to port of entry. Freeway access is generally ubiquitous throughout all these regions, and therefore it may no longer be dominant in the warehousing location choice. The areas close to the seaports in LA and SF are currently no longer among the first choices to warehousing developers (see Figures 1 and 2) due to decreased land availability and increased land rent. This tendency might partly explain the unexpected sign of the coefficients for distance to seaport. Cargo airports are of particular importance in express deliveries and transporting high value goods. Warehousing facilities of postal service and delivery companies can be easily found near major cargo airports. As a border city, San Diego has two busy ports of entry, and a large number of warehouses are built in surrounding areas. The model results well reflect these spatial colocation patterns.

The industrial connection variables are statistically significant and with expected signs. The neighborhoods with lower employment densities in retail and higher employment densities in manufacturing and wholesale would have higher warehousing activity densities. These variables have strong explanatory power in the models.

Finally, warehousing activities are in general more concentrated in the neighborhoods with lower population density, higher densities of residents in the transportation, warehousing and utility industry, and lower median housing rents. Some of these coefficients are not statistically significant but have expected signs. The overall fit of the models is good given the pseudo R-squared values. The Sacramento and San Diego models have far fewer observations, but the adjusted R-squared values are only slightly lower than that in LA.

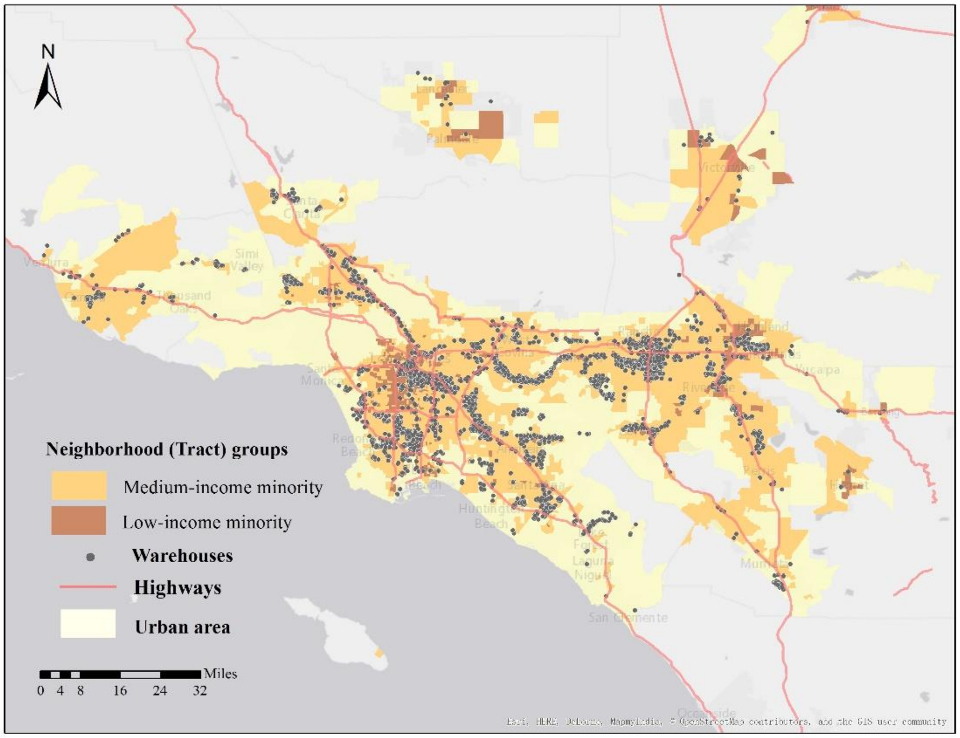

FIGURE 9 Spatial distribution of warehouses and different types of neighborhoods in the Los Angeles region

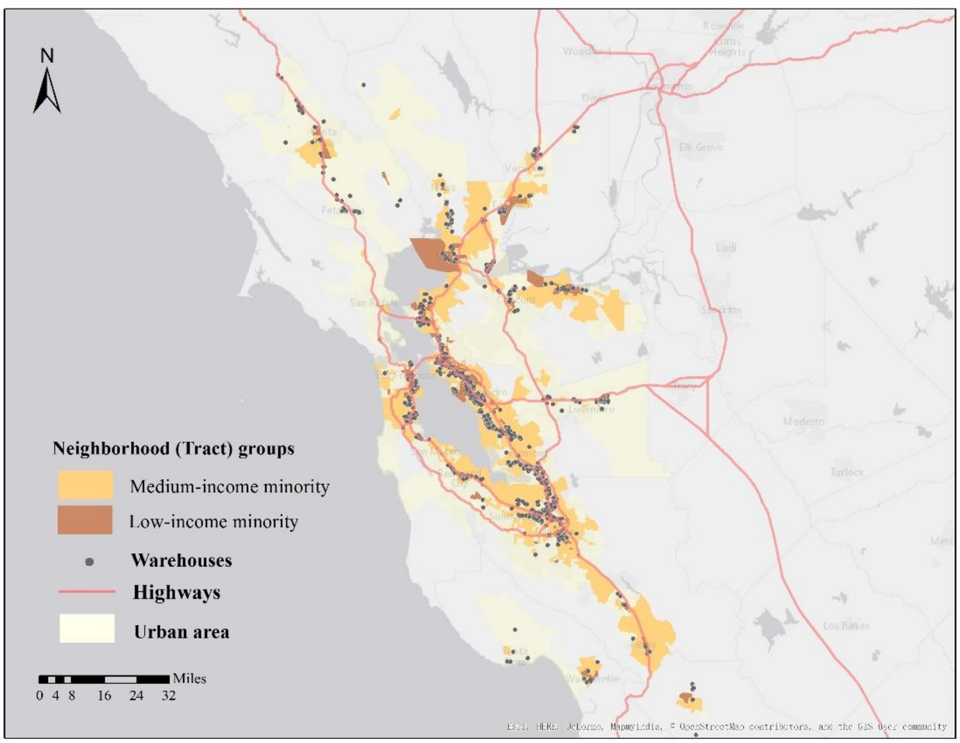

FIGURE 10 Spatial distribution of warehouses and different types of neighborhoods in the San Francisco region

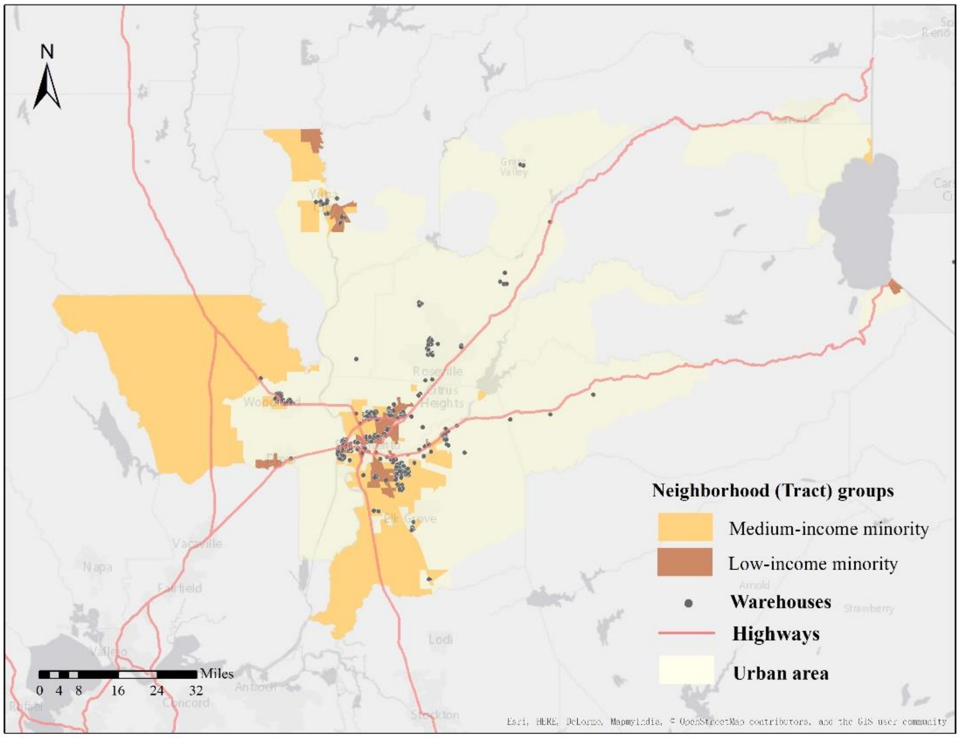

FIGURE 11 Spatial distribution of warehouses and different types of neighborhoods in the Sacramento region

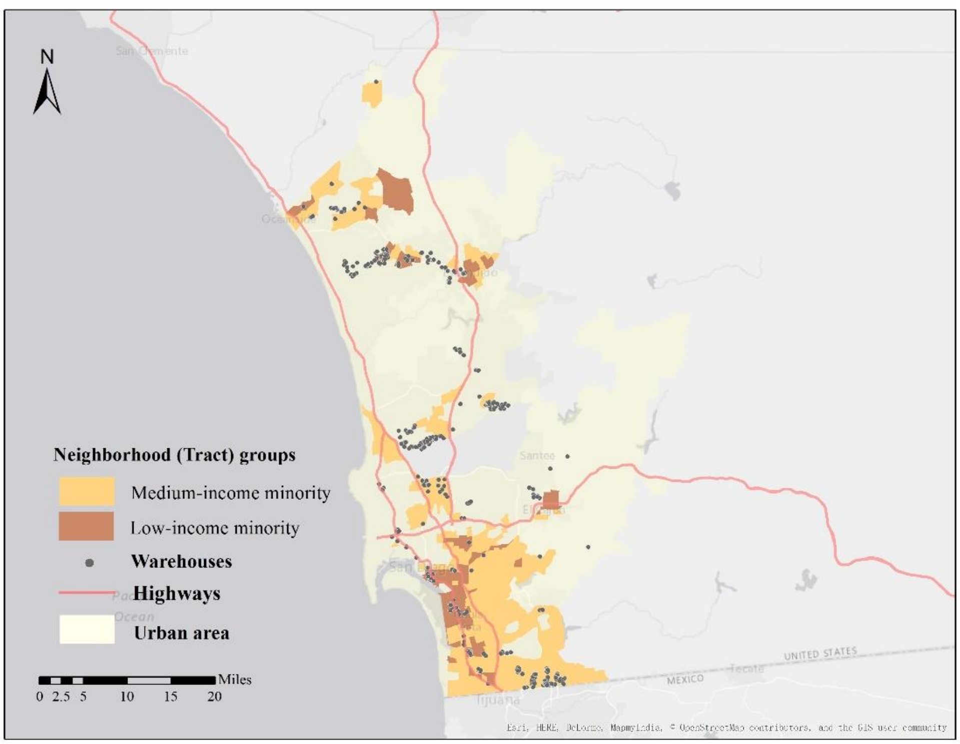

FIGURE 12 Spatial distribution of warehouses and different types of neighborhoods in the San Diego region

TABLE 3 Regression analysis results (Dependent variable: Warehousing activity intensity)

	Warehousing activity intensity							
	Los Angeles		San Francisco		Sacramento		San Diego	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
High-income minority	0.153	(0.363)	0.267	(0.426)	-0.094	(0.796)	1.297*	(0.732)
Medium-income minority	1.359***	(0.165)	0.932***	(0.202)	0.858**	(0.354)	0.789***	(0.305)
Low-income minority	1.531***	(0.253)	1.710***	(0.327)	1.295***	(0.49)	0.221	(0.453)
High-income white	0.325	(0.243)	-0.091	(0.333)	0.346	(0.525)	-0.210	(0.424)
Distance to freeway	-0.116**	(0.055)	0.008	(0.083)	-0.117	(0.143)	0.132	(0.129)
Distance to airport	-0.323***	(0.096)	-0.200*	(0.116)	-0.436**	(0.216)	0.221	(0.184)
Distance to seaport	0.126	(0.124)	0.072	(0.119)	/	/	/	/
Distance to intermodal	-0.116	(0.086)	/	/	/	/	/	/
Distance to port of entry	/	/	/	/	/	/	-0.365*	(0.204)
Population density	-1.865***	(0.106)	-1.471***	(0.135)	-0.944***	(0.251)	-0.791***	(0.219)
Manufacturing employment density	0.728***	(0.037)	0.681***	(0.053)	0.790***	(0.112)	0.877***	(0.088)
Wholesale employment density	0.896***	(0.049)	0.757***	(0.073)	1.424***	(0.151)	0.596***	(0.120)
Retail employment density	-0.339***	(0.040)	-0.256***	(0.055)	-0.440***	(0.104)	-0.128	(0.084)
WH resident density	0.486***	(0.083)	0.462***	(0.112)	0.335	(0.214)	0.023	(0.157)
Median housing rents	-0.941***	(0.274)	-0.647*	(0.394)	0.258	(0.668)	-0.496	(0.616)
Constant	19.324***	(2.323)	13.876***	(3.241)	4.495	(5.040)	9.111*	(4.946)
Adjusted R-squared	0.426		0.389		0.420		0.401	
Sample Size	**3636**		**1538**		**511**		**588**	

Our results have some interesting environmental justice implications. First, the results provide solid evidence on the disproportionate distribution of warehouses in minority neighborhoods. The spatial patterns between warehousing location and minority neighborhoods are consistent across regions regardless of the vast differences in demographics. Second, the relationship between warehousing location and socioeconomic status is less apparent. In three of the four regions, low-income minority neighborhoods have higher warehousing activity intensities than the reference group, but there is no consistent evidence that low-income minority neighborhoods are different from medium-income ones in terms of warehousing concentration. In San Diego, high-income minority neighborhoods also have higher warehousing activity intensities, suggesting an even mixed warehousing-income relationship.

According to the literature of environmental justice, low-income neighborhoods should be more vulnerable to disproportionate distribution of LULUs than neighborhoods with higher income. But why don't they attract more warehousing facilities? Many of the low-income neighborhoods do not provide certain necessities for warehousing development. In all regions, a high proportion of low-income neighborhoods is located in the old city cores, where residential density is high and land availability is strictly limited (see Figures 9-12). These areas are not among the best choices across the region for developers, especially when warehousing facilities are growing substantially in sizes and consuming a huge amount of land. In Los Angeles, Sacramento, and San Diego, many low-income neighborhoods are scattered in the periphery of the regions, where access to customers and transportation infrastructure is relatively poor. In contrast, it is not difficult to identify that many medium-income neighborhoods have clusters of warehousing facilities (see Figure 9-12). For instance, a large number of zones in the Inland Empire (in the Los Angeles region) provide conveniences for warehousing development including inexpensive land, good regional access, and favorable local policies, and they will probably remain popular among developers in the near future. Third, control variables, especially industrial connection variables, are found to be highly critical as a whole in estimating the distribution of warehouses. To account for the effects of these variables is key to accurately testing the environmental justice problem in warehousing location.

Multiple social and institutional factors could also contribute to environmental injustice. The long-term path dependence of zoning regulations and high variances in land use policies across municipalities may greatly affect the distribution of warehousing facilities and local residents. For instance, land use regulations and policies on warehousing and relevant industries like manufacturing have been in effect for many decades. Municipalities have traditional strategies in land use development. This could be another important reason why some low-income neighborhoods are largely free from warehousing facilities but nearby medium-income neighborhoods have an enormous number of them. Finally, warehouses hire blue-collar workers, many of whom live in medium-income neighborhoods. Proximity to the labor pool is another reason that warehousing developers prefer medium-income neighborhoods to low-income ones. Due to these factors, low-income minority neighborhoods do not usually have a higher probability of being targeted for warehousing development than medium-income minority neighborhoods.

CONCLUSIONS

This study tests whether an environmental justice problem exists in warehousing location using data for four major metro areas. Multivariate regression models are used to estimate the relationship between warehousing activity intensity and disadvantaged neighborhoods. Although the urban contexts in the four regions are different, the results across models are generally consistent. The results confirm that transport access, industrial connection and economic attributes of a certain zone are closely associated with warehousing distribution in that zone. With all these variables controlled, the models show that warehouses and distribution centers are disproportionately located in medium-income minority neighborhoods. And low-income minority neighborhoods in general do not have a higher concentration of warehousing development than medium-income minority ones. Overall, environmental injustice exists in the distribution of warehousing facilities. The distribution of warehousing facilities and activities is related to percentage of minorities as expected, but its relationship with household income is mixed. Such inconsistency may partly result from the nature of the warehousing industry. In the four regions, low-income neighborhoods are not always attractive to warehouse developers as they could not provide adequate conveniences including land availability, transport access and labor pools for warehousing development.

This study examines environmental justice from a new perspective of warehousing distribution. It can provide government policy makers and planners a general overview of the disproportionate distribution of warehousing related externalities. State governments, and regional planning agencies, which have research capacities and frameworks for regional collaboration, could monitor the spatial distribution of environmental impacts associated with warehouses, and provide guidance to local authorities on how to mitigate these impacts. County and city governments, on the other hand, have much stronger influences on the warehousing location choice. Through land use, building and environmental regulations, these governments could effectively attract warehousing development or on the contrary, push such development to neighboring locations. To simultaneously achieve sustainable industrial growth and maintain a just environment for residents, the governments need to develop policy packages in line with their backgrounds and long-term visions.

Environmental advocates may consider including warehousing facilities in the examination of environmental justice and help the disadvantaged protect their rights to avoid disproportionate environmental burdens. If local residents are well organized to fight for justice, many neighborhoods probably would not suffer from environmental degradation due to the siting of warehouses.

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