Urban Sprawl and Transportation

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Abstract:

This paper examines the relationship between urban sprawl and the particular outcomes of urban sprawl which are basically travel and transportation outcomes in 2000. The 4 determination factors of sprawl index for 65 US largest metropolitan areas has taken into account which had been calculated and collected by Reid Ewing, Rolf Pendall, Don Chen (2002) and used in their research. In the first part of this research, we will apply correlation studies to see the statistical significant associations between variables to make it easies to justify the argument that one variable causes or contributes to another. In the next, we will use multiple regression analysis to test for significant relationship between dependent and independent variables.

Introduction:

Carruthers and Ulfarson define urban sprawl as 'characterized by the low density suburban style development patterns that have been the dominant model of growth in the United States over the last 50 years.' They also talk about the state and regional programs which are basically aim to reduce the urban sprawl. Their hypothesis is rely on the efficacy of this approach by examining the relationship between governmental fragmentation and several measurable outcomes of urban development; density, urbanized land area, property values and public expenditures on infrastructures. They emphasize the importance of the governmental institutions in terms of urban development and sprawl. They concluded that political fragmentation contributes to urban sprawl via Tiebout mechanism, which force growth to the urban fringe as potential residents are priced out of land markets. They also found that fragmentation is associated with lower densities and higher property values but has no direct effect on public service expenditures. As a result, the strong connection between political fragmentation and urban sprawl suggest that they have significant potential for altering the outcome of development in United States metropolitan areas.

In fact, when one searches the literature about urban sprawl, he or she may encounter different respects of the definition of urban sprawl, mostly hard to differentiate urban growth from urban development. Conceptual definitions of urban sprawl and urban development differ from one researcher to another that confuses readers. If the purpose is the most compact controlled and coordinated development within the urban areas, finding a best solution to the urban sprawl is depend on the definition of urban sprawl and urban development.

Statistical Technique and Data Collection

The crucial point of this study is defining the urban sprawl index. In this data set, urban sprawl index is defined with four factors representing density, land use mix, degree of centering, and street accessibility.

Residential density is on everyone's list of sprawl indicators but the characterization of the density may differ. For example Ulfarson and Caruthers take population and employment and add them together to define the density in the metropolitan areas. In this dataset we observe that they took seven different variables to define the density factor (Table1).

Table1. Variables Used to Define Sprawl Index

Factor	Variables	Source
Residential Density	Gross Population Density in persons per square mile	US Census
	Percentage of population living at densities less than 1,500 persons per square mile (low suburban density	US Census
	Percentage of population living at densities greater than 12,500 persons per square mile (urban density)	US Census
	Estimater density at the center of the metro area	US Census
	Gross population density of urban lands	USDA Natural Resources Inventory
	Weighted average lot size for single family dwellings (in square feet)	American Housing Survey
	Weighted density of all population centers within a metro area	Claritas Corporation
Neighborhood Mix of Homes, Shops and Offices	Percentage of residents with businesses or institutions within 1/2 block of their homes	American Housing Survey
	Percentage of residents with satisfactory neighborhood shopping within 1 mile	American Housing Survey
	Percentage of residents with a public elementary school within 1 mile	American Housing Survey
	Balance of population serving jobs to residents. Population serving jobs include retail, personal services, entertainment, health, education, and professional services	Census Transportation Planning Package
	Mix of population-serving jobs	Census Transportation Planning
Strength of Metropolitan Centers	Variation of population density by census tract	US Census
	Rate of decline in density from center (density gradient)	US Census
	Percentage of population living within 3 miles of the central business district	Edward Glaeser, Brookings Institution
	Percent of the population living more than 10 miles from the CBD	Edward Glaeser, Brookings Institution
	Percentage of the population relating to centers within the same metropolitan statistical area	Claritas
	Ratio of population density to the highest density center in the metro area	Claritas
Accessibility of the Street Network	Average block length in urbanized portion of the metro area	Census TIGER files
	Average block size in square miles	Census TIGER files
	Percentage of small blocks	Census TIGER files

In addition to density variable, Table1 also shows all the definitions and data sources of variables that determine the sprawl index.
They accomplished defining the sprawl index via principal component analysis, an analytical technique which takes larger number of correlated variables and extracts a small number of factors that embody the common variance in the original data set.

Data is based on 65 metropolitan areas of the United States which representing nearly half of the nation's population. Table 2 shows all the rankings of these metropolitan areas respect to four different sprawl factors and overall sprawl index.

Outcome measures attribute to sprawl are related to travel and transportation which are dependent variables in this analysis.

Sprawl Outcome Measures:

Vehicle	=	vehicle per 100 households.
Transit	=	transit to work (%)
Walk	=	percentage of commuters walking to work
Commute	=	mean journey to work time in minutes
Delay	=	annual hours of delay per capita
Distance	=	daily vehicle mile traveled per capita
Fatal	=	annual fatal highway accidents per 100.000 persons
Ozone	=	fourth highest daily maximum 8-hour average ozone level

Finally the following variables were used to control for influences on travel other than those of the built environment.

Control Variables:

Pop	=	metropolitan area population (MSA or PMSA)
Hhsize	=	average household size for the metro area
Workage	=	percentage of population of working age in the metro area (20-64 years)
Income	=	per capita income in the metro area

Table2. Rankings of Density, Land Use Mix, Degree of Centering, and Street Accessibility and overall Sprawl Index over 65 Metropolitan Areas of United States

Density Rank		Mix Rank		Centeredness Rank		Streee Rank		Sprawl Rank	
Raleigh,NC	1	Raleigh,NC	1	Vallejo,CA	1	Rochester,NY	1	Riverside,CA	1
Birmingham,AL	2	Riverside,CA	2	Riverside,CA	2	Syracuse,NY	2	Raleigh,NC	2
Little_Rock,AR	3	West_Palm_Beach,FL	3	Tampa--St,FL	3	Hartford,CT	3	West_Palm_Beach,FL	3
Tulsa,OK	4	Orlando,FL	4	West_Palm_Beach,FL	4	Cleveland,OH	4	Bridgeport,CT	4
Albany,NY	5	Birmingham,AL	5	Detroit,MI	5	Oklahoma_City,OK	5	Rochester,NY	5
Oklahoma_City,OK	6	Little_Rock,AR	6	Los_Angeles,CA	6	Buffalo,NY	6	Dallas,TX	6
Jacksonville,FL	7	Syracuse,NY	7	San_Diego,CA	7	Fresno,CA	7	Vallejo,CA	7
Syracuse,NY	8	Jacksonville,FL	8	Fort_Lauderdale,FL	8	Albany,NY	8	Detroit,MI	8
Hartford,CT	9	Columbus,OH	9	St. Louis,IL	9	Memphis,TN	9	Syracuse,NY	9
Akron,OH	10	Washington,DC	10	Raleigh,NC	10	Toledo,OH	10	Little_Rock,AR	10
Cincinnati,OH	11	Seattle,WA	11	Dallas,TX	11	Riverside,CA	11	Albany,NY	11
Memphis,TN	12	Tampa--St,FL	12	Norfolk,VA	12	Bridgeport,CT	12	Hartford,CT	12
Austin,TX	13	Las Vegas,NV	13	Hartford,CT	13	Raleigh,NC	13	Oklahoma City,OK	13
Indianapolis,IN	14	New_Orleans,LA	14	Chicago,IL	14	Akron,OH	14	Tampa--St,FL	14
St. Louis,IL	15	Rochester,NY	15	Houston,TX	15	Indianapolis,IN	15	Birmingham,AL	15
Tucson,AZ	16	Dallas,TX	16	Sacramento,CA	16	Cincinnati,OH	16	Washington,DC	16
Pittsburgh,PA	17	Honolulu,HI	17	Kansas_City,MO	17	Minneapolis,MN	17	Columbus,OH	17
Tacoma,WA	18	Tacoma,WA	18	Phoenix,AZ	18	Tucson,AZ	18	Jacksonville,FL	18
Kansas_City,MO	19	Pittsburgh,PA	19	Miami,FL	19	Little_Rock,AR	19	Kansas_City,MO	19
Colorado_Springs,CO	20	Norfolk,VA	20	Salt_Lake_City,Utah	20	Kansas_City,MO	20	Cleveland,OH	20
Toledo,OH	21	Tulsa,OK	21	San_Jose,CA	21	Dallas,TX	21	Memphis,TN	21
Rochester,NY	22	Albany,NY	22	Bridgeport,CT	22	Detroit,MI	22	Houston,TX	22
Columbus,OH	23	Minneapolis,MN	23	Oklahoma_City,OK	23	Milwaukee,WI	23	Indianapolis,IN	23
Bridgeport,CT	24	Fort_Lauderdale,FL	24	Philadelphia,PA	24	Austin,TX	24	St._Louis,IL	24
Fresno,CA	25	Cincinnati,OH	25	Washington,DC	25	Houston,TX	25	Norfolk,VA	25
Riverside,CA	26	Indianapolis,IN	26	Seattle,WA	26	Tulsa,OK	26	Minneapolis,MN	26
Tampa--St,FL	27	San_Jose,CA	27	Albany,NY	27	Colorado_Springs,CO	27	Cincinnati,OH	27
Orlando,FL	28	Memphis,TN	28	Jersey_City,NJ	28	Columbus,OH	28	Orlando,FL	28
West_Palm_Beach,FL	29	Kansas_City,MO	29	Las_Vegas,NV	29	Washington,DC	29	Tulsa,OK	29
Minneapolis,MN	30	San_Antonio,TX	30	Cleveland,OH	30	Sacramento,CA	30	Seattle,WA	30
Norfolk,VA	31	Oklahoma_City,OK	31	Columbus,OH	31	ElPaso,TX	31	Los_Angeles,CA	31
San_Antonio,TX	32	Portland,OR	32	Jacksonville,FL	32	San_Antonio,TX	32	San_Diego,CA	32
Houston,TX	33	Detroit,MI	33	Indianapolis,IN	33	Birmingham,AL	33	Sacramento,CA	33
Omaha,NE	34	Salt Lake City,Utah	34	Orlando,FL	34	Jacksonville,FL	34	Las Vegas,NV	34
Albuquerque,NM	35	ElPaso,TX	35	Memphis,TN	35	Omaha,NE	35	Akron,OH	35
Detroit,MI	36	Albuquerque,NM	36	Pittsburgh,PA	36	West Palm Beach,FL	36	Tacoma,WA	36
Vallejo,CA	37	Miami,FL	37	Little_Rock,AR	37	Baltimore,MD	37	Pittsburgh,PA	37
Providence,RI	38	San Diego,CA	38	Tucson,AZ	38	San Diego,CA	38	Toledo,OH	38
Sacramento,CA	39	Baltimore,MD	39	Minneapolis,MN	39	St._Louis,IL	39	San_Antonio,TX	39
Salt_Lake_City,Utah	40	San_Francisco,CA	40	San_Antonio,TX	40	Phoenix,AZ	40	Fort_Lauderdale,FL	40
Dallas,TX	41	Cleveland,OH	41	Denver,CO	41	Las_Vegas,NV	41	Tucson,AZ	41
Cleveland,OH	42	St._Louis,IL	42	Boston,MA	42	Vallejo,CA	42	San_Jose,CA	42
ElPaso,TX	43	Houston,TX	43	Cincinnati,OH	43	Tacoma,WA	43	Austin,TX	43
Portland,OR	44	Sacramento,CA	44	Toledo,OH	44	Philadelphia,PA	44	Fresno,CA	44
Milwaukee,WI	45	Austin,TX	45	Birmingham,AL	45	Norfolk,VA	45	Salt_Lake_City,Utah	45
Buffalo,NY	46	Chicago,IL	46	Fresno,CA	46	Honolulu,HI	46	Phoenix,AZ	46
Seattle,WA	47	Denver,CO	47	Tulsa,OK	47	Salt_Lake_City,Utah	47	Philadelphia,PA	47
Denver,CO	48	Phoenix,AZ	48	Baltimore,MD	48	Seattle,WA	48	Baltimore,MD	48
Baltimore,MD	49	Vallejo,CA	49	Austin,TX	49	Albuquerque,NM	49	ElPaso,TX	49
New Orleans,LA	50	Milwaukee,WI	50	Milwaukee,WI	50	Boston,MA	50	Milwaukee,WI	50
Phoenix,AZ	51	Akron,OH	51	Akron,OH	51	Orlando,FL	51	Buffalo,NY	51
Washington,DC	52	Colorado Springs,CO	52	ElPaso,TX	52	Los Angeles,CA	52	Chicago,IL	52
Las_Vegas,NV	53	Omaha,NE	53	Rochester,NY	53	Pittsburgh,PA	53	Colorado_Springs,CO	53
San Diego,CA	54	Hartford,CT	54	Portland,OR	54	San Jose,CA	54	Albuquerque,NM	54
Boston,MA	55	Philadelphia,PA	55	Tacoma,WA	55	Denver,CO	55	Denver,CO	55
Fort_Lauderdale,FL	56	Toledo,OH	56	New_Orleans,LA	56	Portland,OR	56	New_Orleans,LA	56
Philadelphia,PA	57	Tucson,AZ	57	Albuquerque,NM	57	Tampa--St,FL	57	Miami,FL	57
Honolulu,HI	58	Los_Angeles,CA	58	Syracuse,NY	58	Chicago,IL	58	Portland,OR	58
San_Jose,CA	59	Boston,MA	59	San_Francisco,CA	59	Providence,RI	59	Boston,MA	59
Miami,FL	60	Buffalo,NY	60	Omaha,NE	60	Miami,FL	60	Omaha,NE	60
Chicago,IL	61	New_York,NY	61	Colorado_Springs,CO	61	Fort_Lauderdale,FL	61	Honolulu,HI	61
Los_Angeles,CA	62	Fresno,CA	62	Buffalo,NY	62	New_Orleans,LA	62	San_Francisco,CA	62
San_Francisco,CA	63	Bridgeport,CT	63	Providence,RI	63	San_Francisco,CA	63	Providence,RI	63
Jersey_City,NJ	64	Providence,RI	64	New_York,NY	64	New_York,NY	64	Jersey_City,NJ	64
New_York,NY	65	Jersey_City,NJ	65	Honolulu,HI	65	Jersey_City,NJ	65	New_York,NY	65

Low Density / High Density

Low Mix / High Mix

Low Centeredn / High Centeredness

Low Street Acces / High Street Access

More Sprawl / Less Sprawl

Scatter plots, Regression Lines, and Simple Correlation Coefficients for Selected Outcomes

Chart1: vehicle=index r= -0.53425

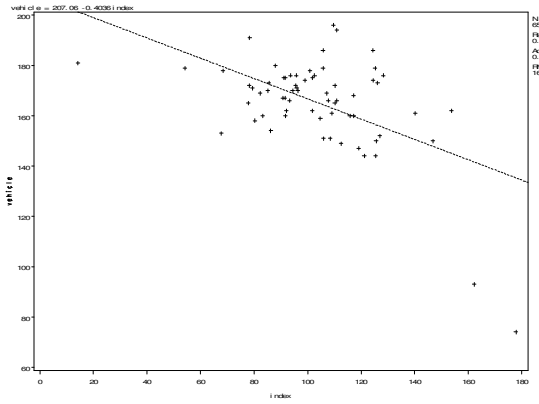


Chart2: transit=index r= 0.58346

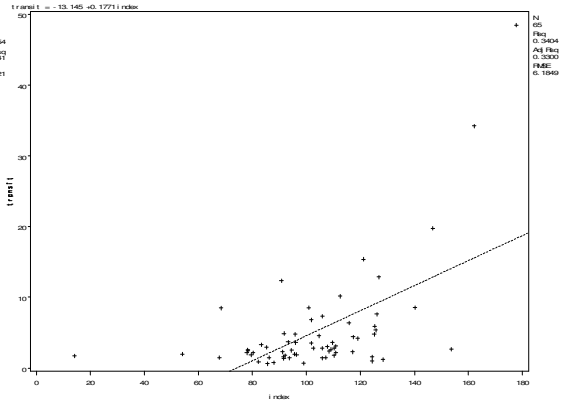


Chart3: distance=index r= -0.35903

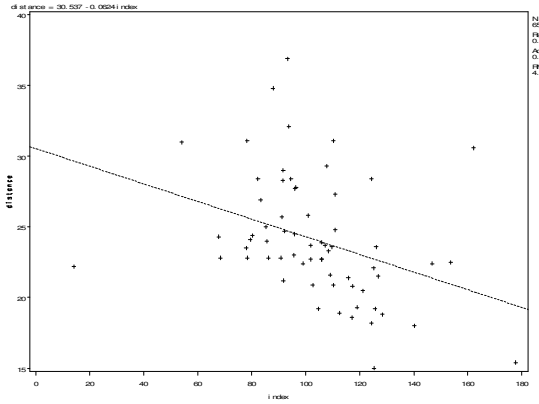


Chart4: fatal=index r=-0.46074

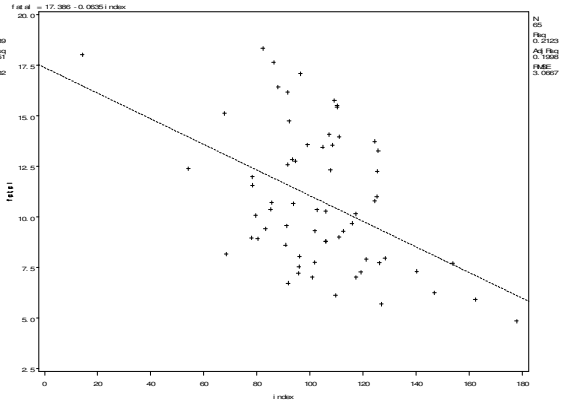
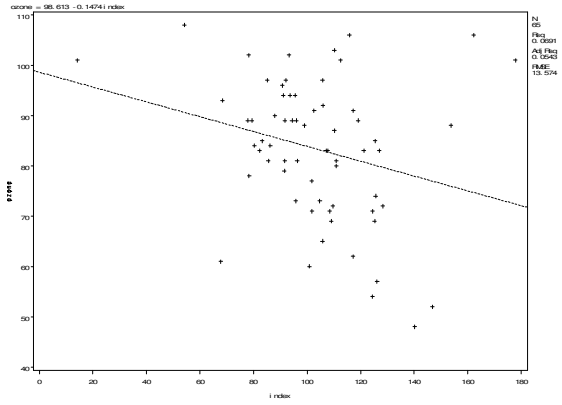


Chart5: ozone=index r= -0.26287



First test of this study is checking the assumption of linearity between the index and different outcomes. His study reveals that the relationship between sprawl index and transportation outcomes appears fundamentally linear. After that, I regressed each outcome on the index and the set of control variables. Results are represented in the Table3. Regression coefficients and t-statistics appear across from their respective independent variables (with standard errors in parentheses). Adjusted R2 statistics appear at the bottom of the table.

Table3.

Transportation Outcomes of Overall Sprawl Index

Transportation Outcome = f (index pop hhsize workage income) **n=65**

	vehicle	transit	walk	commute	delay	distance	fatal	ozone
index	-0.39744 ***	0.15115 ***	0.03391 ***	0.01022	-0.04314	-0.08392 ***	-0.06029 ***	-0.17793 *
St. Error	0.074	0.02731	0.00633	0.01392	0.04295	0.01971	0.01535	0.07037
pop	-0.00000443 ***	0.00000174 ***	1.91E-07 *	0.00000109 ***	2.71E-06 ***	-1.99E-07	-2.89E-07	2.33E-06 *
St. Error	0.00000101	3.73E-07	8.65E-08	1.90E-07	5.87E-07	2.69E-07	2.10E-07	9.61E-07
hhsize	29.75679 **	-0.86627	-0.21364	3.56764 *	11.95285 *	-2.37726	-0.27559	-11.57209
St. Error	9.85379	3.63706	0.84336	1.85307	5.71844	2.6243	2.04452	9.37028
workage	1.47684	0.29919	0.07213	0.17859	1.1986 *	0.94064 ***	0.01966	0.35864
St. Error	0.92076	0.33985	0.0788	0.17315	0.53434	0.24522	0.19104	0.87558
income	0.00031273	0.00025652	0.00000775	0.00021148 *	0.000649 *	-0.000266 *	-0.00027 *	-0.000806
St. Error	0.00051246	0.00018915	0.00004386	0.00009637	0.000297	0.000136	0.000106	0.000487
F value	11.7 ***	16.05 ***	9.46 ***	12.92 ***	11.24 ***	5.74 ***	6.34 ***	2.52 *
r-square	0.4978	0.5762	0.445	0.5226	0.4878	0.3272	0.3495	0.1758
adj r-square	0.4552	0.5403	0.398	0.4822	0.4444	0.2702	0.2944	0.106

* .05 probability level ** .01 probability level *** .001 probability level

The *overall sprawl index* shows strong and statistically significant relationships to six outcome variables. All relationships are in the expected directions. As the *index* increases (sprawl decreases), average vehicle ownership, daily VMT per capita, annual traffic fatality rate, and maximum ozone level decrease to a significant extent. At the same time, shares of work trips by transit and walk modes increase to a significant extent.

The *index* is not significantly related to either average commute time or annual traffic delay per capita. Both outcomes are a function primarily of metropolitan area population, and secondarily of other sociodemographic variables. Big metros generate long trips to work and high levels of traffic congestion. After controlling for population size and other sociodemographic variables, sprawl does not appear to have a marginal relationship to either outcome.

After this, next step is relying on the analysis included all four sprawl factors. Each outcome was regressed on the four factors plus the standard set of control variables. Results are presented in Table4. Density factor has the strongest and most significant relationship to travel and transportation outcomes. Center factor has the next most significant environmental influence on these outcomes and it is inversely related to annual delay per capita and traffic fatality rate. Mix factor is significant in only two cases and land use mix is significant in only two cases as well.

When we look at the overall results we notice that average commute time and annual delay per capita are not significantly related to the *overall sprawl index*, they are significantly related to individual sprawl factors. One

possible explanation: Individual sprawl factors pull these outcomes in opposite directions, the *streets factor* being directly related to both outcomes while the *mix factor* is inversely related to average commute time and *centers factor* is inversely related to annual delay per capita. The two effects may cancel each other out.

Table4.

Transportation Outcomes of Sprawl Factors

Transportation Outcome = f (density mix center street pop hhsize workage income) **n=65**

	vehicle	transit	walk	commute	delay	distance	fatal	ozone
density	-0.76288 ***	0.28588 ***	0.05574 ***	0.06079 **	-0.13109 *	-0.04185	-0.03494	0.09544
St. Error	0.07465	0.02472	0.00742	0.01868	0.06811	0.03226	0.02383	0.1109
mix	0.05367	-0.00963	-0.0009166	-0.02535 *	0.02041	0.00689	-0.03521 *	0.10364
St. Error	0.05328	0.01765	0.00529	0.01333	0.04861	0.02302	0.01701	0.07916
center	-0.03937	0.02545	0.01442 **	-0.02739 *	-0.05212	-0.07164 **	-0.04187 *	-0.18563 *
St. Error	0.05313	0.0176	0.00528	0.0133	0.04848	0.02296	0.01696	0.07894
street	0.06479	-0.02913	-0.00991 *	0.02817 *	0.09744 *	-0.02236	0.02054	-0.25789 ***
St. Error	0.05908	0.01956	0.00587	0.01478	0.0539	0.02553	0.01886	0.08776
pop	4.59E-07	-5.39E-08	-1.14E-07	4.97E-07 *	3.15E-06 ***	-1.28E-07	-2.48E-07	1.58E-06
St. Error	8.14E-07	2.69E-07	8.08E-08	2.04E-07	7.42E-07	3.52E-07	2.60E-07	1.21E-06
hhsize	42.77308 ***	-5.71045 ***	-1.04E+00 *	2.11442	12.62496 *	-1.90E+00	0.21203	-1.27E+01
St. Error	6.2163	2.06E+00	6.18E-01	1.56E+00	5.67E+00	2.69E+00	1.98412	9.23E+00
workage	1.89763 **	0.12954	0.03685	0.06172	1.25549 *	1.04588 ***	-0.04341	0.87984
St. Error	0.59321	0.19645	0.05893	0.14845	0.54122	0.25631	0.18934	0.88127
income	0.00084643 *	0.00006458	-2.184E-05	0.00016187 *	0.000651 *	-0.000271 *	-0.00024 *	-0.000966 *
St. Error	0.00032464	0.00010751	0.00003225	0.00008124	0.000296	0.00014	0.000104	0.000482
F value	31.55 ***	49.75 ***	18.89 ***	15.9 ***	8.29 ***	3.93 **	5.58 ***	2.62 *
r-square	0.8184	0.8767	0.7296	0.6944	0.5422	0.3597	0.4434	0.2727
adj r-square	0.7925	0.859	0.691	0.6507	0.4768	0.2682	0.3639	0.1687

* .05 probability level ** .01 probability level *** .001 probability level

Conclusion

The relationships found between urban sprawl and traffic and transportation related problems appear to increase in more sprawling areas. The regression results reveals that people drive more, have to own more cars, breath more polluted air, face greater risk of traffic fatalities, and walk and use transit less in place with more sprawling development patterns.