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Nonlinearities in the relationship between the built environment and metropolitan structure with automobile and walking modal share

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Introduction

The evidence has shown that the built environment has a significant relationship with modal choices, however, there is not a consensus on the precise magnitudes and shapes of these relationships. To address this issue, we propose a new representation of the built environment that will let us capture the internal difference and the variability across different urban areas, and contrast it with travel choices. We use a method of spatial association to generate a new set of spatial units aggregated by spatial correlation of the measures. We apply the method to Los Angeles, New York City, San Francisco, and Seattle metro areas. Results show that there is a significant nonlinear association between the built environment and mode choice and reveal the importance of the relative location of the set of attributes within the metro area.

Methodology

The basic idea is to reduce the number of zones based on the built environment measures and increase the representativity of the sample with the heterogeneity of the built environment by clustering the zones. For the built environment we considered two attributes: population, the gross
population density, and activity density as the density of point of interest from OpenStreetMaps. These measures are set up to the census tract geometry.

For the clustering, we used the Getis-Ord Gi* method to test for spatial association (Ord and Getis, 2010). The Gi* indicator is computed using as an input the sum of the attribute of each zone and its neighbors. The cluster method divided the zone into 4 categories for activity and population density respectively. Consequently, with each of the two scores, for population or activity density, we combined them together generating a list of up to 16 possible combined scores for each zone (1-1, 2-1, 1-2,.., 4-3, 4-4). Here 4 has the highest levels of either population or activity density and 1 the lowest. Those polygons that share the same level are merged reducing significantly the number of tracts.

Finally, we matched the clustered spatial data with travel surveys of each of the metro areas and analyze the relationship with some visualization techniques and with linear regression.

Findings

The panel shows the modal share of walk and car of the travel surveys versus the raw measures of population and activity density for each of the aggregated clusters. We can see that resembles a logarithmic trend of walk share with activity and population density and in clearly nonlinear form. The car modal share is the inverse of walk modal share, as it decreases with population and activity density. This effect resembles a negative exponential pattern that it is more diffuse in New York and at larger values of activity and population density.

The linear regressions have a large adjusted R2, meaning that there is a large explanatory power of the built environment for walk and car mode choice. Levels 3 and 4 of the population density were significant for the walking model, while Levels 3 of population density and Levels 1, 2, and 3 for the activity density were significant for the car mode share. This suggests that the relative position in the metropolitan area plays a significant role in explaining the modal share.
For example, San Francisco in level 2 of population density has 31 people/hectare and 0.21 activities/hectare and a walking share of 11%. Seattle in level 3 has similar levels than those of San Francisco in level 2 with a population density of 28 people/hectare and 0.27 activities/hectare but with a walking share of 17%. This larger walking share that Seattle gets in level 3 is due to the boost that the relative position of the values of population density.

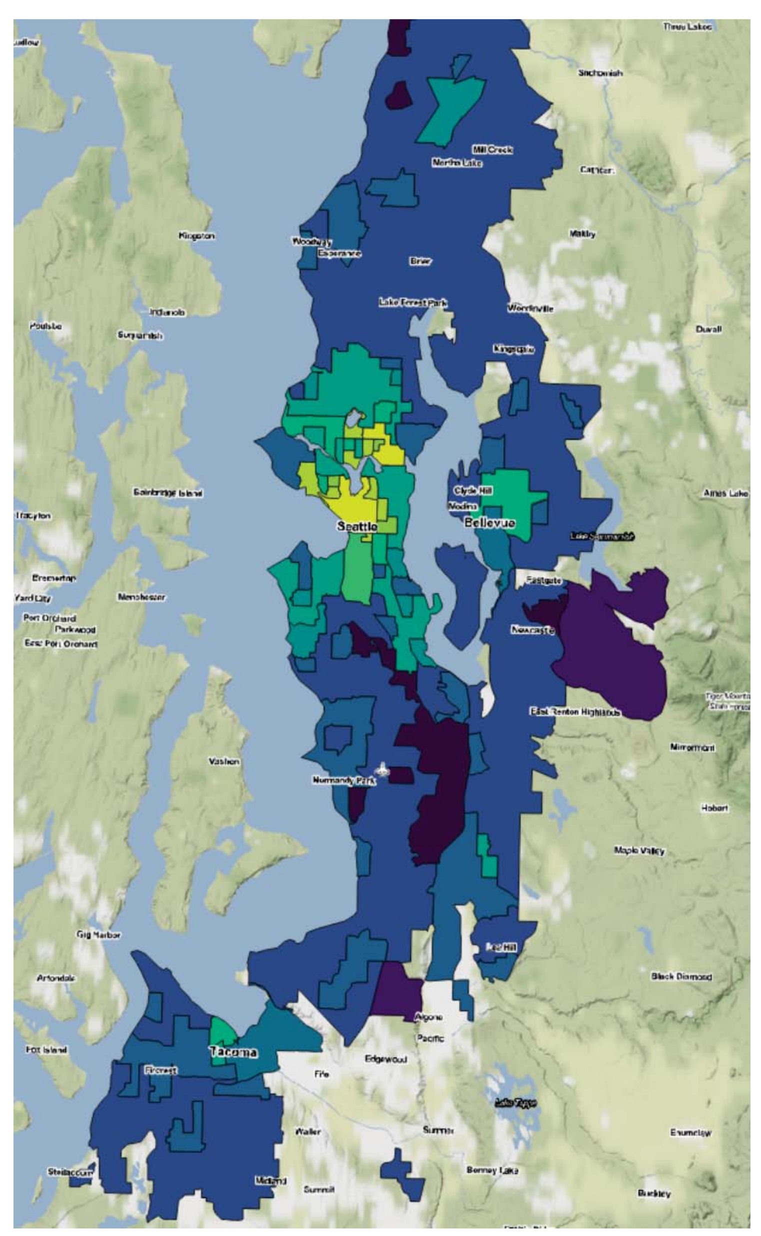
	Automobile		Walk	
Attributes	**Coef**	**p-value**	**Coef**	**p-value**
Intercept	91.11	0.00	3.62	0.00
sqrt(Population density)	-2.78	0.00	1.37	0.00
sqrt(Activity density)	-17.61	0.00	8.03	0.00
New York dummy	-11.76	0.00	5.87	0.00
Distance to central city (km)	0.10	0.00	-0.05	0.00
Level 3 population density dummy	-6.18	0.00	6.13	0.00
Level 4 population density dummy			6.87	0.00
Level 1 activity density dummy	5.42	0.00		
Level 2 activity density dummy	5.26	0.00		
Level 3 activity density dummy	5.06	0.00		
Mean median income (000s)	0.04	0.00	-0.02	0.02
R2 adjusted	0.85		0.72	

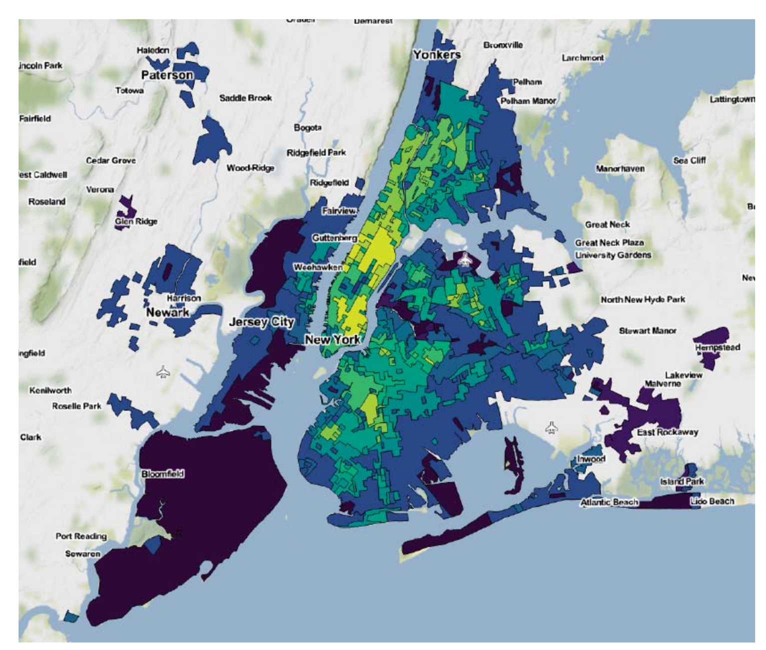
Conclusions

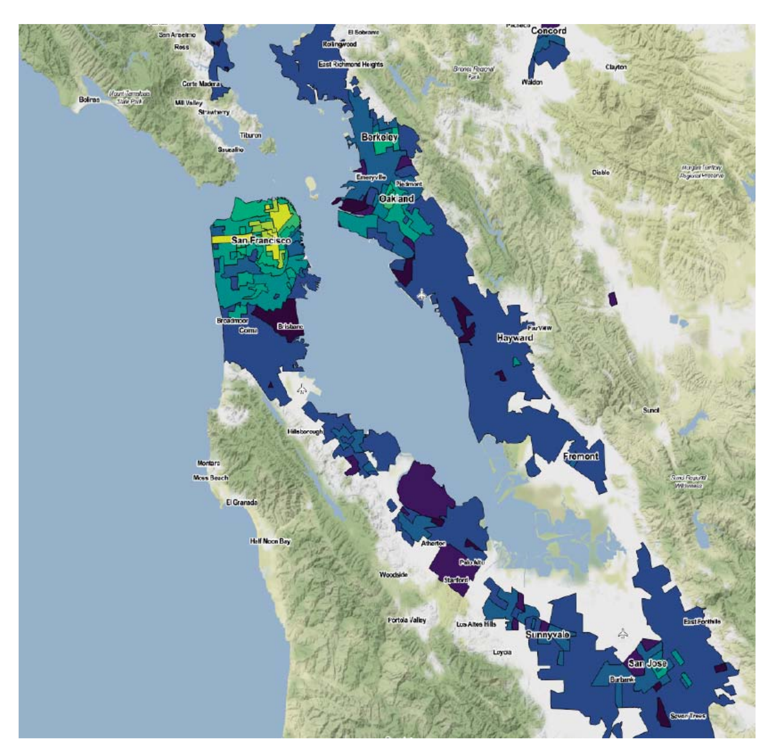
Our findings indicate that the clustering let us understand better the relationship of the built environment and travel choices due to the incorporation of the metropolitan structure in the development of the research. The analysis is conclusive as indicates a strong relationship between the built environment, the metropolitan structure, and the mode choice. This means that similar places with similarly built environment attributes could have a different travel pattern depending on the relative location and values of the attributes within the region. The increase of walk modal share and the decrease of car modal share is steeper with population density in areas with low population densities. Once a certain level of population density is reached, the changes are driven by the activity. If both measures are high, there is not much change in travel patterns with the built environment. Our analysis suggests that there could be a complementary effect of transit and walking in areas with higher population and activity density. This effect would take full form in the case of New York.

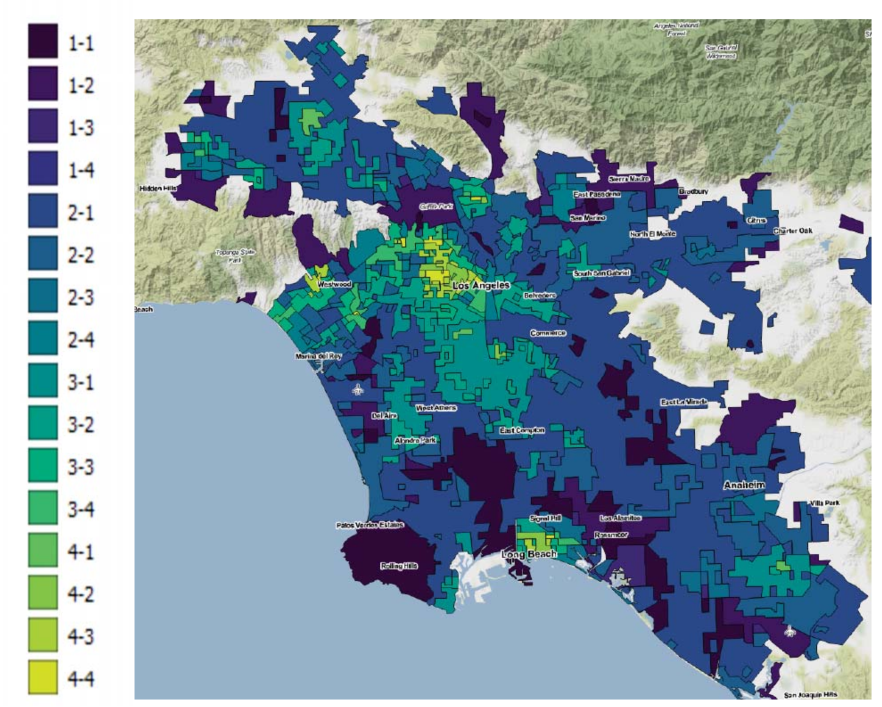
Clustering Results

Cluster type	Los Angeles	New York City	San Francisco Bay Area	Seattle
Population density level	Population density [people/ha]			
1	16	33	19	7
2	33	95	31	16
3	60	198	59	28
4	106	291	119	61
Activity density level	Activity density [activities/ha]			
1	0.03	0.07	0.07	0.07
2	0.06	0.29	0.21	0.11
3	0.15	0.79	0.63	0.28
4	0.30	2.41	1.65	1.00



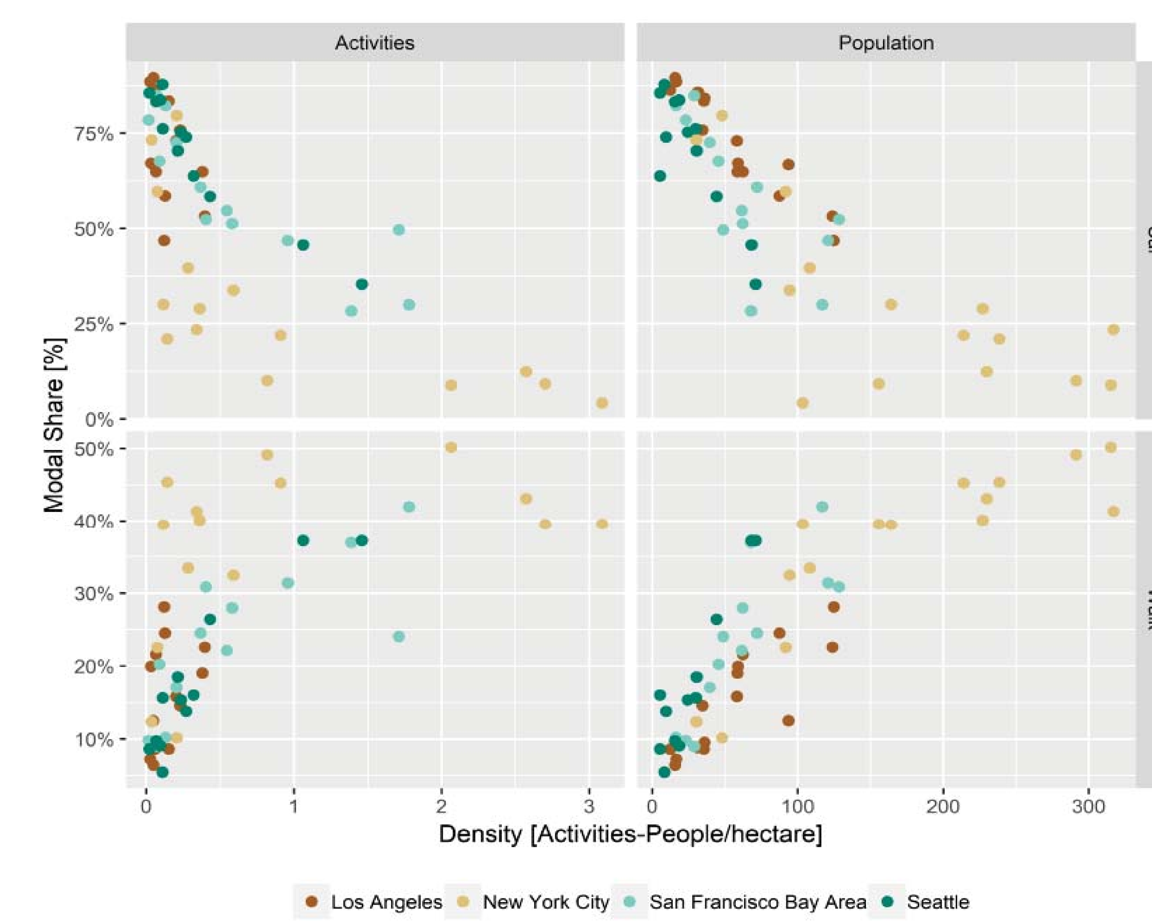






Each polygon has two scores from 1 (lowest) to 4 (largest) connected by a hyphen. The first number is the population density level and the second number the activity density level.

Mode Choice



The mode share of car and walk versus activity and population density aggregated by cluster