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LOCATIONAL PREFERENCES AND TRANSPORTATION MODE CHOICE OF DIFFERENT SOCIO-ECONOMIC GROUPS IN THE US:

A space syntax included case study of two gridded and two non-gridded cities.

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ABSTRACT

It is well understood that transport mode choice is effected by journey-distance and journey-time (Plaut 2005; Pucher and Dijkstra 2003; Schwanen and Mokhtarian 2005; Wardman, Tight, and Page 2007) We also know that configurational attributes effect the locations of retail and commercial activities (Hillier et al. 1993), and these in-turn influence residential location choices. Finally, specific socio-demographic groups have different preferences regarding their choices of transportation.

The research reported in this paper sought to investigate whether configuration, along with other planning variables, have a role on transportation mode choice. Since the regularity or deformity of urban grid may have an effect on Space Syntax analysis (Ratti 2004a, 2004b, 2005), two gridded and two non-gridded US cities were chosen. For this investigation seven land use variables, ten socio-economic and demographic variables, and three transportation variables in addition to six traditional Space Syntax variables were collected and used.

Data were assembled from online open source databases of the respective cities and the US census bureau. Space Syntax topological and angular analysis of CAD drawn axial lines and street centerlines extracted from GIS maps were performed. ArcGIS spatial analysis tools were applied to combine land use, socio-economic & demographic, transportation and Space Syntax variables to the scale of census block-groups that was selected as the study unit. Several multiple regression and linear regression analyses indicated that renters and non-family households are configurationally separated from homeowners and family households: the former locating themselves in integrated areas where businesses are located. Homeowners and family households prefer segregated areas and tend to drive to work. The results also indicated a definite role of city layouts. One important variation observed in our comparative analysis between gridded and non-gridded cities was that choice was an important indicator for gridded cities while integration was for non-gridded ones. Although the reason for this is speculative at this point, this distinction will serve as an important beginning for future investigations and understanding the particular syntactic properties of gridded American cities.

KEYWORDS

Space Syntax, Gridded Cities, Transportation Mode, GIS, Residential Location

1. INTRODUCTION

Over the past three decades, space syntax theory has provided important computational support for the development of spatial morphological studies to analyze both architecture and urban systems. It has been widely used for modelling pedestrian and vehicular movements (Hillier, Penn, Hanson, Grajewski, & Xu, 1993), crime analysis (Jones & Fanek, 1997; Nubani & Wineman, 2005), traffic pollution control (Penn & Croxford, 1997), and way finding processes (Haq, 2003; Peponis, Zimring, & Kyung, 1990). Space syntax provides a configurational description of an urban structure and attempts to explain human behaviors and social activities. This paper investigates whether space syntax variables have any significant relationship with preferences of residential locations and choices of travel mode. To that end, two pairs of American cities (two gridded and two non-gridded) are selected as case studies. This also provides some indications whether the gridded-ness of urban form has any effect on the strength of relationships that space syntax may have with choices of travel mode and preferences of residential locations. Additionally, a new methodology of considering configuration values, one that considers urban areas instead of linear elements, is introduced.

1.1 OBJECTIVE OF THE STUDY

Configuration of the urban grid is an important generator of aggregate patterns of movement in urban areas (Hillier et al., 1993). Retail and commercial land uses migrate to these configurationally hotspot locations to take advantage of the economic opportunities created by movement (Hillier, 1996). This study realizes that these retail and commercial areas are also work places for a good number of people. Since distance of residential location from work is an important factor affecting the choices of transportation mode, this paper aims to investigate the preferences of homeowners and family households on residential locations as opposed to renters and non-family households in the context of configuration. There is a common understanding that renters being more mobile can revise location decisions more easily than homeowners who might be constrained by a larger set of non-flexible housing options. Hence, the study will examine what relationships might exist between tenure type, household type, and travel mode choice. The other objective of this study is to examine the differences between the syntactic properties of gridded and non-gridded cities in the study of transportation mode choice.

1.2 HOW IS CONFIGURATION RELATED TO LAND USE AND TRANSPORTATION?

A series of papers (Hillier et al., 1993; Hillier, 1996, 1999), now classic, have outlined a generic process by which spatial configurations, through their effect on movement, first shape, and then are shaped by, land-use patterns and densities. Inherently land use pattern follows the hidden property of spatial configuration. Some movement-attractive land uses naturally migrate to more integrated streets (axial lines). The process of attracting uses and multiplying movement has a cyclic nature shaping the land use pattern of urban areas (Hillier, 1996; Thakuriah, Metaxatos, Lin, & Jensen, 2012). Topçu, Topçu, and Deniz (2007) states "The layout of space first generates movement, then movement-seeking land use migrates to movement-rich lines, producing multiplier effects on movement which then attract more retail and other uses, and this leads to the adaptation of the local grid to accommodate the greater density and mix of uses. This dynamic process is called the "movement economy".

2. METHOD AND DATA

The primary criterion used for selecting the case studies was urban grid form. This research aimed to compare the syntax performance of gridded and non-gridded urban form on predicting choices of residential locations and transport mode. However, the characteristics of gridded-ness or non-gridded-ness is not a duality; rather it is a continuous property where any city may fall at any point in a sliding scale ranging from a perfect grid to perfect organic urban form. Gridded cities have fewer but much longer streets, while non-gridded cities have a great number of shorter streets. Therefore, cities representing each kind of urban form were selected using the method illustrated in (Figure 1) below. After a comprehensive search of google maps of several cities and online public availability of city data, Boston and Pittsburgh representing non-gridded cities; and Lubbock and Salt Lake City representing gridded cities were selected.

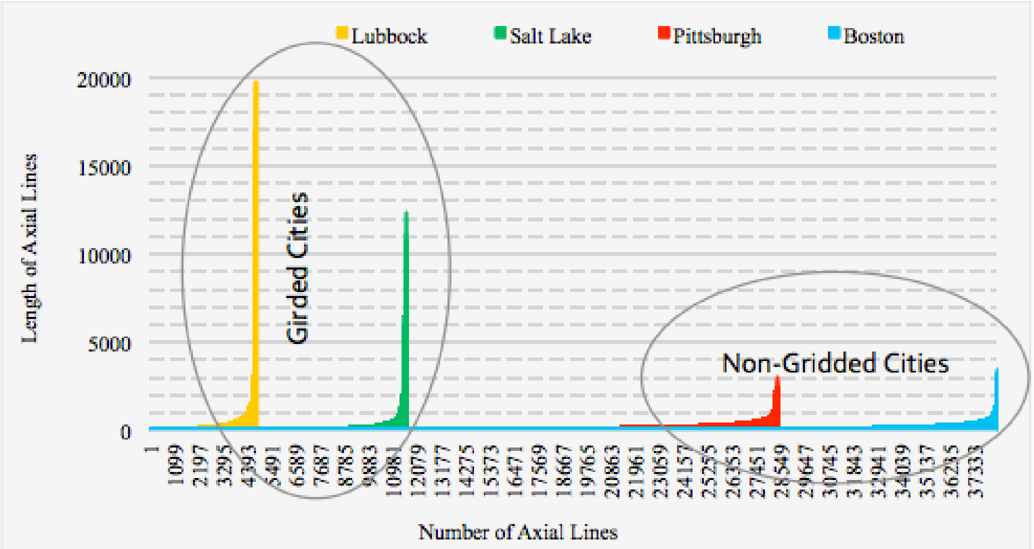


Figure 1 - Graph illustrating number of streets sorted by length

Data were assembled from online open source databases of the respective cities and the US census bureau. Space Syntax topological and angular analysis of CAD drawn axial lines and street centerlines extracted from GIS maps were performed. The angular and topological analysis were performed using axial lines. In addition, angular analysis was also computed using road centerlines. Therefore, six configuration variables were extracted as illustrated in table 1.

	Methods		
Measures of Syntax	Topological (Using axial lines)	Angular (Using segmented axial lines)	Angular (Using road centerlines)
Integration	Topological Integration	Angular Integration	Angular Integration
Choice	Topological Choice	Angular Choice	Angular Choice

Table 1 - Configurational Variables

2.1 OTHER VARIABLES

This exploratory study involved an extensive lists of variables to investigate the predictive power of space syntax variables explaining transportation mode choice. In developing models of transport mode choice through multiple linear regression, two dependent variables, and 27 independent variables were selected. They are shown in table 2.

Dependent variables		
1	Driving	The percentage of people in each census block group who chose to drive to work
2	Walking	Percentage of people in each census block group who chose to walk to work
Independent Variables		
Land Use Variables		
1	Population Density	Number of people per acre of each census block group
2	Street Density	Total length of streets (mile) divided by the area of census block group (Sq. mile)
3	Commercial Density	Area of commercial parcels (Sq. Mile) divided by the area of census block-group (Sq. mile)
4	Building Density	Sum of figure-ground of all buildings in a block group divided by the area of corresponding block group
5	Age of Buildings	The median age of buildings in each block group
6	Rental Vacancy Rate	Percentage of vacant houses for designated for rent
7	Number of Rooms	Median number of rooms of residential buildings in each block group
Transportation Variables		
8	Distance to PTS	Average distance of residential buildings to the nearest public transport stations or stops
9	Travel Time	Average travel time of journeys to work
10	Car Ownership	Median number of vehicles per person

Socio-economic and Demographic Variables		
11	Race Black	Percentage of Black population in each census block group
12	Race White	Percentage of White population in each census block group
13	Hispanic	Percentage of Hispanic population in each census block group
14	Family Households	Percentage of family households in each census block group (family household is defined as a householder and one or more other people related to the householder by birth, marriage, or adoption)
15	Non-Family Households	Percentage of non-family households in each census block group. (Nonfamily households consist of people who live alone or who share their residence with unrelated individuals)
16	Homeowners	Percentage of housing units occupied by owners
17	Renters	Percentage of housing units occupied by renters
18	Household Income	Median household income in each census block group
19	Household Size	Average household size
20	Gross Rent	Median gross rent per month
21	Property value	Median property value
Space Syntax Variables		
22	Topological Integration	Average topological integration values of axial lines in each block group
23	Angular Integration	Average Angular integration values of segmented axial lines in each block group
24	Centerline Integration	Average angular integration values of road centerlines in each block group
25	Topological Choice	Average topological choice values of axial lines in each block group
26	Angular Choice	Average angular choice values of segmented axial lines
27	Centerline Choice	Average angular choice value of road centerlines in each block group

Table 2 - List of variables used

2.2 DATA AGGREGATION

Most studies in space syntax had approached comparing the linear properties of axial lines with variables of corresponding streets. This method is emanated from the assumptions that the effect of syntactic properties of linear elements (streets) are limited to the spaces or properties adjacent to the corresponding streets only. On the contrary, this paper assumes that the effect of syntactic properties of a street transcends the adjacent blocks and extends to the surroundings (Berhie & Haq, 2015). To that end, a new method is employed using GIS tools. Here, aggregate configuration values of census block groups (the spatial unit of the study) are taken into consideration to examine the effect of space syntax on choices of transportation mode and residential location.

As described earlier, the study began with the assumption that integrated areas attract retail and commercial activates which also become workplaces for a good number of people. It is also assumed that people who walk or bicycle to work will choose to stay close to their place of employment. Therefore, this study expects to find more walkers and bikers living close to integrated areas -- not necessarily in the integrated streets themselves. From this point of view, the investigation had to be focused on defined areas of cities rather than streets or axial line (Berhie & Haq, 2015). Hence, the space syntax values of linear features had to be converted to the study unit (census block group) through aggregation process. As indicated in Figure 2, average values of segments that are overlaid in each corresponding block group (in Figure 2b) is computed and the values are displayed in Figure 2c.

a) Census block group polygons

b) Integration values of axial lines overlaid on census block group polygons

c) Average integration values transferred to census block group polygons

Figure 2 - Procedure of converting configuration values of axial lines to census block-group polygons

The colors represent integration values ranging between red indicating most integrated and blue most segregated areas

This was the method used to convert all variables into census block group of all four cities. Examples are shown in Figures 3 and 4 below.

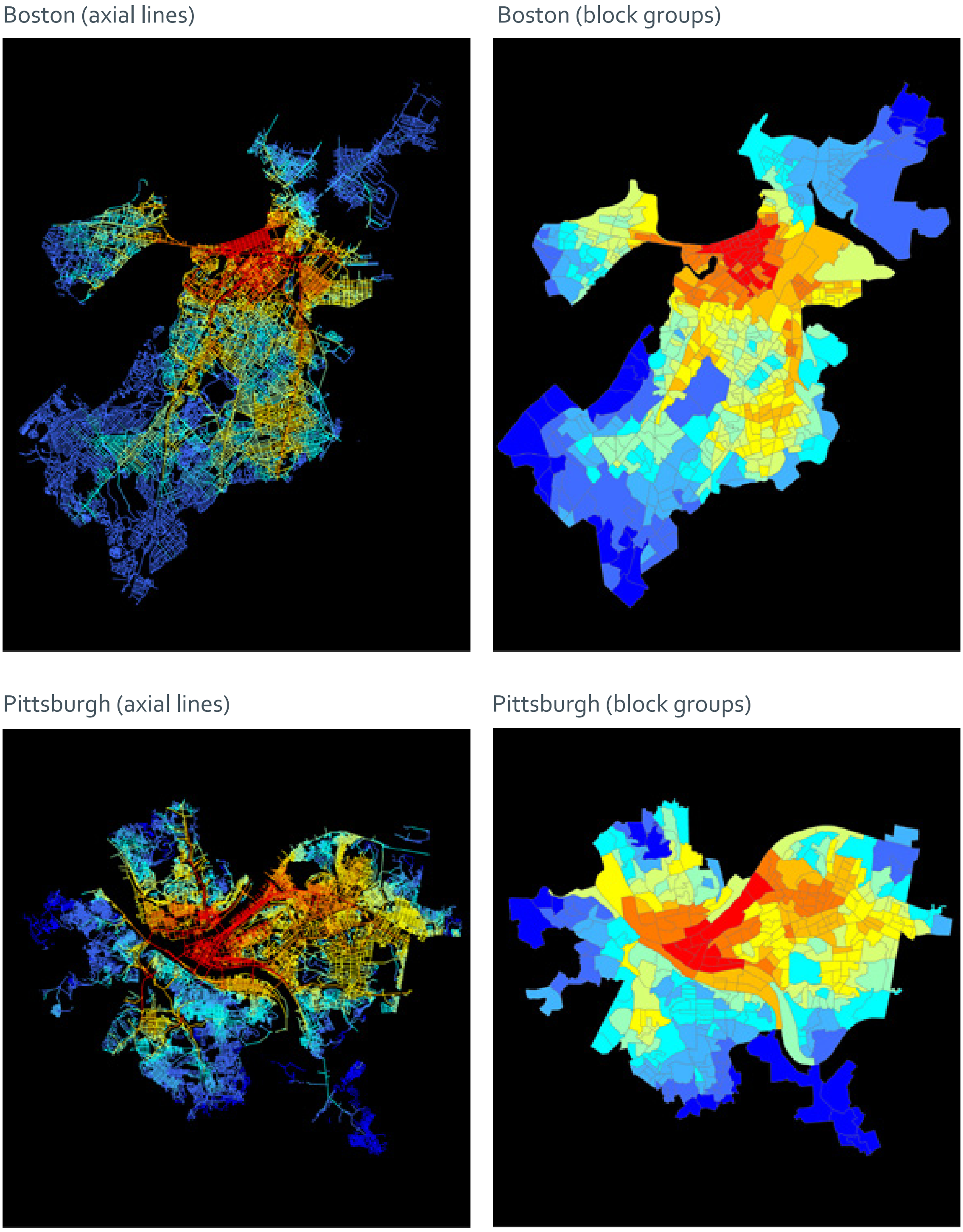


Figure 3 - Illustration of converting topological integration values of axial map (left) to average integration values of census block groups (right) of non-gridded cities

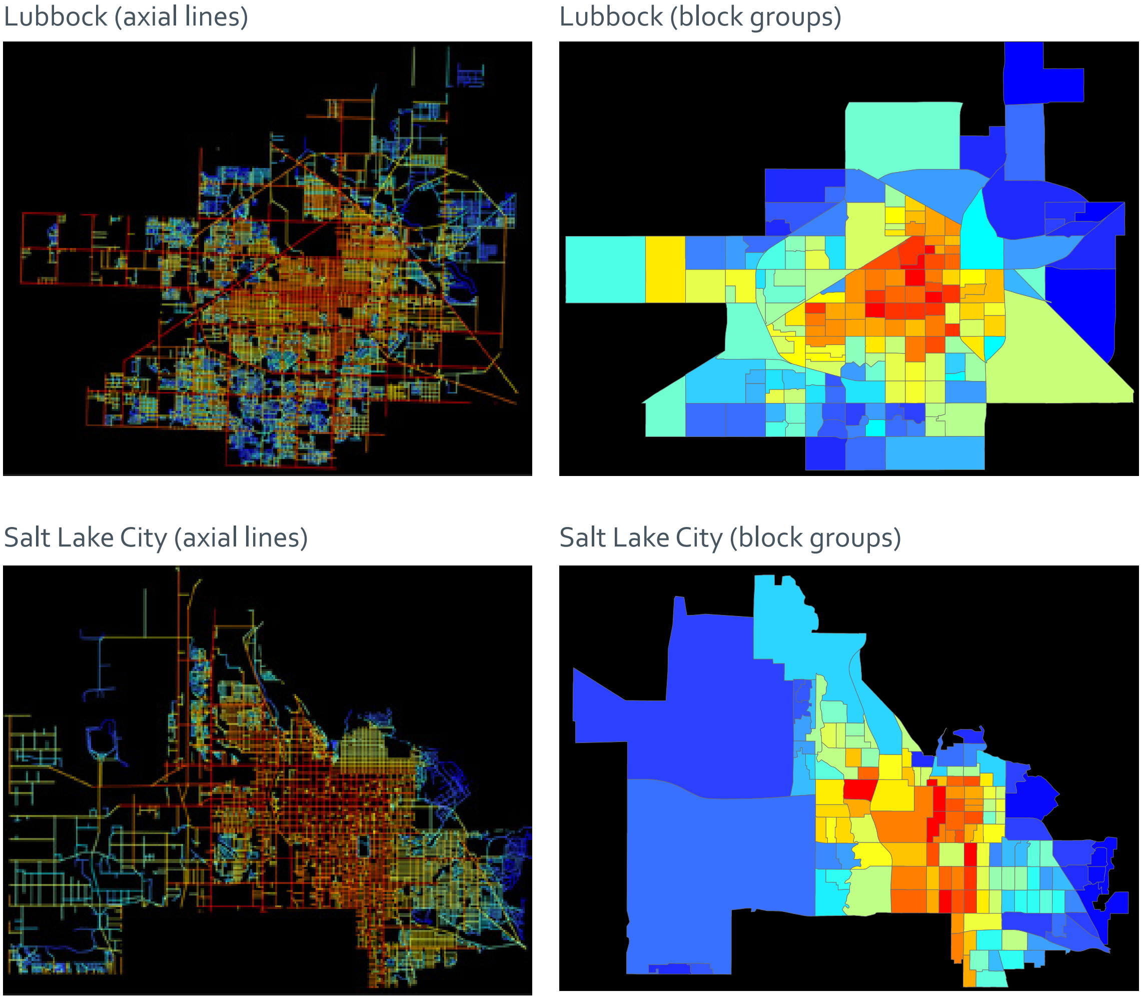


Figure 4 - Illustration of converting topological integration values of axial map (left) to average integration values of census block groups (right) of gridded cities

This study acknowledges that aggregating space syntax data to the census block groups may have weakened the linear descriptive power of axial lines. However, the distribution of axial values across the city remains similar, and can be visually clarified in Figure 4. The pattern and locations of the integration are similar in both axial and census block group maps. One real world advantage of this aggregation method is that it offers significant reduction of data collection costs and efforts because it allows the use of census data that are publicly available (Berhie & Haq, 2015).

Similarly, other variables that are not in the scale of census block-group were also converted to the common spatial unit of the study by the same aggregation method. This means the data that are available at smaller geographical features than census block groups are converted into average values for census block groups.

2.3 ANALYSIS

US census considers four modes of transportation. They are driving, walking, public transport and bicycling. Among them only choices of driving and walking are reported in this analysis. A series of statistical analysis were undertaken to select the best models for each transport mode. Since a large dataset were considered, the research began with a diagnostic test to detect multicollinearity problems between the independent variables. The observed collinearity was not similar in all cities; however, the common collinearities were between races types, homeowners & renters, and the three integration variables. During each step of the collinearity diagnostics test, one variable with highest variance inflation factor (VIF) value was eliminated. The procedure continued until the VIF values of all variables were below 10.

The integration values computed in three different methods (topological integration of axial lines, angular integration of segmented axial lines and angular integration of road centerlines) showed strong correlation as (see Figure 5). This was not a surprise as the three integration variables are meant to measure similar configurational accessibility. However, this test enabled us to display their direct correlation with each other. In previous researches, it was not possible to test their direct correlation to each other since these three syntax variables use different type of lines. Their indirect correlation was only implied from the correlation each had with observed pedestrian and vehicular movement (Turner, 2001).

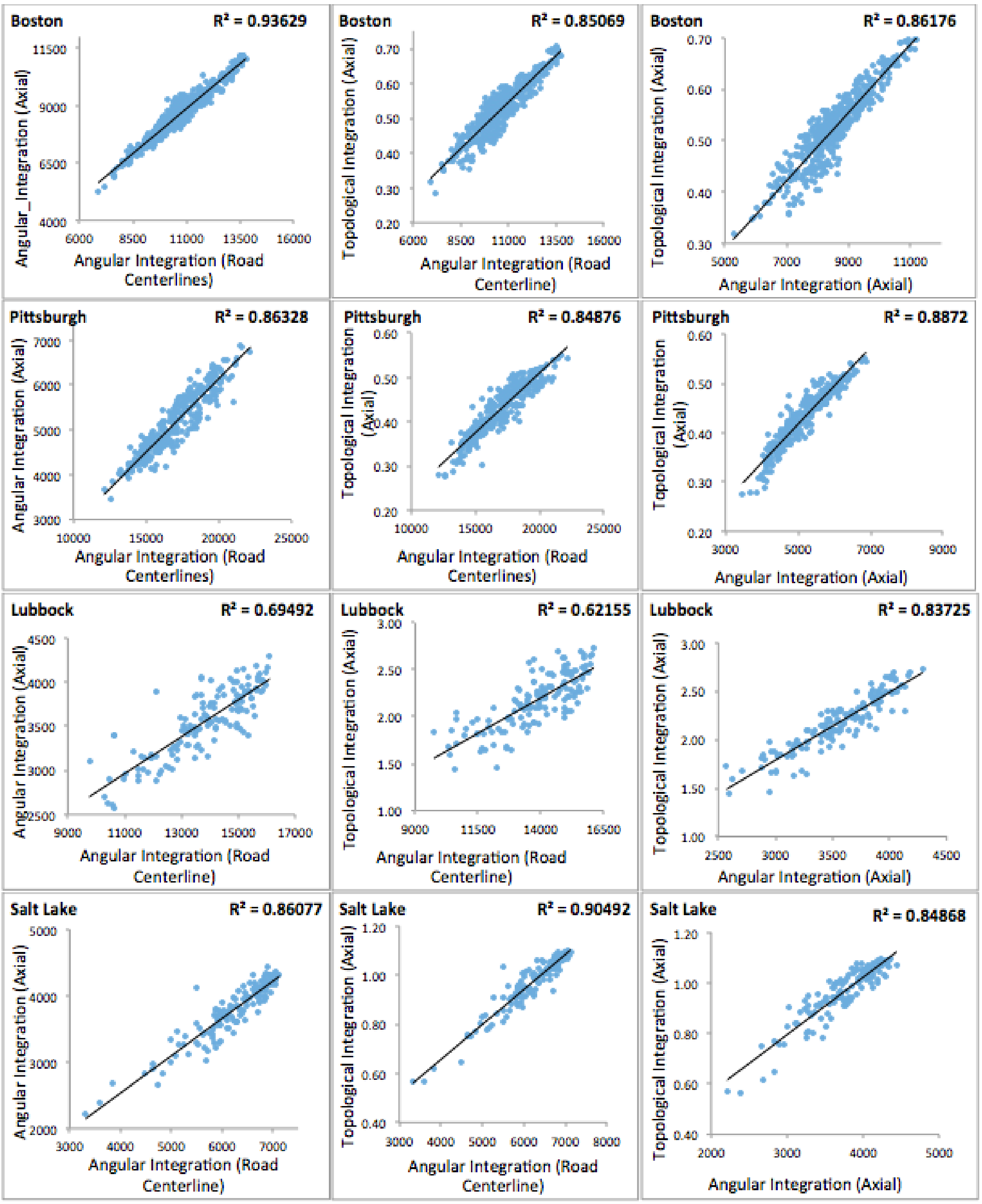


Figure 5 - Correlation between topological integration of axial lines, angular integration of segmented axial lines and angular integration of road centrelines.

Forward regression analysis was performed using SPSS statistical software to select the best model that most explain each of the four dependent variables. Two multiple regressions analysis (one for each transport mode) were performed in each city and a model for each dependent variable was selected with sets of significant independent variables. In addition, a series of simple linear regressions between different variables was performed to analyze the effect of configuration on housing location choice and its implication to the preference variations among homeowners & renters, and family and non-family households.

3. RESULTS AND DISCUSSIONS

As indicated earlier, this research had four goals. The first was whether space syntax is significant to explain transport mode choices for journeys to work places in addition to the variables previously identified in transport planning researches. Second, the study aimed to examine the effect of configuration on residential location choices, particularly to explore variance in residential location preferences among homeowners, renters, family and non-family households. Third, the study attempted to investigate the difference between gridded and non-gridded cities in their effect of configuration on transport mode and residential location choices.

Multiple regression analysis was performed to see if space syntax variables are selected within the models for both dependent variable (Walking and Driving). In addition, multiple simple linear regressions were done to examine the possible relationships of tenure, household type with configuration and travel mode.

3.1 EFFECT OF CONFIGURATION ON TRANSPORT MODE CHOICES

Two dependent variables (Driving & Walking) and 27 independent variables were included in our analysis. Factors affecting mode choices were analyzed using multiple regression models particularly forward and stepwise. One model with sets of explanatory variables was produced for each transportation mode (dependent variable). Both forward and stepwise regression methods produced identical results for all dependent variables in all four cities. The statistical results are discussed below.

3.1.1 DRIVING MODE CHOICE

Table 3 summarizes the multiple linear regression analysis results of driving mode choices. The adjusted R-square value for driving in Boston is 0.61, Pittsburgh 0.55, Lubbock 0.28, and Salt Lake City 0.61. This implies that about 61 percent variation of driving in Boston can be explained by regressing eleven variables listed in the model. Similarly, 55 percent of variation in driving in Pittsburgh is explained by nine variables listed in the model. In Salt Lake City 61 percent of variations are explained by the seven variables. However, only 28 percent of variations in driving can be explained by only four variables in the city of Lubbock.

	BOSTON ---- R2 = 0.62, Adj. R2 = 0.61					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.54	0.09	6.09	0.00	0.36	0.71
Travel time	-0.004	0.00	-3.74	0.00	-0.01	0.00
Topological integration	**-0.32**	**0.10**	**-3.02**	**0.00**	**-0.52**	**-0.11**
% of Hispanic population	-0.10	0.04	-2.40	0.02	-0.18	-0.02
% of family households	0.18	0.05	3.57	0.00	0.08	0.28
% of Renters	-0.16	0.04	-3.84	0.00	-0.24	-0.08
Average household size	0.04	0.02	2.47	0.01	0.01	0.08
Median number of rooms	0.03	0.01	2.77	0.01	0.01	0.05
Car ownership	0.28	0.03	10.68	0.00	0.23	0.34
Median gross rent	-1E-04	0.00	-5.39	0.00	0.00	0.00
Median property value	-9E-08	0.00	-1.99	0.047	0.00	0.00
Street density	-7E-04	0.00	-4.27	0.00	0.00	0.00

	PITTSBURGH ---- R2 = 0.56, Adj. R2 = 0.55					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.94	0.11	8.3	0.00	0.72	1.16
Travel time	-0.003	0	-3.05	0.00	-0.01	0
Topological integration	**-1.01**	**0.18**	**-5.59**	**0.00**	**-1.37**	**-0.66**
% of White population	0.07	0.03	2.19	0.03	0.01	0.13
% of Asian population	-0.23	0.11	-2.16	0.03	-0.45	-0.02
% of family households	0.17	0.06	2.91	0.00	0.06	0.29
Median household income	1.6E-06	5.3E-07	3.06	0.00	6E-07	2.7E-06
% of renters	-0.15	0.05	-2.99	0.00	-0.25	-0.05
Car ownership	0.16	0.03	5.69	0.00	0.11	0.22
Median property value	-5.00E-07	0	-4.6	0.00	0	0

	LUBBOCK ---- R2 = 0.30, Adj. R2 = 0.28					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	107.31	3.35	32.03	0.00	100.68	113.93
Travel time	-0.56	0.17	-3.27	0.00	-0.9	-0.22
Topological choice	**-1.50E-05**	**0**	**-2.92**	**0.00**	**0**	**0**
% of Asian population	-0.53	0.15	-3.6	0.00	-0.83	-0.24
Rental vacancy rate	-0.66	0.12	-5.33	0.00	-0.91	-0.42

	SALT LAKE CITY ---- R2 = 0.64, Adj. R2 = 0.61					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	55.46	9.62	5.77	0.00	36.43	74.48
Travel time	-0.81	0.25	-3.25	0.00	-1.31	-0.32
Topological choice	**-2.20E-06**	**0**	**-2**	**0.047**	**0**	**0**
Distance to PTS	0.01	0	4.11	0.00	0	0.01
Car ownership	15.49	3.43	4.52	0.00	8.71	22.27
% of family households	0.26	0.07	3.51	0.00	0.11	0.4
Average household size	6.38	2.16	2.96	0.00	2.11	10.66
Median property value	-4.10E-05	0	-5.42	0.00	0	0

Table 3 - multiple regression models for driving transport mode.

The models contain some common variables, for instance, travel time is significant to explain driving mode choice in all cities, while property value, car ownership, and percentage of family households were found to be significant in the models of three cities (Boston, Pittsburgh, and Salt Lake). Similarly, variables regarding socio-economic and demographic attributes such as household size, percentage of renters, and variables related to configuration i.e. topological integration and choice each appeared twice out of the four models. An interesting aspect to note on this research is that, space syntax variables were selected in all four models. However, topological integration of axial lines was selected in the models of Boston and Pittsburgh and topological choice of axial lines was included in the models of Lubbock and Salt Lake. These disparities seem to group the cities into two types, gridded and non-gridded. Accordingly, integration was important for non-gridded cities and choice for gridded ones.

A negative relationship between configuration variables and driving mode were found to be invariant in all cities. This suggests that keeping all other variables constant, people who live in topologically segregated neighborhoods of non-gridded cities (Boston and Pittsburgh) are likely to drive to work than people living in integrated areas. Similarly, workers who live in neighborhoods with lower values of topological choice in gridded cities (Lubbock and Salt Lake City) are likely to choose driving than people in areas of higher choice values.

3.1.2 WALKING MODE CHOICE

Table 4 summarizes the results of multiple regression analysis for walking choice in the four cities. Ten variables listed in the model explain 61 percent variation of walking in Boston, nine variables explain 50 percent variation in Pittsburgh, 4 variables explain 26 percent variation in Lubbock and 4 variables explain 40 percent of variation in Salt Lake City.

	BOSTON ---- R2 = 0.62, Adj. R2 = 0.61					
	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	0.18	0.08	2.33	0.02	0.03	0.33
Travel timet3	-0.01	0	-6.24	0.00	-0.01	0
Topological integration	**0.63**	**0.09**	**7.06**	**0.00**	**0.45**	**0.81**
Average household size	-0.04	0.01	-2.82	0.00	-0.06	-0.01
Median number of rooms	-0.02	0.01	-2.42	0.02	-0.04	0
Median building age	-0.001	0	-2.01	0.04	0	0
Car ownership	-0.13	0.02	-5.65	0.00	-0.18	-0.09
Median gross rent	4.00E-05	0	2.92	0.00	0	0
Median property value	2.00E-07	0	4.17	0.00	0	0
Commercial density	0.1	0.04	2.46	0.01	0.02	0.17
Building density	0.19	0.07	2.57	0.01	0.04	0.33

	PITTSBURGH ---- R2 = 0.56, Adj. R2 = 0.55					
	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	-0.01	0.08	-0.1	0.92	-0.17	0.15
Travel time	-0.004	0	-5.02	0.00	-0.01	0
Topological integration	**0.45**	**0.11**	**4.13**	**0.00**	**0.23**	**0.66**
% of Asian population	0.2	0.08	2.61	0.01	0.05	0.35
% Family households	-0.24	0.05	-5.22	0.00	-0.33	-0.15
Median household income	-1.20E-06	0	-3.33	0.00	0	0
Average household size	0.07	0.02	3.95	0.00	0.04	0.11
Car ownership	-0.04	0.02	-2.12	0.03	-0.08	0
Median property value	3.70E-07	0	4.64	0.00	0	0
Commercial density	0.23	0.07	3.54	0.00	0.1	0.36

	LUBBOCK ---- R2 = 0.28, Adj. R2 = 0.26					
	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	1.5	3.83	0.39	0.7	-6.09	9.08
Travel time	0.24	0.12	2.07	0.04	0.01	0.47
Topological choice	**8.70E-06**	**0**	**2.49**	**0.01**	**0**	**0**
Rental vacancy rate	0.45	0.09	4.91	0.00	0.27	0.63
Median no of rooms	-1.15	0.54	-2.13	0.03	-2.22	-0.08

	SALT LAKE CITY---- R2 = 0.43, Adj. R2 = 0.403					
	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	15.22	4.88	3.12	0.00	5.55	24.88
% of Renters	0.13	0.03	4.28	0.00	0.07	0.20
% of Hispanic Population	-0.10	0.03	-3.16	0.00	-0.16	-0.04
Car Per Person	-6.89	2.18	-3.17	0.00	-11.20	-2.59
% of Family Household	-0.08	0.04	-2.03	0.04	-0.15	0.00
Number of Commercial Parcels	0.05	0.02	2.55	0.01	0.01	0.09
Angular Choice	**4.2E-07**	**0.00**	**-2.23**	**0.03**	**0.00**	**0.00**

Table 4 - Multiple regression model for walking mode

The models for walking choice include some common and significant variables. Car ownership and percentage of family household are negatively correlated to walking mode. Like the models of driving illustrated in section 4.1.1 above, topological integration was selected among other variables that explain walking in the non-gridded cities (Boston and Pittsburgh). Choice was included in models of gridded cities (Lubbock and Salt Lake City). Unlike the driving models of gridded cities, a slight difference is observed in walking models. The difference is that angular choice is selected in Salt Lake City while topological choice in Lubbock. Once again, topological integration is among the top variables that obtain 0.00 P-values implying that space syntax is important in predicting walking mode for these particular cities.

The positive coefficients of space syntax variables in all four cities imply that all other variables being equal, people who live in topologically integrated neighborhoods of non-gridded cities (Boston and Pittsburgh) are likely to walk to work places than people living in segregated areas. Similarly, workers who live in neighborhoods with higher values of topological choice in gridded cities (Lubbock and Salt Lake City) are likely to choose walk than areas of lower choice values.

	Non-Gridded Cities		Gridded Cities	
Transport Mode	**Boston**	**Pittsburgh**	**Lubbock**	**Salt Lake City**
Driving	Topological Integration (-ve)	Topological Integration (-ve)	Topological Choice (-ve)	Topological Choice (-ve)
Walking	Topological Integration (+ve)	Topological Integration (+ve)	Topological Choice (+ve)	Angular Choice (+ve)

Table 5 - Summary of space syntax variables selected in multiple regression models of driving and walking

Note: All angular choice in the table are meant angular choice of segmented axial lines.

Table 5 depicts the variation between gridded and non-gridded cities on the type of syntax variables selected in both modes of transportation. Integration was included in the models of both driving and walking for non-gridded cities while choice was selected for gridded cities.

3.2 EFFECT OF CONFIGURATION ON RESIDENTIAL LOCATIONS

Residential location preference variations are observed among different social and demographic groups of people. This included between homeowners and renters, and between family and non-family households. The preferences on residential locations have consistently affected the choices of travel mode. The reader should remember that family household is defined as a householder and one or more other people related to the householder by birth, marriage, or adoption. Non-family household consists of people who live alone or who share their residence with unrelated individuals. These two groups of variables are mutually exclusive and their relationship with any variable is always opposite.

3.2.1 HOMEOWNERS AND RENTERS

A choice of residential location is an intricate subject, which involve numerous factors. This study focuses only on location preferences in the context of street configuration. Particularly, we wanted to understand if configuration contributes to residential location choices and affects decisions of transport mode choices. From the simple linear regressions indicated in Figure 6, a notable asymmetry is observed between renters and homeowners in terms of their respective decisions in the context of configuration. Renters prefer to live in integrated areas while homeowners choose segregated neighborhoods. The two groups seem to consider different factors in their decisions on residential locations.

A remarkable discovery of this research is that location preference of homeowners and renters can be explained by configuration values in all four cities with no regard to city layout. Figure 6 shows that in all cities, renters positively correlate with topological integration values while homeowners do negatively. This implies that renters are likely to choose configurationally integrated neighborhoods, while homeowners prefer segregated areas. Eventually, this disparity in location preferences has revealed considerable differences in their choice of transport mode. This propensity for a specific mode of transportation is discussed now.

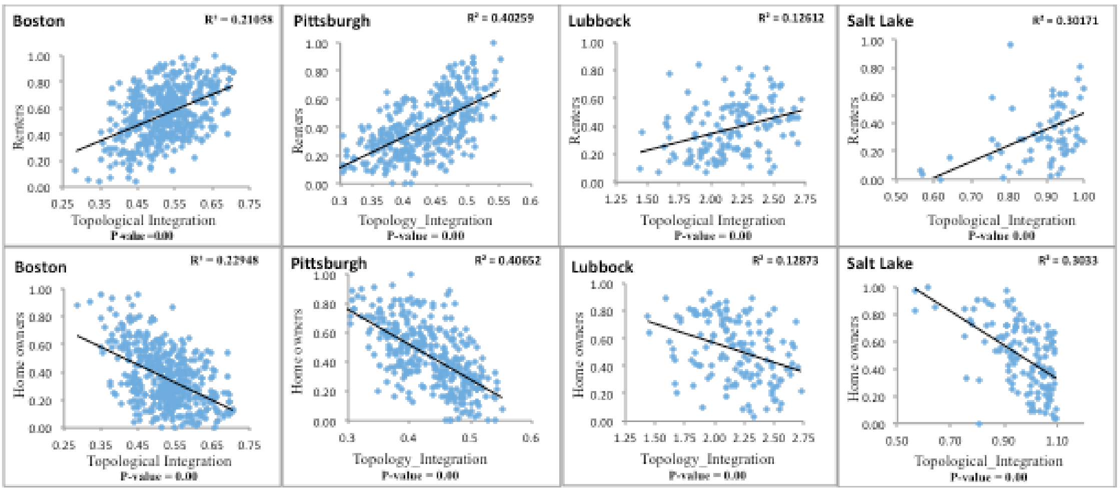
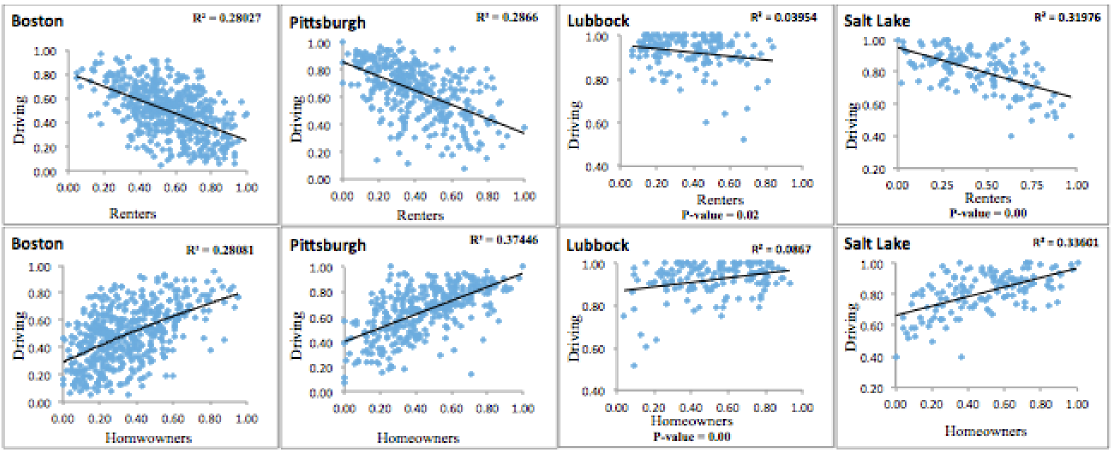


Figure 6 - Scatterplot illustrating the relations of integration with homeowners and renters

3.2.1.1 PROPENSITY FOR DRIVING

Figure 7 depicts that homeowners and renters have opposite preferences regarding driving mode. Homeowners are positively correlated with driving and renters negatively. Since homeowners prefer locations of configurationally segregated area, they are likely to drive more to work. On the contrary, renters seem to prefer configurationally integrated area and therefore, they tend to drive less. Although the strength of the relationships seems weaker in Lubbock, all relationships are consistent in all cities.

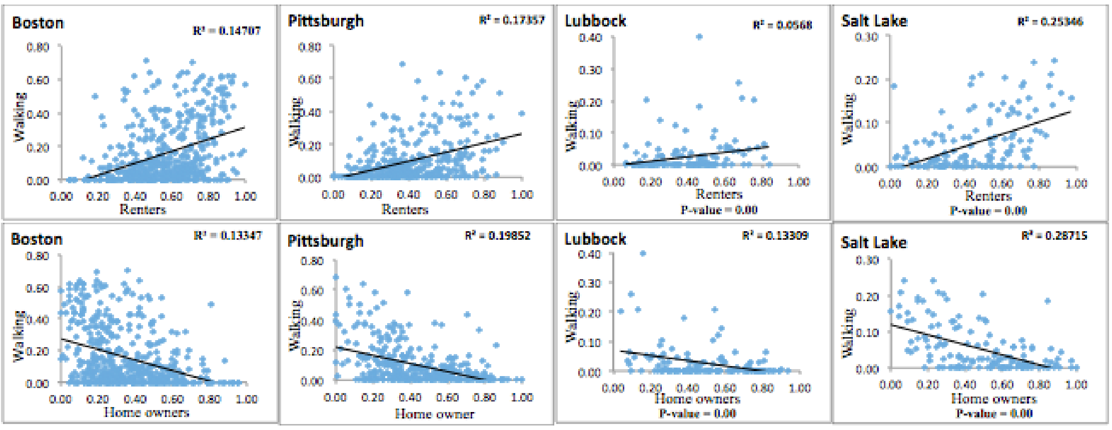


All P-values are less than 0.05

Figure 7 - Propensity of homeowners for driving

3.2.1.2 PROPENSITY FOR WALKING

Unlike for driving, renters positively correlate with walking and homeowners do negatively (Figure 8). This demonstrates that renters lean toward walking. This perhaps has to do with the preferences of residential location. Renters prefer to live in configurationally integrated areas. These areas are the same locations where commercial and retails migrate to take the economic advantages of movement attracted by configurational properties understood by integration. These land uses are also work places. In other words, renters are likely to live in close proximity to their work places making it easier to walk to their work.



All P-values are less than 0.05

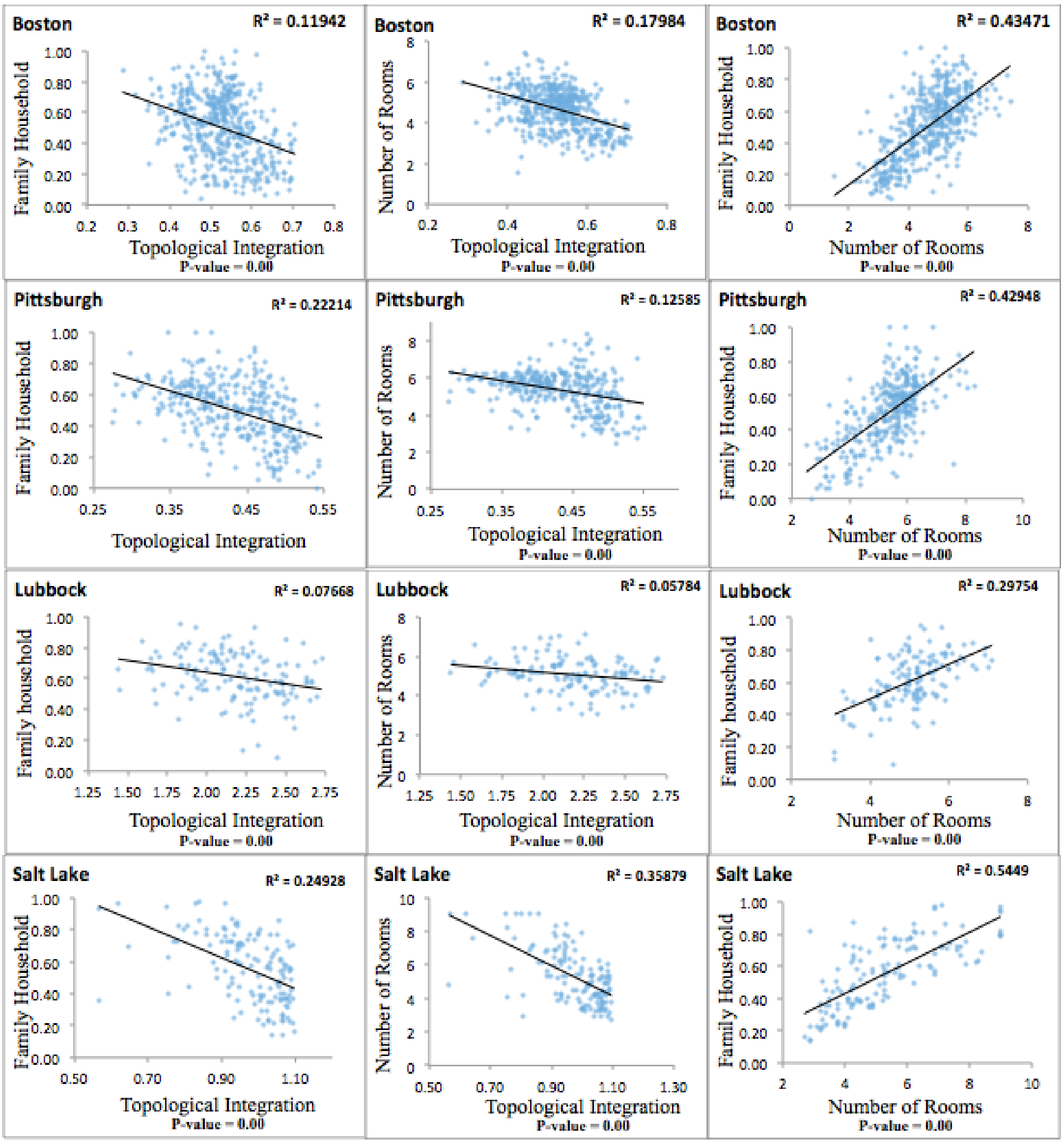
Figure 8 Propensity of renters for walking

3.2.2 DEMOGRAPHIC PATTERN

Statistical evidences are found that configuration has an effect on socio-economic and demographic patterns in our case cities. Variations are observed on choices of residential location and transport modes between family and non-family households in all cities.

3.2.2.1 CONFIGURATION, HOUSEHOLD TYPE AND NUMBER OF ROOMS

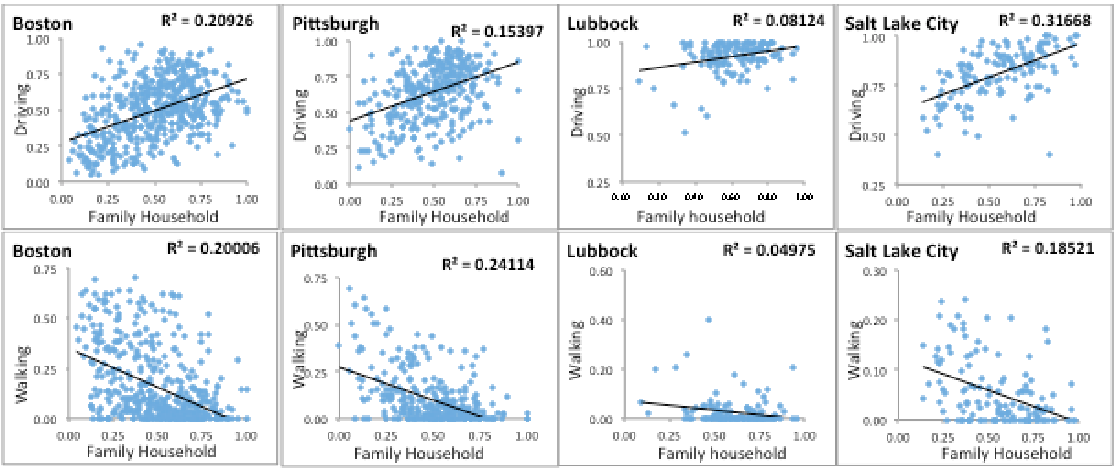
The findings (Figure 9) indicated that configurationally integrated areas are likely to be denser and have compact (smaller) housing units with relatively lower number of rooms. On the contrary, the negative correlation of integration with number of rooms and family household implies the segregated locations or neighborhoods are preferred by family-households; perhaps in part because it fits better to their need of higher number of rooms, flexibility, comfort, and auto travel convenience especially to those who have children. Number of rooms is very important factor for family households in their decisions of residential locations. This assertion can be supported by the fact that the correlation coefficient between number of rooms and family households is relatively big (0.43 Boston, 0.43 Pittsburgh, 0.3 Lubbock and 0.55 Salt Lake City) than correlation of integration with family households and number of rooms in all cities (Figure 9).



All P-values are less than 0.05

Figure 9 - Relationships between integration, household type, and number of rooms

Family household were observed to correlate positively with driving and negatively with walking (see Figure 10). This implies that family households are likely to drive more and walk less, and non-family households the opposite. This pattern of travel mode choice is consistent with their choice of residential

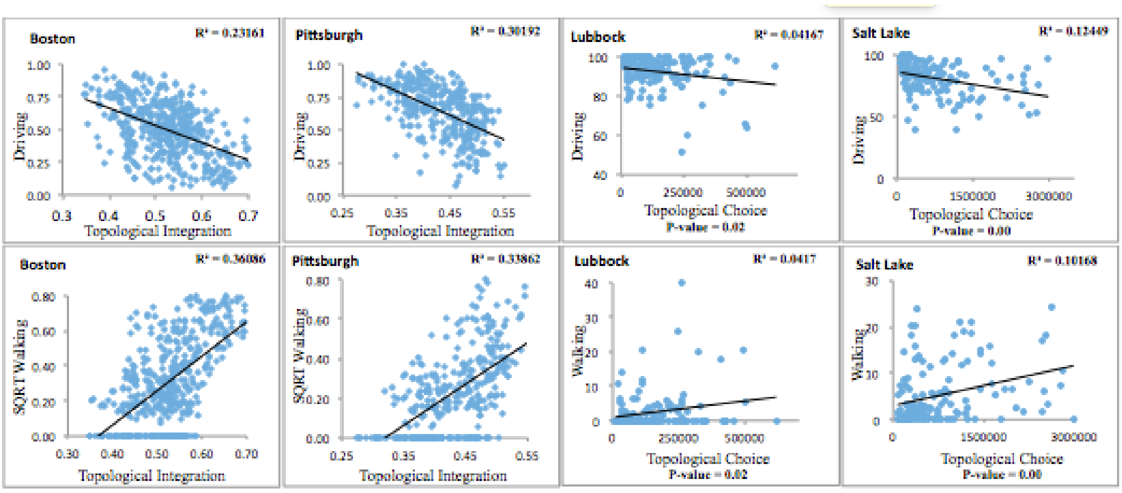


All P-values are less than 0.05

Figure 10 - Scatterplots of family household with driving, and walking

3.2.3 CONFIGURATION VS WALKING AND DRIVING

Driving and walking are related to integration in opposite ways. Figure 11 depicts that driving mode is consistently favored towards segregated areas in all four cities; on the contrary walking is preferred in integrated areas. However, the strength of relationships is stronger in non-gridded cities and weaker in gridded cities.



All P-values are less than 0.05

Figure 11 - Scatterplot of integration vs driving and walking

3.3 COMPARISON BETWEEN GRIDDED AND NON-GRIDDED CITIES

The major findings of this study is that first, space syntax is indispensable in studding the land uses and travel behavior of urban areas regardless of grid type. The theories that configuration first affect the movement and the movement rich areas of the system attract movement-seeking activities is confirmed in all cities (Hillier, Burdett, Peponis, & Penn, 1987). In all cities, statistically significant relationships between configuration and commercial density are found.

Second, multiple regression analysis displayed commonality within groups of cities and variations between gridded and non-gridded ones. Closeness (integration) measure of configuration was relevant to explain both walking and driving transport mode in non-gridded cities and between-ness (choice) for gridded cities (Berhie & Haq, 2015). Although the reason for this result is speculative at this point, this distinction will serve as an important beginning for future investigations and understanding the particular syntactic properties of gridded American cities (Ratti, 2004). We recommend additional studies to investigate why integration was important indicator in predicting transportation preference for non-gridded cities and choice for gridded ones.

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