Spatio-Temporal Analysis of Freight Patterns in Southern California

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Project Objective

Identify potential spatial and temporal changes in freight flow patterns in Southern California.

Problem Statement

Factors such as the economic recession, the rise of the on-demand economy, changes in the regulatory environment, population growth and urbanization have affected the distribution of goods. One example is the shift in the location of warehouses and distribution facilities away from consumer markets. This shift or logistics sprawl brings about unintended consequences such as increased vehicle miles traveled and concentration of freight activity in specific, usually disadvantaged, communities. In California, especially in Southern California, previous research showed an increase in the concentration of these facilities at longer distances from their primary delivery locations *(1-2)*. Additional research also showed that while the trend exists in the region, it has not continued at the same pace in the last decade, or it may have even reversed. The 2008-2009 recession and the growth of e-commerce activity are two of the main factors that potentially explain this phenomenon. These changes are relevant for freight planning because they do not only affect the location of the facilities, but also traffic generation and potential changes in vehicles used. For example, smaller facilities closer to customer may use smaller vehicles distributing smaller shipments at higher frequencies; or, the redistribution of the freight activity and supply chain configurations *(3-4)*.

Research Methodology

This study uses the California Department of Transportation (Caltrans) Weigh-in-Motion (WIM) data from stations located in Southern California from January 2003 to December 2015. WIM devices capture and record axle weight, speed, axle type, vehicle classification and gross vehicle weight for vehicles traveling at reduced or normal speeds over a measurement site *(5).* They help to identify vehicle compliance with weight limit regulations, or collect data for monitoring, planning and management purposes. Caltrans has installed WIM devices in about 150 sites across the State. This study processed 13 years of WIM data (2013-2015) for 39 stations in four districts in Southern California.

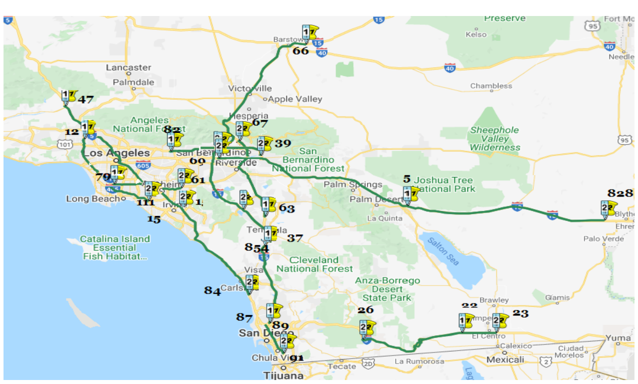

Figure 1 Location of WIM stations

Figure 1 shows the location of those WIM stations. Adopting similar spatial analysis used in the evaluation of logistics sprawl, the study conducts a centrographic assessment of the truck volume, and weight data (gross vehicle weight, and truck load ratio) for aggregated Light-, Medium and Heavy-Heavy duty truck categories. Centrography measures, for example, the distance of the agents of interest' (e.g., warehouse facility, count stations) location to their barycenter and the dispersion from that point *(1)*.

Results

The empirical results from the analysis of WIM data between 2003 and 2015 are consistent with previous studies about the presence of logistics sprawl in Southern California such as (2). Similarly, the analyses show there was a significant change in freight patterns before and after the 2008-2009 period, which again is consistent with the changes in facility location after 2007-2008 given by (2). Moreover, estimates for the different vehicle categories exhibit distinct geographic concentration and temporal patterns (when aggregated into Light-, Medium-, and Heavy-Heavy duty trucks).

The observed trends could be the result of new logistics needs, for instance the reduction of delivery costs based on the economic recession during 2008-2009 (and reduced import flows); e-commerce; policy and environmental implications; and/or land value and availability. However, the nature of the WIM data did not allow identifying the specific reason and their respective effects. Despite this, the results of this research show that the behavior (GWV, TLR, and Volume) of vehicle classes have significantly changed over time, and most of the statistical measurements of each vehicle class have a non-linear relationship, handled by the piecewise simple linear models analyzing the before and after the 2008-2009 trends.

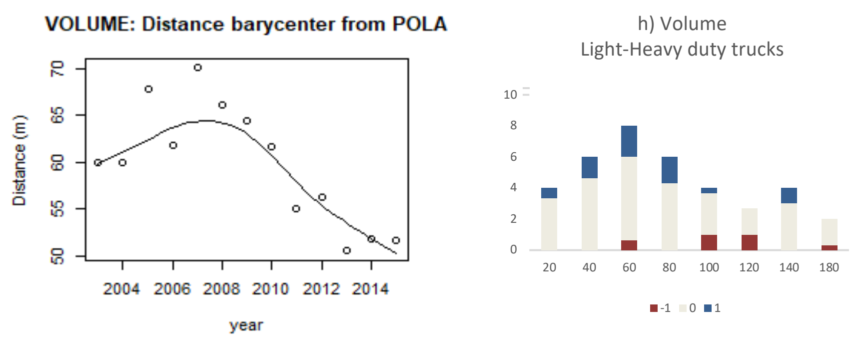

Figure 2 Distance of barycenter with time (left), volume changes in WIM stations with distance (right)

Two interesting result are: i) on average, the spatial concentration of the volume of vehicle class 5, the lightest heavy duty trucks, is moving closer to the reference point (Port of Los Angeles, or the LA core market). And, ii) their gross vehicle weight have decreased, though their volume have increased in the proximity of consumer market. Those two aforementioned results could be attributed to the growth in e-commerce. Strictly speaking, because of 1) more home deliveries, 2) population growth, 3) geographic shifting of distribution centers, because businesses have been purchasing, or renting facilities closer to the core markets for warehousing and distribution *(4)*. These facilities tend to be an order of magnitude smaller than traditional facilities in the Inland Empire. Consequently, with lesser capacities, and shorter time delivery windows, the transport of goods out of these facilities uses smaller vehicles with lesser loads.

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