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Impacts of Urban Growth Boundaries on Urban Density and Sprawl : A Comparative Approach

Pettygrove, Margaret* · Hwang, Chulsue**

도시성장경계가 도시 밀도와 도시 스프롤에 미치는 영향 : 비교 연구

페티그로브 마가렛* · 황철수**

Abstract : This study is to investigate the relative impacts of urban growth boundaries(UGBs) on metropolitan growth patterns in the United States over a period of time. Through statistical analyses, we evaluate the extent to which UGBs affect the density of residential development in metropolitan areas with UGBs. We also attempt to understand the overall impact of UGBs and the importance of UGBs relative to other determinants of urban growth patterns. Our works found that urban growth patterns differ significantly between cities with UGBs and cities without. UGBs have significant causal effect on urban housing and population densities, but are relatively less important than other factors. This implies that there are factors affecting the variation for which the given data cannot account. Despite the limitations of the data, the findings of this analysis suggest that UGBs have some positive effects on curbing urban sprawl.

Key Words : urban growth boundary(UGB), urban density, urban sprawl, growth pattern

요약 : 본 연구는 특정 기간 동안 미국 대도시가 성장하는 패턴에 도시성장경계(UGB)가 어떻게 영향을 미치는가를 상대적 관점에서 조사하는데 목적을 두고 있다. 이를 위해 통계분석을 통해 도시성장경계를 규정하고 있는 대도시권에서 거주지역밀도에 도시성장경계가 어느 정도 영향을 미치고 있는가를 살펴보았다. 다음으로 도시성장의 패턴에 영향을 미치는 요소들과 도시성장경계를 비교 분석하여 도시성장경계의 중요성을 분석하였다. 그 결과 도시성장 패턴이 도시성장경계를 규정하고 있는 도시와 이를 규정하지 않는 도시 사이에 유의한 차이가 있음을 확인하였다. 그러나 도시성장경계가 갖는 유의성에도 불구하고 다른 요인들에 비해 상대적으로 낮게 영향을 미치고 있는 점 역시 발견되었다. 이는 본 연구에서 활용한 자료가 설명하기 어려운 요인들이 복잡하게 영향을 주고 있음을 시사한다. 또한 연구자료의 한계에도 불구하고 도시성장경계가 도시 스프롤을 억제하는데 어느 정도 효과를 미치고 있음을 밝히고 있다.

주요어 : 도시성장경계(UGB), 도시 밀도, 도시 스프롤, 성장 패턴

1. Introduction

1) Background of the Study

Urban Growth Boundaries (UGBs) are a widely utilized tool for urban growth management and rural land preservation in the United States. Since the first institution of an UGB in 1958, over 100 United States cities and counties have adopted UGBs (Nelson and Duncan, 1995; Jun, 2004). Three U.S. states—Oregon, Washington, and Tennessee—require growth boundaries in all urban jurisdictions statewide(Knapp and Nelson, 1992). Generally, UGBs are established to promote compact development, protect agricultural and natural land, and reduce automobile congestion (Jun, 2004; Martin, 2007). UGBs are part of a broader response to low-density sprawl development caused by explosive rates of suburbanization.

In its basic form, an UGB is a line around an urban area, denoting the maximum extent of urban development. Beyond the UGB, development is discouraged through tax increases, zoning restrictions, or refusal by the city to supply basic

* Graduate Student, Department of Geography, University of Wisconsin(위스콘신대학교 지리학과 대학원과정)
** Associate Professor, Department of Geography, Kyung Hee University(경희대학교 지리학과 부교수)(hcs@khu.ac.kr)

services (e.g. sewer, water, electricity) to developments outside of the boundary. Local governments typically draw the boundary around an amount of land that they predict will serve the city for a 20 to 50 year period. This is intended to allow for some natural population growth while creating or maintaining higher-density development.

Despite the abundance of research on UGBs, there remain considerable debates about the effects of UGBs on urban development patterns (Galster *et al.*, 2001). Some empirical studies find significant sprawl reduction as a result of UGBs, while others show no difference in growth patterns between cities with UGBs and cities without. Furthermore, several studies find that UGBs negatively impact local metropolitan areas by increasing sprawl, congestion, and metropolitan fragmentation (Jun, 2004; Ruddiman, 2007). In some cities, such as Portland, Oregon, the presence of an UGB has caused inflation of land values and housing markets within the UGB, reducing the supply of affordable housing (Jun, 2004, 2008).

The concept of sprawl is itself poorly defined, adding to the difficulties of conclusively analyzing the impacts of UGBs on urban sprawl. In its most simple conception, "sprawl" denotes the expansion of urbanized land area at a rate that exceeds the population growth rate. In other words, sprawl indicates a general increase in the urbanized area coupled with a decrease in the density of houses within the urbanized area (Brueckner, 2000).

2) Objectives and Hypotheses

The objective of this study is to analyze the relative impacts of urban growth boundaries (UGBs) on metropolitan growth patterns in the United States over a period of time. Through statistical analyses, we evaluate the extent to which UGBs affect the density of residential development in metropolitan areas with UGBs. We also attempt to understand the overall impact of UGBs and the importance of UGBs relative to other determinants of urban growth patterns.

This project will seek to answer three research questions: (1) how do growth patterns in urban areas with Urban Growth Boundaries (UGBs) compare to growth patterns in other urban areas; (2) do UGBs significantly affect the density of urban residential development in metropolitan areas with UGBs; (3) what are the impacts of UGBs on metropolitan growth patterns in the United States since 1990, relative to other factors affecting urban growth.

To evaluate the influence of UGBs on urban growth patterns, we will investigate that the pattern of development in a metropolitan area with an UGB is significantly different from metropolitan areas without UGBs. If UGBs have an appreciable correlation with urban density and growth patterns, then the density of urbanized housing units and urbanized population (as proportions of urbanized land) will be greater in cities with UGBs than in cities without UGBs. If there is no statistically significant variation in terms of housing and population density between cities with and without UGBs, this suggests that UGBs are not significantly correlated with urban growth patterns. Secondly, we will test the hypothesis that the presence or absence of UGBs plays a significant role in determining the change in urban population density or urban housing density over time.

2. Methodology and Data

For this analysis, 24 U.S. cities were selected (Table 1). 12 of these cities have an UGB established prior to 1995, and 12 of these cities have no UGB. The 24 cities are distributed

throughout the U.S., primarily along the Western and Eastern coasts (Fig. 1). These cities are not intended to be representative of the U.S. overall. They were chosen based on their status as large metropolitan cities and therir populations, and to ensure an equal number of cities with and without UGBs. The data for each of the 24 Urban Areas and corresponding Metropolitan Statistical Areas (MSAs) are taken from the 1990 and 2000 U.S. Census. Using data from the two census years allows for calculation of percent change over time, from 1990 to 2000. Percent change for each was calculated as the difference in 1990 values and 2000 values, divided by the 1990 value.

Table 1. Metropolitan Statistical Areas (MSAs) used in analysis. 24 total MSAs were selected: 12 with UGBs and 12 without UGBs.

MSA without UGB	MSA with UGB
Atlanta, GA	Austin, TX
Bloomington, IN	Baltimore, MD
Boston, MA	Boulder, CO
Chicago, IL	Kenosha, WI
Cincinnati, OH	Knoxville, TN
Detroit, MI	Lancaster, PA
Louisville, KY	Lexington, KY MSA
Milwaukee, WI	Minneapolis-St. Paul, MN
Philadelphia, PA	Portland, OR
Phoenix, AZ	Sacramento, CA
Pittsburgh, PA	San Jose, CA
Raleigh, NC	Seattle, WA

Percent change in urban population density and percent change in urban housing density were used as measures of sprawl for the purposes of this analysis. Urban population density is defined as urban persons per urban area (persons/mi^2). Urban housing density is defined as urban housing units per urban area (units/mi^2). Greater increase in the urbanized population

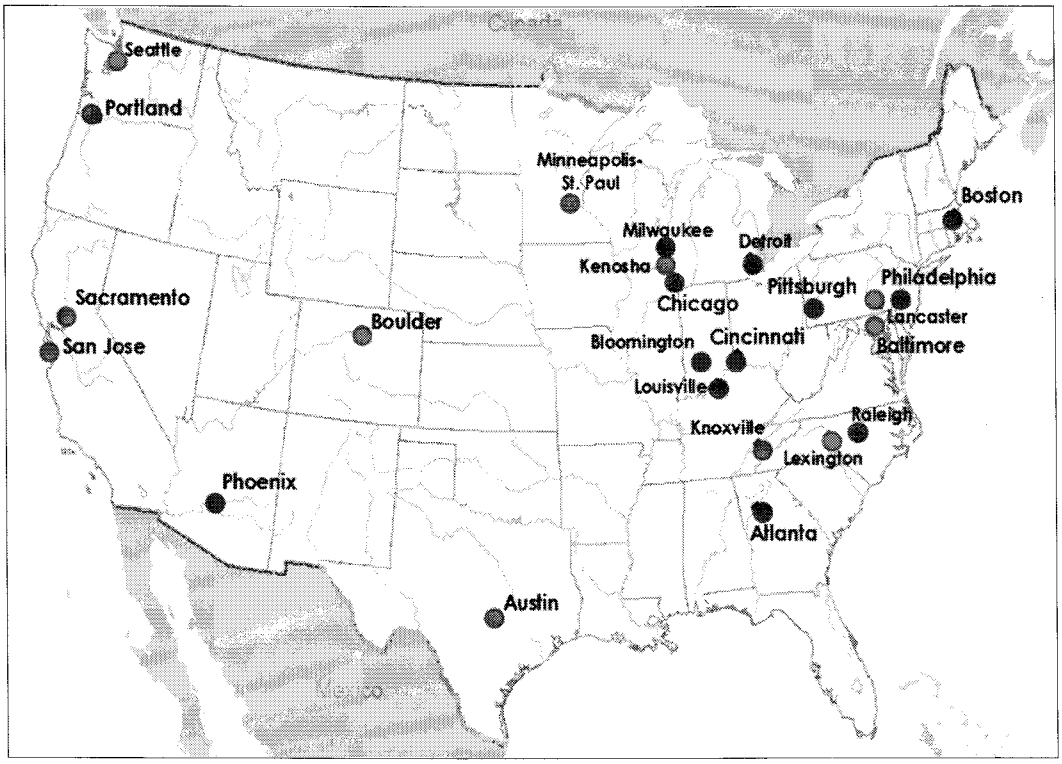

Figure 1. Map of Metropolitan Statistical Areas used in analysis. Blue circles denote MSAs with UGBs; red circles denote MSAs without UGBs.

density relative to the change in urbanized land indicates lower rates of sprawl and more compact development. Considering changes in urban population density and urban housing density over time, greater percent change in either density variable would indicate more compact growth. There are other measures of sprawl that have been used, but these require data collection methods that are beyond the scope of this project.

In addition to urban population and urban housing densities, we considered a number of other variables that are associated with sprawl or with urban growth patterns in general. These variables include: change in median household income (U.S. dollars), change in median home value (U.S. dollars), total housing units in 1990, change in number of single-unit houses, and percentage of workers in 2000 traveling to work by car.

To analyze the correlation between presence or absence of an UGB and the urban growth variables listed above, I conducted 2-sample t-tests of variance in mean in SPSS for each of the variables, with non-UGB cities as the first sample and UGB cities as the second sample.

To assess the importance of UGBs relative to other factors affecting sprawl, we developed two multiple regression models, with percent change in urban population density and percent change in urban housing density as the respective dependent variables. We performed stepwise linear regression analysis for each of the two dependent variables considering all of the independent variables: change in median household income, change in median home value, total housing units in 1990, change in number of single-unit houses, percentage of workers in

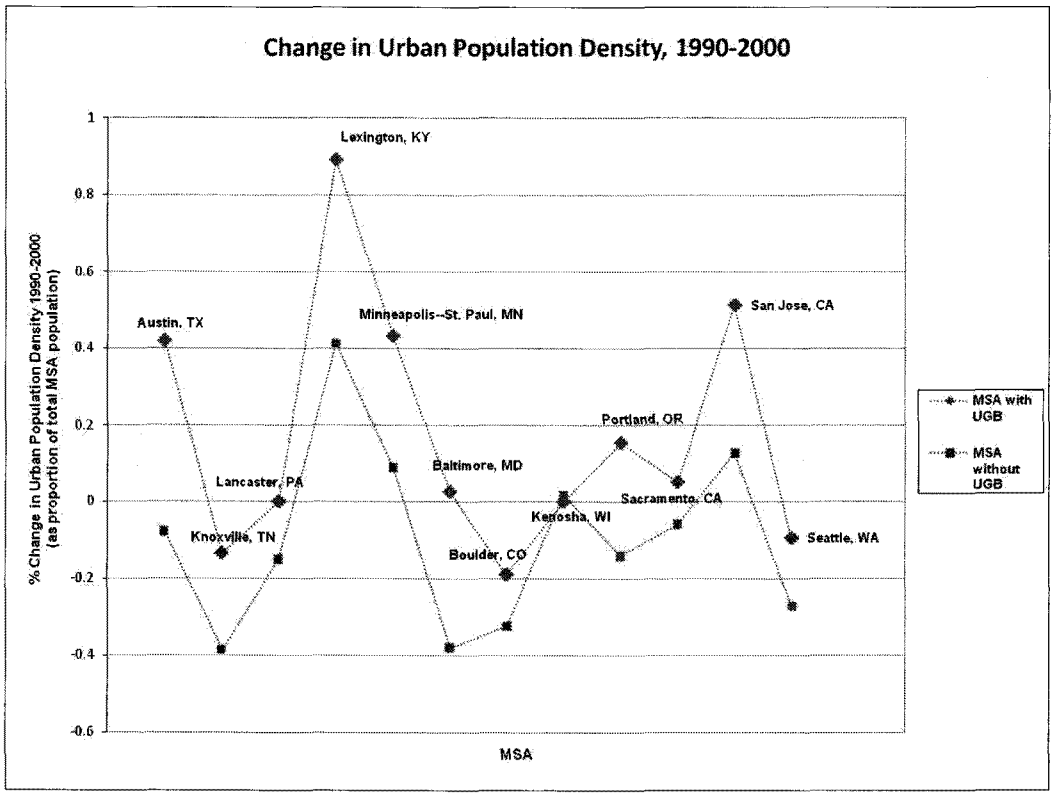

Figure 2. Percent Change in Urban Population Density for individual MSAs from 1990~2000.

2000 traveling to work by car, and UGB dummy variable (with 0 for no UGB and 1 for UGB).

3. Results

For MSAs without urban growth boundaries (UGBs), mean percent change in urban population density is 0.000833; mean Percent Change in Urban Population Density is 0.0792 for MSAs with UGBs. For MSAs without UGBs, mean Percent Change in Urban Housing Density is −0.0525; mean Percent Change in Urban Population Density is 0.351 for MSAs with UGBs. 〈Table 2〉 reports values of all variables for each MSA and the means for MSAs grouped by presence or absence of UGB.

Variance in means was analyzed with SPSS using 2-sample independent t-tests. Two sample groups were used for the t-test, defined as

Table 2. Values for each MSA for selected variables. Percent change is measured over the 10 year period, 1990 to 2000.

MSA without UGB	% Change Urban Area	% Change Urban Population	% Workers Traveling by Car in 2000	% Change Urban Pop Density	% Change Urban Housing Density	Median family income in 1990	% Change Median Family Income
Atlanta, GA	0.72	0.59	0.906	−0.08	−0.16	41618	0.25
Bloomington, IN	−0.94	13.23	0.839	−0.31	−0.28	32859	0.01
Boston, MA	18.3	−0.11	0.764	−0.4	−0.43	49266	0.12
Chicago, IL	3.03	−0.98	0.803	0.55	0.47	41745	0.24
Cincinnati, OH	−0.46	1.64	0.910	0.16	0.22	37175	0.19
Detroit, MI	0.13	−0.93	0.940	−0.17	−0.15	40962	0.2
Louisville, KY	−0.77	9.36	0.929	−0.35	−0.28	33179	0.23
Milwaukee, WI	−0.35	0.06	0.895	0.28	0.23	39005	0.18
Philadelphia, PA	3.1	−0.06	0.823	−0.06	−0.09	41959	0.13
Phoenix, AZ	−0.39	−0.93	0.900	0.3	0.34	36078	0.24
Pittsburgh, PA	19.09	−0.71	0.871	−0.04	−0.57	33035	0.13
Raleigh, NC	1.16	−0.34	0.914	0.13	0.07	41572	0.17
Mean	**3.552**	**1.735**	**0.875**	**0.000833**	**−0.0525**	**39038**	**0.174**
Standard Deviation	**7.202**	**4.601**	**0.055**	**0.291**	**0.321**	**4843.3**	**0.0689**
MSA with UGB							
Austin, TX	0.12	−0.42	0.902	0.42	0.27	36325	0.35
Baltimore, MD	7	−0.57	0.870	0.19	−0.51	42206	0.18
Boulder, CO	−0.8	6.06	0.811	0.71	0.64	43782	0.28
Kenosha, WI	−0.94	24.81	0.935	0.02	−0.09	30638	0.53
Knoxville, TN	14.46	12.23	0.942	−0.58	−0.49	30447	0.21
Lancaster, PA	−0.8	11.73	0.884	−0.32	−0.33	33255	0.37
Lexington, KY MSA	1.04	5.93	0.916	−0.05	0.01	33792	0.16
Minneapolis-St. Paul, MN	0.98	−0.23	0.884	0.06	0.03	43252	0.26
Portland, OR	2.08	−0.29	0.846	0.03	−0.01	36768	0.28
Sacramento, CA	0.09	0.14	0.897	0.05	0.03	38689	0.2
San Jose, CA	−0.25	0.13	0.895	0.51	0.44	53670	0.39
Seattle, WA	0.39	0.26	0.830	−0.09	−0.11	43528	0.21
Mean	1.948	4.982	0.884	0.0792	−0.01	38863	0.285
Standard Deviation	4.486	7.848	0.040	0.351	0.345	6756.5	0.108

MSAs with UGBs and MSAs without UGBs. The t-tests showed that differences in mean between sample groups were significant, at the 0.05 level, for the following variables: percent Change in Urban Housing Density, Change in Urban Population Density, Change in Median Family Income and 2000 Urban Area (mi^2). Differences in mean between sample groups were significant, at the 0.08 level, for 2000 Urban Population Density (population/area) and 2000 Urban Housing Density (units/area) (Table 3). Where Levene's test showed that equality of variance was not valid, t-tests were calculated with fewer degrees of freedom to account for unequal variances. For all other variables, differences in means between sample groups were not significant.

Stepwise multiple linear regression on the dependent variable Percent Change Urban Population Density produced 3 significant explanatory variables: UGB dummy, Percent Change Urban Area, and Urban Housing in 1990 (% of total housing units). With these three variables, R-squared for the model is 0.825, with p-value less than 0.0001. The explanatory variable Percent Change Urban Area has the largest magnitude beta-value, equal to -0.896; the beta-value for the UGB dummy variable is 0.369 (Tables 4, 5).

Stepwise multiple linear regression on the dependent variable Percent Change in Urban Housing Density also produced three significant explanatory variables: UGB dummy, Percent

Table 3. Analysis of variance in means for selected variables between MSAs with UGB and MSAs without UGB.

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
% Change Urban Housing Density	Equal variances assumed	1.930	.179	-2.117	22	.046	-.2503374	.1182565
% Change Urban Population Density	Equal variances assumed	2.283	.145	-2.141	22	.044	-.2629322	.1227923
% Change Median Family Income	Equal variances assumed	2.143	.157	-3.023	22	.006	-.11017	.03645
Urban Area, 2000 (mi^2)**	Equal variances assumed	5.371	.030	2.436	22	.023	.1570505	.0644596
	Equal variances not assumed			2.436	13.276	.030	.1570505	.0644596
Urban Population Density, 2000 (pop/area)**	Equal variances assumed	4.590	.043	-1.903	22	.070	-3.44786	1.81157
	Equal variances not assumed			-1.903	15.791	.075	-3.44786	1.81157
Urban Housing Density, 2000 (units/area)**	Equal variances assumed	4.626	.043	-1.909	22	.069	-1.29474	.67824
	Equal variances not assumed			-1.909	16.132	.074	-1.29474	.67824

* Variance was analyzed in SPSS using 2-sample independent t-tests.

** F-tests showed assumption of equal variances for this variable is not valid. Reported p-value is calculated assuming unequal variances.

Table 4. Stepwise multiple regression models for the dependent variable Percent Change in Urban Population Density.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1- Predictors: (Constant), Pct_Change_UrbanArea	.792	.627	.610	.2018343
2- Predictors: (Constant), Pct_Change_UrbanArea, UGB_Dummy	.885	.783	.762	.1578073
3- Predictors: (Constant), Pct_Change_UrbanArea, UGB_Dummy, Pct_urban_housing_1990	.908	.825	.798	.1452078

Table 5. Coefficients of multiple regression model for dependent variable Percent Change Urban Population Density.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-.004	.045		-.086	.932		
Pct_Change_UrbanArea	-.614	.074	-.896	-8.352	.000	.762	1.313
UGB_Dummy	.233	.060	.369	3.907	.001	.984	1.016
Urban_housing_1990 (%)	.013	.006	.236	2.191	.040	.756	1.324

Change Urban Area, and Total MSA population in 1990 (in millions). With these three variables, R-squared for the model is 0.800, with p-value less than 0.0001. Variance Inflation Factor (VIF) and tolerance values indicate that collinearity between variables is not significant. The variable Percent Change Urban Area has the largest magnitude beta-value, equal to -0.844; the beta -value for the UGB dummy variable is 0.273 (Tables 6, 7).

4. Discussion

Results of the t-tests for variance in mean indicate that both Percent Change in Urban Housing Density and Percent Change Urban Population Density differ significantly between cities with Urban Growth Boundaries (UGBs) and cities without UGBs. The means for percent change in urban housing density and percent change urban population density are greater for cities with UGBs than for cities without UGBs. These results indicates that cities with UGBs tended to become more dense between 1990 and 2000—in people and in housing units—than did

Table 6. Stepwise multiple regression models for the dependent variable Percent Change in Urban Housing Density.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1- Predictors: (Constant), Pct_Change_UrbanArea	.775	.600	.582	.2009468
2- Predictors: (Constant), Pct_Change_UrbanArea, UGB_Dummy	.868	.753	.729	.1617670
3- Predictors: (Constant), Pct_Change_UrbanArea, UGB_Dummy, Pop_Total_1990 (in millions)	.895	.800	.770	.1489729

Table 7. Coefficients of multiple regression model for dependent variable Percent Change Urban Housing Density.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.150	.079		1.902	.072		
Pct_Change_UrbanArea	-.556	.070	-.844	-7.927	.000	.880	1.136
UGB_Dummy	.166	.069	.273	2.403	.026	.774	1.292
Pop_Total_1990 (in millions)	-.052	.000	-.259	-2.182	.041	.707	1.415

cities without UGBs during this same period. These results support the first proposed hypothesis that change over time in urban housing and population densities differs significantly between cities with UGBs and cities without UGBs.

The mean Percent Change in Urban Area did not differ significantly between cities with and without UGBs. This result is important because it suggests that the higher levels of change in urban density did not occur in cities with UGBs simply because the urban area grew less for these cities. Even as the total urban area grew over time for some cities with UGBs, they became increasingly dense relative to cities without UGBs. Although a growing urban area will generally still challenge rural land preservation, a growing urban area that is supported by a growing urban housing density does make more efficient use of land than typical sprawl development. Most discussions of urban sprawl criticize growth patterns because residential development spreads more rapidly than the rate of increase of the population and the overall housing density goes down. Thus, if urban land is spreading but is keeping pace with population growth, this may alleviate a major concern associated with sprawl.

The results of the t-test show that MSAs with UGBs do have significantly higher mean for Percent Change in Median Family Income. This indicates that the average income level increased more between 1990 and 2000 for cities with UGBs than for cities without UGBs. While there appears to be a correlation between change in median family income level and the presence or absence of an UGB, it is not clear whether there is a causal (directional) relationship between these variables. Greater rate of increase in average income levels may be a positive consequence of the presence of an UGB, or it may indicate that UGBs tend to be created where the potential for economic growth already exists. Alternately, it might suggest that the presence of an UGB causes lower-income residents to move because of increasing costs of living.

While the analysis of variance shows a correlation between presence of an UGB and reduced urban sprawl, the multivariate regression models provide information about the directionality of the relationship between UGBs and urban density. The regression models also indicate the importance of UGBs, relative to other factors, in affecting urban housing and population densities. The results of the multiple regression analyses show similar parameters for the dependent variables, Percent Change in Urban Housing Density and Percent Change in Urban Population Density. Both models are statisingally significant with p-values less than 0.0001. Both models are strong, as indicated by the R-squared values of 0.800 and 0.825, respectively. With the 3 independent variables, the models explain large portions of the variation in Percent Change in Urban Housing Density and Percent Change in

Urban Population Density. In each model, the UGB Dummy variable has a lower beta-value than does the Percent Change Urban Area variable, indicating that the UGB Dummy variable was less important than the explanatory variable Percent Change Urban Area for explaining overall variation in the dependent variable.

That most of the variation in rate of change in urban densities is explained by the rate of change in urban area suggests that changes in urban housing and population densities are caused primarily by intrinsic urban growth rates or by some other driver of urban growth that is not described directly by the data. Nevertheless, holding all other measured factors constant, the presence or absence of an UGB does have a significant affect on the level of change in urban density. According to the linear regression model for Percent Change in Urban Housing Density, the UGB variable explains approximately 15 percent of the total variation in Percent Change in Urban Housing Density for an MSA (Table 6). Similarly, the UGB variable explains approximately 15 percent of the total variation in Percent Change in Urban Population Density (Table 4). The results of the regression models support the second proposed hypothesis that the presence or absence of an UGB explains significant portions of the variation in either percent change in urban population density or percent change in urban housing density. The UGB variable explains a relatively small portion of the variation in urban densities, but it does significantly improve the strength of the overall regression models.

5. Conclusion

Urban growth patterns, as measured by changes over time in urban population and housing densities, differ significantly between cities with UGBs and cities without. UGBs have significant causal effect on urban housing and population densities, but are relatively less important than other factors.

The most significant explanatory factor for change over time in both urban housing and population densities is percent change in urban area, which is itself associated with the density variables. This suggests that there are factors underlying the variation in percent change in urban area for which the given data cannot account. Clearly, the relationship between urban sprawl and UGBs is more complex than census data can reflect. Urban housing density and urban population density are proxy measures of metropolitan sprawl, and as such they are imperfect proxies.

Despite the limitations of the data, the findings of this analysis suggest that UGBs have some positive effects on curbing urban sprawl. The UGB is a tool for growth management, but one that warrants careful consideration of local conditions and needs. As my analysis found no significant correlation between UGBs and transportation patterns, additional research on UGBs would be useful to clarify the affects of UGBs on transportation and traffic congestion.

An urban growth boundary (UGB) is a local government (state or city level) regulatory measure for delineating limits for urban growth over a period of time in U.S.A. Land within the UGB is made available for urban development while land outside the UGB remains primarily rural for farming, forestry, or low-density residential development. Recently, local UGB initiatives have been promoted by the Greenbelt Alliaale as the solution to preventing urban sprawl. Considering the Korean governmental policy adopting the Greenbelt Alliaale as the strict regulation governing urban sprawls, the following comparative research between U.S.A. and Korea is needed. And futureseasearches

aresneeded to consider the circumstaales of the local governments and related regions in order to investigate the specific effects on the local UGBs.

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• Correspondence : Chulsue Hwang, Department of Geography, Kyung Hee University, #1 Hoegi-dong, Dongdaemun-gu, Seoul, 130-701, South Korea (e-mail: hcs@khu.ac.kr, phone: +82-2-961-9313)

교신 : 황철수, 130-701, 서울특별시 동대문구 회기동 1번지 경희대학교 지리학과(이메일: hcs@khu.ac.kr, 전화: +82-2-961-9313)

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