Logistics Sprawl
Differential Warehousing Development Patterns in Los Angeles, California, and Seattle, Washington

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The warehousing industry experienced a period of rapid growth from 1998 to 2009. This paper compares the growth in geographic distribution of warehouses in the Los Angeles, California, and Seattle, Washington, metropolitan areas during that period. These two West Coast cities were chosen because of their geographic spread, proximity to major ports, as well as their size difference. The phenomenon of logistics sprawl, or the movement of logistics facilities away from urban centers, which has been demonstrated in past research for the Atlanta, Georgia, and Paris regions, is examined for the two metropolitan areas. To measure sprawl, the barycenter, or geographic center of warehousing establishments, is determined, as is the average distance of warehouses to that center. The average distance of warehouses to the warehousing barycenter was compared with the average distance from the barycenter for all establishments. Between 1998 and 2009, warehousing in Los Angeles sprawled considerably, with the average distance increasing from 25.91 to 31.96 mi, an increase of more than 6 mi. However in Seattle, the region locations remained relatively stable, showing a slight decrease in average distance from the geographic center. Possible explanations for that difference are discussed.

In the 1990s the United States logistics industry began experiencing rapid growth. For the purposes of this paper, “warehousing” is defined as those establishments falling under North American Industry Classification System (NAICS) Code 493—Warehousing and Storage. General, refrigerated, farm product, and other warehousing and storage are included. Code 493 did not change in its definition during the present study period. Across the United States, employment in the warehousing industry increased by almost 400% between 1998 and 2006 at a compound annual growth rate of 22.25%. In contrast, total U.S. employment grew by 1.3% annually (1). The number of warehousing establishments more than doubled, from 6,712 in 1998 to more than 14,000 in 2008 (2). The trend continued until the recession, at which point growth in the warehousing industry began to slow. The number of warehousing establishments increased every year through 2007. In 2008 there was a 1% decrease in the number of establishments. From 2008 to 2011 the number of establishments decreased at an average of 0.4% per year. Similarly the number of warehousing employees increased every year through 2008; there then followed a 4% decrease in warehousing employment in 2009, a further 3% decrease in 2010, and less than a 1% percent increase in 2011 (3). This paper compares the locations of warehouses in two major population centers on the West Coast: Los Angeles, California, and Seattle, Washington. These two cities can be compared with Atlanta, Georgia, for which a similar analysis was completed by Dablanc and Ross (4).

Specifically, this paper focuses on a phenomenon known as “logistics sprawl,” which is the tendency of warehouses to move away from urban regions toward more suburban and exurban areas (4). Dablanc and Ross show this phenomenon to be occurring in the Atlanta area, which has a metropolitan population of approximately 5.5 million people (5).

The Seattle area is smaller than that of Atlanta, with a population of 3.5 million. The Greater Los Angeles area is much larger at approximately 18 million (5). Los Angeles and Seattle are located next to the Pacific Ocean and house major intermodal terminals, including the largest and the third largest container terminal complexes in the United States, respectively. A demand for warehouses is consequently created in the nearby area. Geographic features such as the Pacific Ocean and mountain ranges constrain both regions geographically (but in diverse ways), influencing urban expansion patterns.

In the current study, the Los Angeles area includes Ventura, Los Angeles, Orange, San Bernardino, and Riverside Counties in California, shown in Figure 1. Los Angeles is bordered to the southwest by the Pacific Ocean, and is separated from much of northern Los Angeles and San Bernardino Counties by the San Gabriel Mountains to the north. There are also several smaller mountain ranges in the area; the recent expansion of both population and industry has been largely to the east.

The Seattle area counties studied were King, Snohomish, Pierce, Kitsap, and Thurston in Washington State, stretching from Everett, Washington, in the north to Olympia, Washington, in the south, shown in Figure 2. The Puget Sound provides a geographic barrier to the west, and the Cascade Mountains border the east. There are a few residential and industrial areas to the west of Puget Sound, but most of the population and businesses are to its east. Transportation across Puget Sound is difficult as there is only one road crossing the body of water in the southern end and all other travel must be made by ferry. The vast majority of the population lives to the east of the water.

The Los Angeles metropolitan area economy grew from approximately $578 billion [real gross domestic product (GDP)] in 2001 to $653 billion in 2009, a growth of approximately 13% (6). The highest yearly GDP during that time period was $692 billion in 2008, which
FIGURE 1  Los Angeles study area. (Source: U.S. Census Bureau.)

FIGURE 2  Seattle study area. (Source: U.S. Census Bureau.)
decreased by 5.6% in 2009. Major sectors in the Los Angeles economy include manufacturing, trade, banking, and finance. Transportation and warehousing make up about 2.4% of total GDP (6).

Between 2001 and 2009 the Seattle metropolitan area economy grew from $173 billion real GDP to $204 billion, a growth of approximately 18% (6). The highest yearly GDP during that time was $211 billion in 2008, which decreased by 3.3% in 2009. Major sectors include aerospace, information technology, trade, and tourism (7). Transportation and warehousing make up about 2.9% of total GDP (6).

Trade is a major industry in both metropolitan areas. Transportation and warehousing make up a similar percentage of total GDP in both areas (2.4% and 2.9%). Most sectors in both regions experienced moderate growth until 2008 before declining as a result of the recession. However, the Los Angeles metropolitan area experienced a greater percentage decline in GDP from 2008 to 2009.

LITERATURE REVIEW

Sivitadinou made one of the first empirical studies of the location of warehouses in a U.S. metropolitan area (Los Angeles) and examined its links with land prices, but her efforts were not followed by many others (8). “Urban economists have traditionally focused on the labor decisions of firms and households to try and account for various aspects of urban form. The location and transportation decisions made by the various entities in the supply chain as these parties manage logistics costs have received considerably less attention,” even while they have become increasingly important, especially in metropolitan areas (9). The warehousing industry has undergone major restructuring, transforming into a distribution industry that serves major importers and big box retailers and is based on direct access to consumption markets, globalized networks of goods distribution, hub-and-spoke networks, and just-in-time operations (10, 11). This restructuring has led to a rise in hub distribution centers (12). Very large distribution centers, or “mega DCs,” have driven the early growth in warehousing establishments (1). Between 1998 and 2005, the number of distribution centers with more than 100 employees increased twice as fast as smaller facilities (1). Today’s supply chains require a number of logistics facilities, and the efficiency of goods distribution depends on the optimal location and sizing of freight terminals. Freight transportation costs have decreased dramatically during the past 30 years (13). Low freight costs create an “increased locational flexibility” for freight and logistics facilities (14). The opportunity for good regional and national networking between facilities in a supply chain is a key factor (15). Finally, some warehousing activities that were previously performed as part of a manufacturing or distribution activity (and on the same premises) have been outsourced to logistics providers, increasing the number of warehouses. In some cases manufacturers have implemented a warehousing logistics facility when previously logistics functions (which required less space) were performed in the manufacturing facility itself [see the example of Vernon, in Southern California, presented in Dablanc (16)]. As noted by Hall and Hesse, metropolitan areas retain logistics facilities because they have a “freight advantage” that includes “labour, skills, infrastructure, technology,” among others (17).

The distribution centers required by the current organization of supply chains and a consumer-based economy are directly responsible for logistics sprawl, that is, the tendency for warehouses to move from urban to suburban and exurban areas (4). Historically, warehouses and freight terminals have tended to be close to city centers and rail stations. Today, they need more space and are located as close as possible to highway networks and airports (18). Suburban areas are attractive because of the availability and low cost of land and also because of the availability of transportation infrastructure that connects to a more complex system of regional and national flows. The availability of transportation infrastructure has an effect on urban landscapes by generating congestion, carbon dioxide (CO₂) emissions, and local atmospheric pollution. These effects are the result of additional vehicle miles traveled generated by the increase in distances traveled by trucks and vans to deliver commodities to urban areas where jobs and households remain concentrated. Dablanc and Rakotomarivo calculated that cross-dock terminals for parcel and express transport companies moved an average of 6 mi farther away from the center of Paris between 1975 and 2008 (19). During the same period, jobs in general moved only 1.3 mi, meaning that logistics sprawl is more prevalent than the general sprawl of economic activities in metropolitan areas. They estimated the net increase in annual CO₂ emissions resulting from the relocation of facilities serving the Paris region to be 16,500 tonnes in 2008 compared with emissions in 1974.

The issue of logistics sprawl has recently generated some discussion among scholars, particularly economic geographers. Cidell has shown that in 47 of the 50 large metropolitan areas she surveyed, “decentralization” of freight activity had taken place during the past 20 years (1986 to 2005), as measured by Gini coefficients (20). Because data were processed at the county level, however, it was difficult to account for some of the relocation patterns, as central counties can be very widespread and changes in location within counties were not accounted for in Cidell’s studies. Bowen confirms that logistics activities have experienced enormous, largely unnoticed, growth in recent years (15). He shows that the growth in warehousing was more marked in suburban counties than in central and rural counties: central city metropolitan statistical area (MSA) counties saw warehousing establishments grow at an annual growth rate of 10.2%, while the increase for non-MSA counties and other MSA counties were, respectively, 9.3% and 11.8%. Hesse, using two case studies from Germany, concludes that logistics activities favor distant locations for many reasons, some of which are specific to this industry while others, such as overcoming congestion, planning requirements, or even the influence of unions, apply to many economic sectors (21).

Looking at the Inland Empire in Southern California, De Lara emphasizes the role of temporary work availability and a low-wage flexible workforce, demonstrating substantial wage differences in transportation and warehousing industries in Los Angeles and Orange Counties compared with Riverside and San Bernardino Counties (22). These changes are embedded in a general transformation of the logistics real estate industry, increasingly dominated by global players organizing large networks of distribution centers. Allen and Browne have found a tendency for warehousing to move away from urban areas to suburban areas in the United Kingdom and elsewhere in Europe. Land prices in Europe have been steadily increasing recently, so the authors theorize that this move has occurred partially as a result of cheaper land prices in suburban areas (23). The expansive roadway network in Europe allows companies to construct large warehouses in more centralized locations. In England, specifically, they have found that warehousing districts are often strategically clustered along motorways close to, but just outside, large cities. While this clustering of warehouses is partly the result of accessibility to the road network, it is also “a result of planning policy that encourages a concentration of such land use” (23). This paper addresses land use policies further in the discussion.
DATA

Data for all establishments for the years 1998 and 2009 were downloaded from the County Business Patterns (CBP) website (http://www.census.gov/econ/cbp/). CBP provides zip-code-level establishment data. Structured query language was used to isolate establishments under NAICS Code 493 and to aggregate establishment totals within a given region. The final data sets were all zip codes in Ventura, Los Angeles, Orange, San Bernardino, and Riverside Counties in California and King, Pierce, Snohomish, Kitsap, and Thurston Counties in Washington State. ArcGIS software was used to create maps of warehouse and establishment data. In addition, the barycenter, or geographic mean (distance weighted), was calculated and plotted for each region for each year by using standard ArcGIS procedures. These procedures are discussed further in the sections on results.

LOS ANGELES RESULTS

In 1998 the bulk of warehousing establishments in the Los Angeles metropolitan area were located in southern Los Angeles County and east and southeast of downtown. Figure 3 shows the locations of distribution centers in the Los Angeles study area in 1998 (displayed by zip code). The only zip code outside Los Angeles County with more than 10 establishments is 91761 in Ontario, California, which has 16 facilities listed under NAICS Code 493.

By 2009 the warehousing industry had expanded, as shown in Figure 4. The total number of warehousing establishments increased substantially, and two distinct concentrations of warehouses appeared: one near the city of Los Angeles and one around Ontario and Zip Code 91761.

There was moderate growth in the number of zip codes with warehousing establishments and the total number of warehousing establishments, as shown in Figure 3 and Figure 4. Of zip codes with at least one establishment in 1998, 60 showed at least a 100% increase in the number of establishments. The number of establishments in Los Angeles County increased 134% from 220 in 1998 to 515 in 2009. Orange and Ventura Counties experienced moderate growth. The most striking increase, however, appeared in western San Bernardino and Riverside Counties, where in 1998 just one zip code had more than 10 establishments. Total establishments in San Bernardino County increased 641% from just 34 establishments in 1998 to 252 in 2009. Zip Code 91761 increased from 16 establishments in 1998 to 82 in 2009.

To quantify a potential shift in the location of warehousing establishments, a centrographic analysis of all establishments under NAICS Code 493 was performed. The barycenter of these was calculated in ArcGIS for both years by averaging the x and y coordinates of all warehouses, respectively. No other warehouse characteristics, such as square footage or number of employees, were included in the calculation of the barycenter. The distance from the barycenter to each establishment was calculated and averaged.
across all warehousing establishments. A similar analysis was done for all NAICS establishments. The findings are as follows:

- The average distance of warehousing establishments from their barycenter increased from 25.9 to 32.0 mi.
- The average distance of all establishments from their barycenter remained stable, changing from 41.8 to 41.7 mi.

On the whole, there was very little change in the distribution of all establishments, but warehousing has sprawled more considerably. While establishments in the Los Angeles metropolitan area have not sprawled, warehouses have moved out an average of 6 mi. That result suggests that within the Los Angeles metropolitan area, more truck miles were required to reach customers (for shipments or deliveries) in 2009 than was the case in 1998. This type of sprawl is “relative sprawl,” that is, a situation in which logistics facilities move farther away than the businesses they serve for pickups and deliveries.

**SEATTLE RESULTS**

In the Seattle area, the same analyses were performed. The number of warehouses increased significantly in the study area, from 85 in 1998 to 212 in 2009, an increase of 149%. Figures 5 and 6 show the number of warehouses by zip code for these 2 years.

In 1998, Zip Code 98032 had the most warehousing establishments, and Zip Code 98134 was the only other zip code with more than seven (15). There were a total of 35 zip codes with a warehousing establishment, and 85 total warehousing establishments in the area. All but five zip codes had three or fewer warehouses. There was nothing to the west of Puget Sound, and only two zip codes with establishments in the Olympia area. The barycenter was plotted as a star.

By 2009, however, the total number of warehousing establishments had increased to 212. The number of zip codes with at least one warehousing establishment increased 74% from 35 to 61. To the southwest, there are now five zip codes with warehousing establishments compared with two in 1998. Where there had previously been nothing to the west of Puget Sound, there are now seven zip codes with at least one warehouse. There are also more zip codes with more warehousing establishments to the north.

The bulk of the new warehouses were built in the Kent–Renton area of Washington State. Zip Code 98032 had a 140% increase in the number of warehouses, from 15 warehousing establishments in 1998 to 36 in 2009. There was a high concentration of warehouses near the barycenter in 1998, and additional warehouses were constructed in all of those zip codes by 2009. The barycenter shifted 2.3 mi to the southwest between 1998 and 2009.

As was done with the Los Angeles data, the average distance of warehouses and all establishments from their barycenter was calculated, with results as follows:

- In 1998 the average distance of warehouses from the barycenter was 12.8 mi, which decreased slightly to 12.0 mi by 2009.
The average distance of all establishments from the barycenter was 16.3 mi in 1998, compared with 16.5 in 2009. These data suggest that establishments in the Puget Sound region have not sprawled significantly since 1998.

DISCUSSION AND DIRECTIONS FOR FUTURE RESEARCH

Warehousing in the Los Angeles area has increased in two geographically distinct places—in the metropolitan center, both in the city and in Los Angeles County near the city, and much farther from the city in western Riverside and San Bernardino Counties. The city of Los Angeles has long been a warehousing hub because of its proximity to the San Pedro Bay ports in California and has a long tradition of manufacturing. However there is limited room for further expansion because it is densely populated and there is little land available for development. Farther east in Riverside and San Bernardino Counties, there is more available land for new warehouses, and this land is considerably less expensive. Suburban and exurban areas such as these can connect to a more complex system of regional and national flows than can the more urban areas. Zip Code 91761, for example, had more establishments than any other zip code studied. While located farther away from the San Pedro Bay ports, this zip code connects to Interstate 15, Interstate 10, and State Route 60. Ontario International Airport is also located in this zip code (air cargo activity was 437,000 tons in 2012). In addition, many cities in these counties are taking steps to attract warehousing. The Coachella Valley Economic Partnership has stated that developing warehousing in the valley, which currently lies on the far eastern edge of the Inland Empire, is a high priority. Many have engaged in promotional activities to attract logistics such as Moreno Valley, California (16, 24).

In the Seattle area, the number of warehouses and zip codes with warehouses increased, including zip codes far to the southwest of the barycenter in Olympia, west across the Puget Sound, and north of Seattle. However few of these zip codes had more than one or two establishments. Only seven zip codes had more than five warehousing establishments in 2009, and all were located less than 12 mi from the barycenter. Zip Code 98032 in Kent, Washington, which has more than twice as many warehouses as any other zip code in the Seattle area, is approximately 10 mi by road to the port of Tacoma, Washington, and the port of Seattle, and is less than 2 mi from the Seattle–Tacoma International Airport. The significant clustering of warehouses in the Kent–Renton area, near the weighted geographic center, affected the distribution such that the overall distribution hascontracted slightly.

In Seattle, it was found that several zip codes that previously did not have any warehouses gained some. The effect of this expansion was mathematically negated by the much larger increase in warehouses near Kent, which is relatively close to both Seattle and Tacoma. In addition, Kent is very close to SeaTac International Airport and is located next to Interstate 5 and State Route 167, the two major north–south routes in the area.
Why is there a clustering, and increased concentration, of warehousing activity in the Puget Sound region, but sprawl in the Los Angeles area? Several factors may be significant, some of which provide opportunity for further research.

Local Factors

Some factors explaining the Seattle situation pertain specifically to Seattle. Zip Code Area 98032 is in a very favorable situation relative to the ports, airport, and freeways, and land was still available there at the end of the 1990s. Besides, there is a lack of available land elsewhere, the result, in part, of the physical geography of the Seattle metro area.

Size of Metropolitan Areas

One hypothesis is that logistics sprawl is characteristic of very large metropolitan areas, which serve both as trade nodes to the entire region and country as well as enormous consumer markets. Distribution centers need to be located close to regional infrastructure networks to serve the local, regional, and national economy. Differences in land prices (suburban–exurban land prices compared with central land prices) may also be more important in the largest metropolitan areas. To the authors’ knowledge, no empirical or theoretical studies are available that could verify a relationship between city size and warehouses’ locational behavior. Although not looking at this particular question, Hall and Hesse from several case studies identify an ideal typology of the relationship between places and goods flows, drawing lines between cities that clearly have very different sizes (17).

Growth Management

Growth management looks at ways of conditioning residential and other developments to the provision of necessary services (utilities, infrastructure) and the minimization of negative effects. It may have played a role in explaining the differences between Seattle and Los Angeles in regard to the siting of logistics activities, although this second hypothesis requires further research. Unfortunately, freight is generally omitted from the literature on growth management and sustainable transportation. Research assessing policy tools aimed at mitigating sprawl and the climate effects of transportation (25, 26) or proposing planning tools such as the “transport energy specification” are provided but do not mention freight (27). “Urban growth boundaries” and “form-based codes” are two planning strategies increasingly adopted in U.S. cities that are deemed interesting because they are regional and long term (28). These are the policies implemented by the states of Oregon, Washington, and Tennessee. Indeed, in 1990 the Washington State legislature adopted the Growth Management Act. The purpose of this act is to ensure coordination between local and state governments in regard to growth. Local governments are required to follow a comprehensive planning process for any potential developments. The act creates a framework that actually constrains...
how and where warehouses can be constructed and may have been affected how the distribution of warehouses has changed over time. However, specific assessment of the Growth Management Act on warehouses has not been made.

California has not implemented a similar policy of coordinated planning. SB375, the state’s CO2 mitigation through growth management legislation, leaves much leeway to local communities for final decisions on land uses. It has led to some interesting developments in freight planning. In 2011, for example, the San Diego Association of Governments (SANDAG) became the first urban region of California to adopt a sustainable communities strategy as a mandatory component of its regional transportation plan. Two actions directly related to freight land uses are included: “Update the SANDAG Regional Comprehensive Plan (RCP) to include policies, programs, and guidelines to integrate goods movement land uses and facilities, with minimal impact to adjacent communities” and “Support and provide assistance for the update of local general plans to identify the long-term needs of moving goods, industrial warehousing infrastructure, and connectors to the regional freight network. Coordinate this effort with economic studies and RCP updates.” SB375, however, is not comparable with the strategy adopted in Washington State. In metro Los Angeles, there happened to be a lot of open space to the east in the Inland Empire, the Riverside–San Bernardino–Ontario metropolitan area, which contributed to a substantial increase in the number of warehouses there. The increase in warehousing in the Inland Empire had the effect of expanding the region and moving the barycenter to the east. While roughly 60 mi by road from the ports of Los Angeles and Long Beach, California, these new warehousing districts are located in suburban areas near major freeways and an international airport. Because of the availability of cheap land, actions by suburban communities to encourage growth, and potentially, the lack of legislation to discourage growth, logistics sprawl is occurring in the Los Angeles metropolitan area.

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