Development Patterns and Municipal Finances:

An Analysis of Sprawl and Spending in 82 U.S. Cities

By

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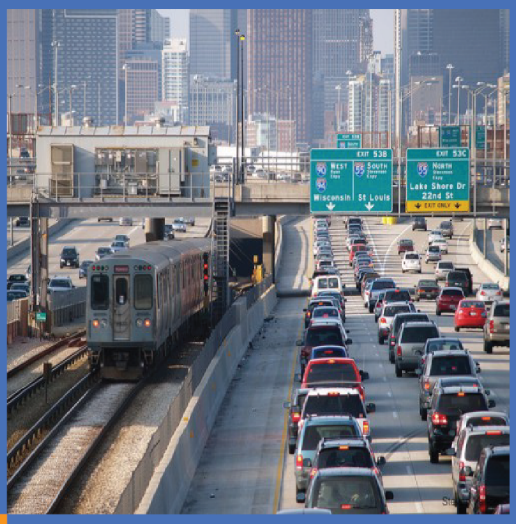

DEVELOPMENT PATTERNS AND MUNICPAL FINANCES

AN ANALYSIS OF SPRAWL AND SPENDING IN 82 U.S. CITIES

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ABSTRACT

Sprawl has long been lamented in urban planning circles for its detrimental environmental, social, and financial impacts. However, most of the widely cited literature use theoretical models to measure the financial impacts and inefficiencies of sprawling development. This paper examines the relationship between sprawl and municipal finances empirically, by analyzing 23 separate financial categories in 82 of the largest cities in the United States between the years 2000 and 2010. First, the concept of sprawl is defined and a brief overview of existing literature on the impacts of sprawl is presented. Then, 23 separate multivariate regression models are created and analyzed using a sprawl index calculated by Hamidi and Ewing (2014) to predict each of the financial categories, including various expenditure categories, debt outstanding, and capital outlay. In line with existing literature, the research finds that there is a significant and negative relationship between sprawl and capital outlay expenses. More compact, accessible cities spend less on capital outlay. The findings indicate that urban form and land use patterns have serious financial implications and that cities should consider investments in compact, accessible development.

I. INTRODUCTION

From glancing at the local issues section of any local newspaper, it may seem like two new crises are threatening towns across the nation: density and sprawl. Headlines such as "Homeowners fear high-density zoning" (Levenson 2015), "Residents fear housing density" (Gonter 2008), and "Residents fear 'urban sprawl'" (Sholtis 2016) highlight the contentious debate that often surrounds new developments. The terms "high-density" and "sprawl" have been demonized and used to attack new development proposals by conjuring up images of either Manhattan-like skyscrapers or a suburban wasteland void of natural elements in order to foster public outrage. These arguments appeal to residents' and local politicians' emotions, while ignoring the facts of what "density" and "sprawl" actually are and their implications, both positive and negative. Both "sprawl", and its adversary "density", carry serious environmental, social, and economic consequences that should be evaluated carefully by decision-makers. This paper aims to shed light on some of these issues, specifically the financial impacts bore by cities and service providers, in order to provide much needed empirical evidence to a debate that is full of hyperbole and emotion.

II. DEFINITIONS

WHAT IS SPRAWL?

First, it is important to establish a clear definition of sprawl, while also gaining a better understanding of its presence in American cities. Sprawl is widely considered an American phenomenon, promulgated by widespread automobile ownership, cheap land, and poor planning (Hamidi and Ewing 2014). But a true objective definition is often missing in conversations. For example, take the following definitions of sprawl by several well-known organizations:

- The Sierra Club: "Sprawl—scattered development that increases traffic, saps local resources and destroys open space."
- Natural Resources Defense Council: "Sprawling development eats up farms, meadows, and forests, turning them into strip malls and subdivisions that serve cars better than people." (Poland, CPBG)

These definitions are problematic because they define sprawl in terms of their negative outcomes, rather than the objective characteristics of sprawl. They also define sprawl using words that carry negative connotations, further emotionalizing the debate. Ewing (1997) offered one of the first objective and comprehensive definitions of sprawl that is still used widely today. He defines sprawl as having one or more of the following four elements:

1. Leapfrog or scattered development,
2. Commercial strip development,
3. Expanses of low-density development, and
4. Expanses of single-use development.

An additional indicator of sprawl that Ewing established was poor accessibility – large areas of vacant land separating uses, poor linkages with transportation networks, and a dependence on the automobile. For this paper, I will use Ewing's definition of sprawl, as it is still one of the most comprehensive definitions that attempts to consider the many complex elements of sprawl.

FIGURE 1. THE FOUR ELEMENTS OF SPRAWL: LEAPFROG DEVELOPMENT, COMMERCIAL STRIP DEVELOPMENT, LOW-DENSITY AND SINGLE-USE DEVELOPMENT. NOTE THE DOMINANCE OF THE AUTOMOBILE AND GENERAL INACCESSIBILITY. IMAGE CREDITS (CLOCKWISE FROM TOP-LEFT): URBAN TORONTO; PRICE TAGS WORDPRESS; SMART GROWTH AMERICA; ETSY.

But what is the difference between sprawl and suburbanization? Unfortunately, in the United States they are often one in the same, but this is not necessary. One of the main elements of sprawl is that it is suburbanization that occurs rapidly without careful planning, leading to a

patchwork of low density, single-use development arranged around the automobile. Suburbanization in the U.S. all too often follows this pattern, but it is possible for suburbanization to occur in a deliberate, planned fashion that does not result in urban sprawl. In fact, many cities in the United States have actively managed to grow without sprawling uncontrollably.

Measuring Sprawl in the United States

Much of the literature on urban sprawl focuses on its definition and how to accurately measure it. Scholars have long had a difficult time differentiating sprawl from suburbanization (Carruthers and Ulfarsson 2003). Early measurements of sprawl focused on density, with lower densities being more sprawling areas (Pendall 1999). While these calculations were critiqued for not capturing the full idea of sprawl, they were very easily calculated from readily-accessible data. As technology advancements made satellite imagery cheaper and more available to the public, new measurements of sprawl emerged that tried to account for other dimensions beyond density, including fragmentation (leap-frog development) and edge density (Huang, Lu, and Sellers 2007). The most advanced measures of sprawl consider sprawl's multidimensional nature and combine multiple factors into a single sprawl index. One of the most widely cited sprawl indices was developed by Smart Growth America in collaboration with the U.S. Environmental Protection Agency (Ewing et. al. 2000). This sprawl index takes into account four different indicators of sprawl, with an average score of 100 for each indicator. The indicators directly relate to Ewing's definition of sprawl mentioned earlier and include: residential density; neighborhood mix of homes, jobs, and services; strength of activity centers and downtowns; and accessibility of the street network. These four indicators are then averaged for each given city, resulting in an

overall sprawl indicator. While these indices are more robust and better capture the complexity of sprawl, they are extremely time-consuming to compute for multiple cities over many years.

III. THE IMPACTS OF SPRAWL

While the literature on how to define and measure sprawl varies greatly still, the negative impacts of sprawl are widely cited. Increased traffic fatalities, physical inactivity, obesity, air pollution, extreme heat events, energy use, commute distances and times, and social capital have all been shown to worsen because of sprawl (Hamidi at. al. 2015). Other research has tried to connect sprawl to positive benefits, such as increased homeownership, affordable housing, and more open space (Glaeser and Kahn 2004). This project, however, will focus on the financial impacts of sprawl on municipal governments and service providers, rather than the environmental and social costs.

One of the most widely-cited and reviewed studies on sprawl and its associated service provision costs was conducted by the Real Estate Research Corporation in 1974. This study, commissioned by the Environmental Protection Agency, the Department of Housing and Urban Development, and the U.S. Council on Environmental Quality, examined the impact on infrastructure costs for six hypothetical communities of 10,000 housing units with different densities. The explanatory variable of density ranged from 3-4 units per acre to 19-20 units per acre (for reference, housing densities in Manhattan can exceed 350 units/acre, while the typical American town has housing densities of around 6.5 units/acre). The results found that street systems would cost 51 percent less to maintain in a high-density community of townhouses than low-density, single-family homes. Furthermore, utilities (i.e. water, sewer, storm drainage, gas, electricity and wiring) were estimated to cost 30 percent less to maintain in higher-density developments (Burchell et. al. 1998). A more recent follow-up study also found that for roads, water, and sewage, contiguous development is 45 percent less costly than sprawling, leapfrog

development (Frank 1989). Although this research provides strong evidence that higher-density developments are more cost-efficient for cities, it is both dated and based on theoretical modeling and not observed empirical data, thus failing to fully address the reality of expenditures in existing U.S. cities.

Perhaps the most relevant literature that provides cross-sectional, empirical evidence that sprawl increases the cost of providing public services examines twelve measures of public expenditure in 283 metropolitan counties between 1982 and 1992 (Carruthers and Ulfarsson 2003). Using Ordinary Least Squared (OLS) regression, it was found that density is negatively and significantly related to several measures of public expenditure including total direct, capital facilities, roadways, police protection, and education. It also found urbanized land to be significant and positively related to most expenditure measures. This dated study however, focused on metropolitan areas in only 14 states, and did not capture trends across the nation as a whole.

Relevant analyses on Canadian and Spanish cities provide more evidence to support the theory that urban sprawl is costlier for cities. Research done by Enid Slack on Canadian cities argues that developers do not take the full costs of low-density development into account, especially the resulting increased costs of providing services incurred by the city (Slack 2002). Additionally, a study prepared by the IBI Group focuses on city expenditures for the Greater Toronto Area by using models to estimate public infrastructure costs. The study concludes that if sprawling development patterns in Toronto were to continue as they had for the past 25 years, $59 billion would be required to build and operate road, sewer and water networks. However,

with a more compact development pattern, the model estimates a savings of $12.2 billion to the city over 25 years (Slack 2002). Similar to other studies, it lacks empirical follow-up for the predicted model of Toronto's spending in recent years and does not provide cross sectional data on sprawl.

Another international study examines 2500 Spanish municipalities in the year 2003 (Hortas-Rico & Sole-Olle 2008). The research employs a piecewise linear function and ordinary least squares regressions to analyze the relationship between sprawl and local government per capita spending on public services. In this case, sprawl is measured based on several indicators including: urbanized land per capita, urbanized land, residential houses, percentage of scattered population, and number of population centers. Similarly, the expenditure variable takes into account six different factors, including: basic infrastructure and transport, community facilities, local police, housing, culture/sports, and general administration. Expenditure is measured on a per capita basis. The study also accounts for many demographic, economic and social control variables. The results of this study are important because they reveal results that were significant and positive at the 95 percent confidence level, showing that sprawl was positively correlated with increased spending. In this case, a 1 percent increase in urbanized land raised city spending by 0.11 percent. Additionally, the expenditure functions used in the regression analysis account for about 81 percent of the total increase in costs due to urban sprawl (Hortas-Rico & Olle 2008).

Although the analysis of Spanish municipalities used empirical evidence to analyze sprawl and spending, the cross-sectional empirical evidence on U.S. cities remains poor. The Canadian and somewhat dated U.S. models are helpful forecasting tools that predict increases in spending

as development sprawls; however, they lack the robustness of a cross sectional study based on current data from real cities.

IV. METHODOLOGY

This paper explores the relationship between sprawl and municipal expenditures and finances with the hope to empirically answer the question, "Does it cost more to provide services to sprawling developments than a more compact, traditional development?" I hypothesize that cities with greater levels of sprawl spend more per capita on providing services to its citizens than more compact cities. I also hypothesize that more sprawling cities will have more debt outstanding in the form of bonds (in order to pay for more expansive and expensive infrastructure networks). This hypothesis is in line with the previous theoretical and conceptual models, and the few empirical analyses. This paper, however, will take these studies further by using empirical, cross-sectional data from a large, representative sample of U.S. cities over a more recent timeframe. The results of this project will also make it possible to quantify the financial impacts of sprawl that have long-been estimated. This paper will look at the change in the sprawl between the years 2000 and 2010 along with the change in various categories of municipal expenditure during the same time period in 82 U.S. cities. The outcome variable of interest is the change in city expenditures between 2000 and 2010, while the explanatory variable is the change in sprawl between 2000 and 2010.

SPRAWL INDEX

To measure sprawl and compactness, I use a sprawl index developed by Hamidi and Ewing (2014). This index is robust and considers the multidimensional nature of sprawl by taking into account four factors, all indicators of the four main dimensions of sprawl identified earlier in the paper:

1. **Development Density**: This factor is comprised of multiple measures of density including population densities, employment densities, the percentage of population living in low density developments, and the percentage of population living in medium to high density developments. Higher densities translate into more compact development.

2. **Land Use Mix**: This factors combines two primary variables. The first is the balance between jobs and population, and the second is a measure of the diversity of land uses. Sprawling areas would see a low mix of uses and an imbalance between jobs and population.

3. **Activity Centering**: This centering factor measures the concentration of both population and employment within the central business district (CBD) and various sub-centers. Sprawling areas have little to no activity centering, as a characteristic of sprawl are strips of commercial development located along roadways.

4. **Street Accessibility**: This factor is computed using variables that measure the efficiency and accessibility of the road network, including average block size, percentage of small urban blocks, density of intersections, and percentage of 4-or-more-way intersections. Greater accessibility, like that seen in compact development, is related to smaller block sizes and more 4-way intersections.

Hamidi and Ewing calculated a sprawl/compactness index for the 162 largest urbanized areas (UZA) in the United States by summing the 4 calculated factors, all equally weighted. Table 1 below summarizes the ten most compact and ten most sprawling urbanized areas in 2010 (See Appendix A for a complete list).

Rank		Compactness index	Density factor	Mix factor	Centering factor	Street factor
Ten most compact UZAs						
1	San Francisco-Oakland, CA	180.94	205.69	129.92	164.34	153.38
2	Reading, PA	169.32	127.71	150.87	124.45	147.46
3	Madison, WI	152.87	118.16	121.82	182.19	99.33
4	Eugene, OR	152.54	114.84	134.37	134.15	123.07
5	Laredo, TX	151.80	123.87	131.21	81.56	166.54
6	Oxnard, CA	146.19	147.55	137.14	82.42	135.08
7	Atlantic City, NJ	144.25	93.87	91.07	157.06	143.86
8	Los Angeles-Long Beach-Anaheim, CA	143.42	212.21	144.75	102.23	138.92
9	Lincoln, NE	143.38	118.63	127.46	97.02	141.77
10	New York-Newark, NY-NJ-CT	142.71	197.50	106.80	179.10	125.06
Ten most sprawling UZAs						
153	Baton Rouge, LA	64.38	81.92	75.30	77.21	77.61
154	Fayetteville, NC	61.05	79.40	73.65	67.16	64.43
155	Chattanooga, TN-GA	60.96	68.92	54.18	97.03	70.33
156	Greenville, SC	60.57	67.92	75.26	89.88	57.88
157	Nashville-Davidson, TN	60.27	87.51	47.43	111.18	70.03
158	Charlotte, NC-SC	57.41	82.95	64.56	115.94	53.01
159	Winston-Salem, NC	55.56	66.31	68.97	88.15	54.29
160	Victorville-Hesperia, CA	54.15	82.38	67.79	57.01	61.88
161	Hickory, NC	48.64	46.92	78.41	72.20	44.94
162	Atlanta, GA	37.45	84.64	75.63	107.29	36.84

TABLE 1. THE MOST AND LEAST SPRAWLING CITIES IN 2010 (HAMIDI & EWING).

This paper, however, examines the changes in the sprawl index between the years 2000-2010. The map below (Figure 1) shows these changes in 82 U.S. cities, and highlights those that have changed the most. The cities in red have become more sprawling, while the cities in green have become more compact, with color intensity representing the degree of change. The numbers indicate the actual numerical change. Tallahassee, FL, saw the sharpest increase (26.73 points), while Austin, TX, saw the greatest decline (-17.14 points).

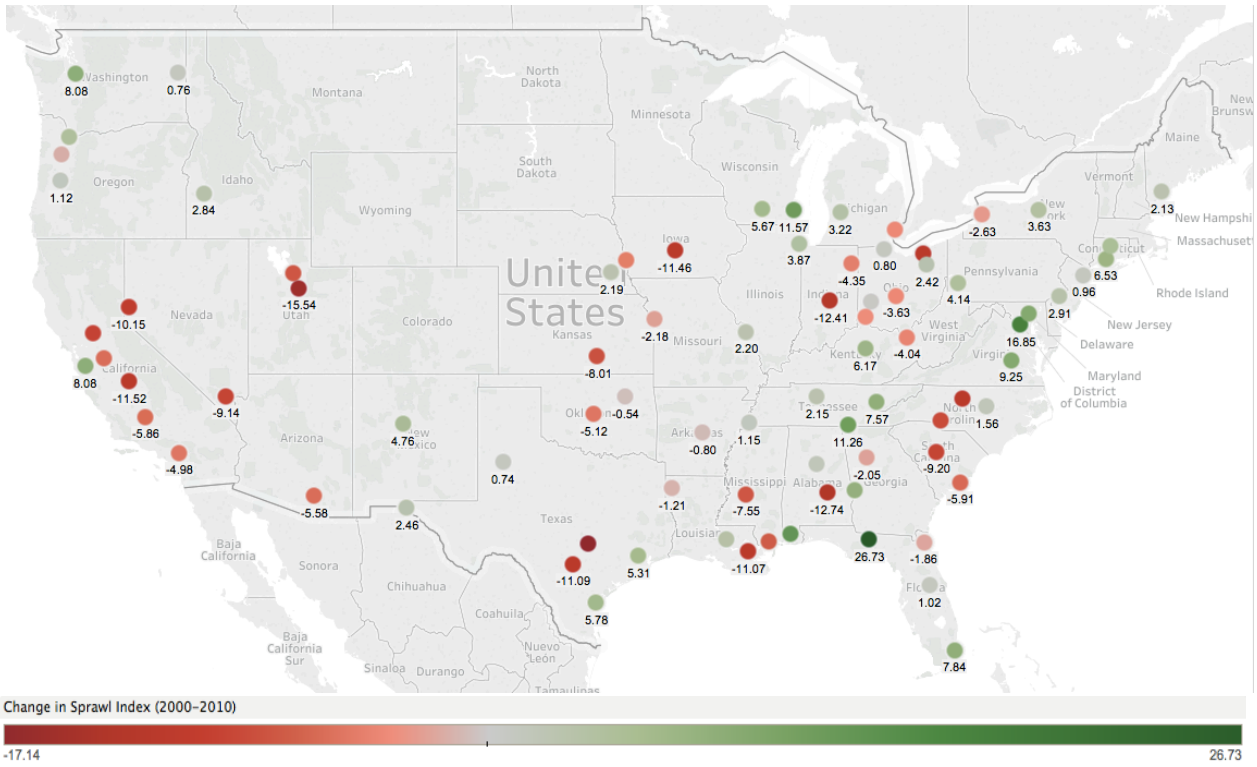

FIGURE 2. MAP OF CHANGE IN SPRAWL INDEX FROM 2000-2010.

MUNICIPAL EXPENDITURES

Data on municipal finances are taken from the Lincoln Institute of Land Policy's Fiscally Standardized Cities (FiSC) database. This database has compiled more than 120 categories of municipal revenues, expenditures, debt, and assets for 150 of the largest U.S. cities for the years 1977 and 2012. This database allows for meaningful comparisons of complex municipal finances across cities and time. The key to this dataset is that it considers the many overlapping jurisdictions and agencies responsible for providing services, including city and county governments, special districts, and school districts, and aggregates them at a city-wide level. "FiSCs provides a full picture of revenues raised from city residents and businesses and spending on their behalf, whether done by the city government or a separate overlying

government" (Lincoln Institute). For this study, I have selected the fiscal categories most likely to be impacted by sprawling development, as identified in the literature. These include:

- Total Direct Expenditures: Includes all spending categories, except for intergovernmental expenditures. This category includes utility expenditures (water, electric, gas, and transit).
    - Educational Services Expenditures: Includes spending on elementary, secondary, and higher education, in addition to libraries.
    - Social Services Expenditures: Includes spending on public welfare, hospitals, and health.
    - Transportation Expenditures: Includes spending on highways, airports, parking, and port facilities.
        - Highway Expenditures
        - Parking Facilities Expenditures
    - Public Safety Expenditures: Includes spending on police, fire protection, correction, and inspections and regulations.
        - Police Expenditures
        - Fire Protection Expenditures
        - Inspections and Regulations Expenditures
    - Parks and Recreation Expenditures
    - Housing and Community Development Expenditures
    - Sewerage Expenditures
    - Solid Waste Management Expenditures
    - Government Administration Expenditures: Includes spending on financial administration, judicial, legal, and general public buildings.
    - Interest on General Debt Expenditures
    - Utility Expenditures
        - Water Utility Expenditures:

    - Electric Utility Expenditures:
    - Gas Utility Expenditures:
    - Transit Expenditures:
- Capital Outlay: Includes spending on the construction or purchase of any fixed asset or asset upgrade.
- Debt Outstanding: Includes both short- and long-term debt, as well as public debt for private purposes.
- Charges and other Miscellaneous Revenue: Includes revenue from a variety of sources including, but not limited to, education (i.e. school lunch sales), hospitals, highways, sewerage, solid waste management, interest, special assessments, and the sale of property.

All of the categories are presented in per capita 2012 dollars, in order to control for differences in population and inflation. Appendix B contains more a detailed summary and comparison on the selected cities' financial data. As mentioned previously, this paper will not look at one point in time, but rather will compare changes between 2000 and 2010. The map below (Figure 2) shows the changes in per capita total direct expenditure between these years. As you can see, nearly all of the cities increased real spending over this decade, as shown by the color green. However, six cities did decrease their spending: Columbia, SC; Richmond, Provo, Detroit, Knoxville, Lexington; Washington, D.C. saw the largest increase by far of the 82 selected cities.

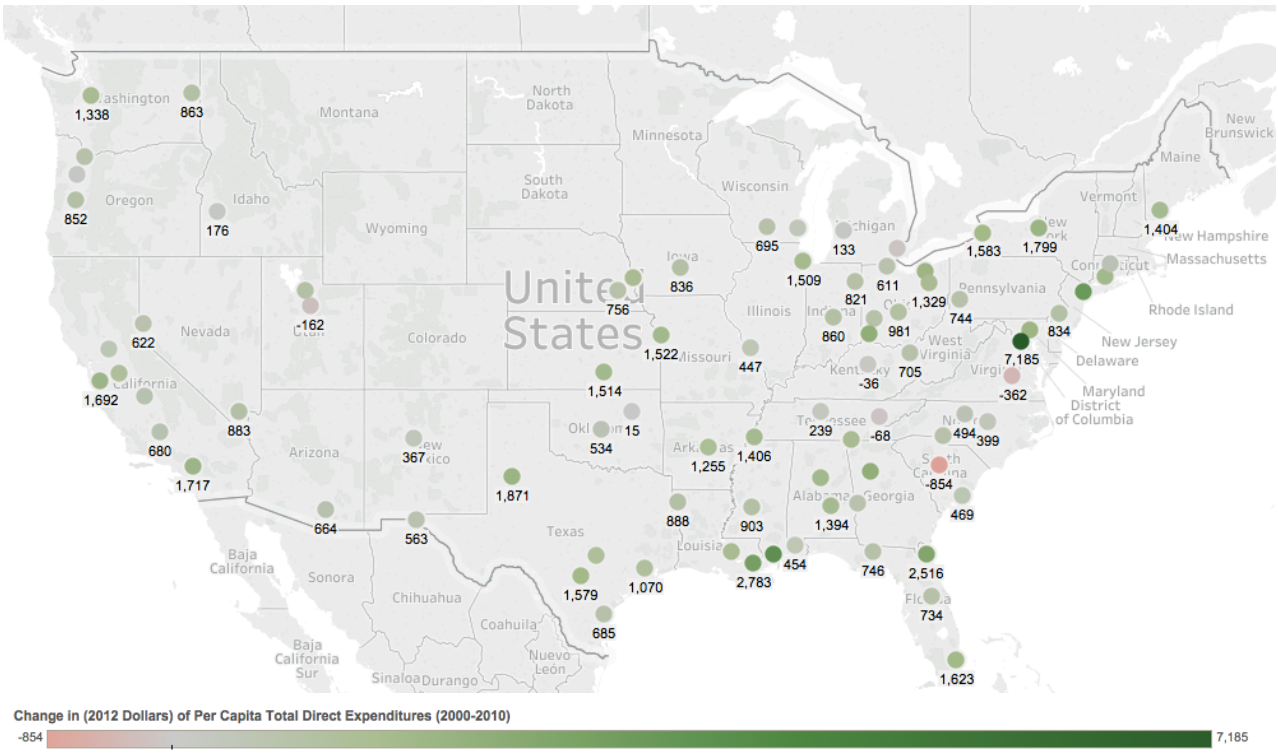

FIGURE 3. CHANGE IN PER CAPITA TOTAL DIRECT EXPENDITURE (2000-2010) IN 2012 DOLLARS.

CONFOUNDING FACTORS

Many confounding factors could contribute to the relationship between sprawl and municipal finances (Table 2). These include population growth, the age of the city and infrastructure, house values, income, tax revenues, and the supply of land. Considering this, several variables are included to control for these confounding factors, including population change, change in the median age of structures, change in the median house value for all owner-occupied units, change in median household income, difference in tax revenues, and change in the total land area of the city. These data have been collected from the Lincoln Institute's FiSC database, the 2000 U.S. decennial census, and the American Community Survey 3-year estimates (2008-2010). By analyzing the differences over time, inherent differences between cities will be

accounted for, such as regional variations.

Variable Name	*2010 Average (Change 2000-2010)*	*Variable Name*	*2010 Average (Change 2000-2010)*
Population	517,750 (18,942)	***Land Area***	151.5 mi^2 (7.5 mi^2)
Age of Structures	44.1 years (7.5 years)	***Per Capita Tax Revenue***	$2,012 ($272)
Median Housing Value	$187,357 ($48,781)	***Per Capita Total Direct Expenditures***	$6,460 ($1,060)
Median Household Income	$43,729 (-$4,792)	***Sprawl Index***	101.5 points (0.55 points)

TABLE 2. DESCRIPTIVE STATISTICS FOR KEY VARIABLES.

The data on sprawl is calculated at the geography of urbanized area, while the financial data is calculated at the municipal level. The analysis is still appropriate, despite this misalignment in geographies, as the overall sprawl/compactness measure for the urbanized area is representative of the primary central city. Due to the fact that some urbanized areas encompass multiple cities (consider the urbanized area around San Francisco that includes Oakland and San Jose), it was necessary to remove cities from the study that fell into the same urbanized area. After removing these anomalies, 82 large cities remained in unique urbanized areas that could be analyzed in this study (see Figure 3).

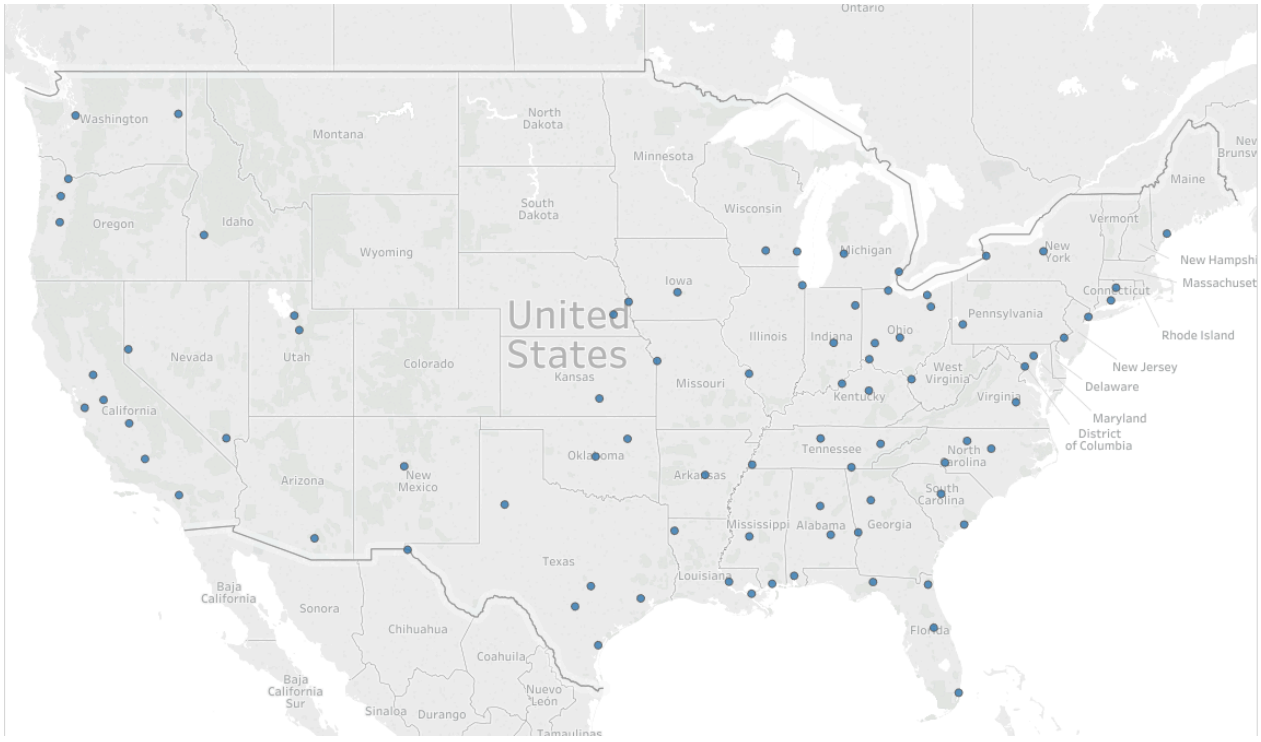

FIGURE 4. THE 82 SELECTED CITIES INCLUDED IN STUDY.

REGRESSION MODELS

In order to test the hypothesis, multivariate regression analyses were used to determine the correlation between the explanatory variable (*sprawl*) and different municipal financial variables (*exp*), controlling for confounding factors, represented by the following equation:

$$\Delta exp = \alpha + \beta_1(sprawl_{\ 2010} - sprawl_{\ 2000}) + \beta_2(pop_{2010} - pop_{\ 2000}) + \beta_3(age_{2010} - age_{2000}) + \beta_4(huvalue_{\ 2010} - huvalue_{2000}) + \beta_5(income_{2010} - income_{2000}) + \beta_6(size_{2010} - size_{2000}) + \beta_7(taxr_{2010} - taxr_{2000}) + \varepsilon,$$

where *exp* is one of the 23 measures of expenditure, *sprawl* is the calculated sprawl index developed by Hamidi and Ewing, *pop* is the total population, *age* is the median age of structures, *huvalue* is the median house value of owner-occupied units, *income* is the median household income, *size* is the spatial extent of the city in square miles, and *taxr* is the total per capita locally

assessed tax revenue. Twenty-three separate regression models were used, one for each of the twenty-three fiscal measures.

V. RESULTS

The scatter plot in Figure 4 presents the relationship between the change in total municipal expenditures and the change in sprawl/compactness between the years 2000 and 2010. As illustrated by the best-fit line, there appears to be a slightly positive linear relationship between these two variables, although the statistical significance of this line is low ($p = 0.32$). It is important to keep in mind that the higher the value in the Sprawl Index, the less sprawling the city is. The upper-left quadrant of the scatterplot represents the cities that have become more sprawling and also have increased their per capita total expenditures. Moving clockwise, the cities in the upper-right quadrant are those that have become more compact while also seeing an increase in expenditures. The bottom-right quadrant represents the cities that have become more compact and have reduced their expenditures. This quadrant is the one most linked with the hypothesis. The final quadrant, the bottom-left, represents the cities that have become more sprawling and also reduced per capita total expenditures. While the best-fit line suggests a slightly positive relationship, it is not statistically significant. As the scatterplot shows, cities exist in all quadrants, showing that cities exist for every combination of spending and sprawl. It is possible to become more compact and increase spending, or to become more sprawling and decrease spending. The following regression models will further explore this relationship, as well as the relationship between sprawl and individual fiscal categories.

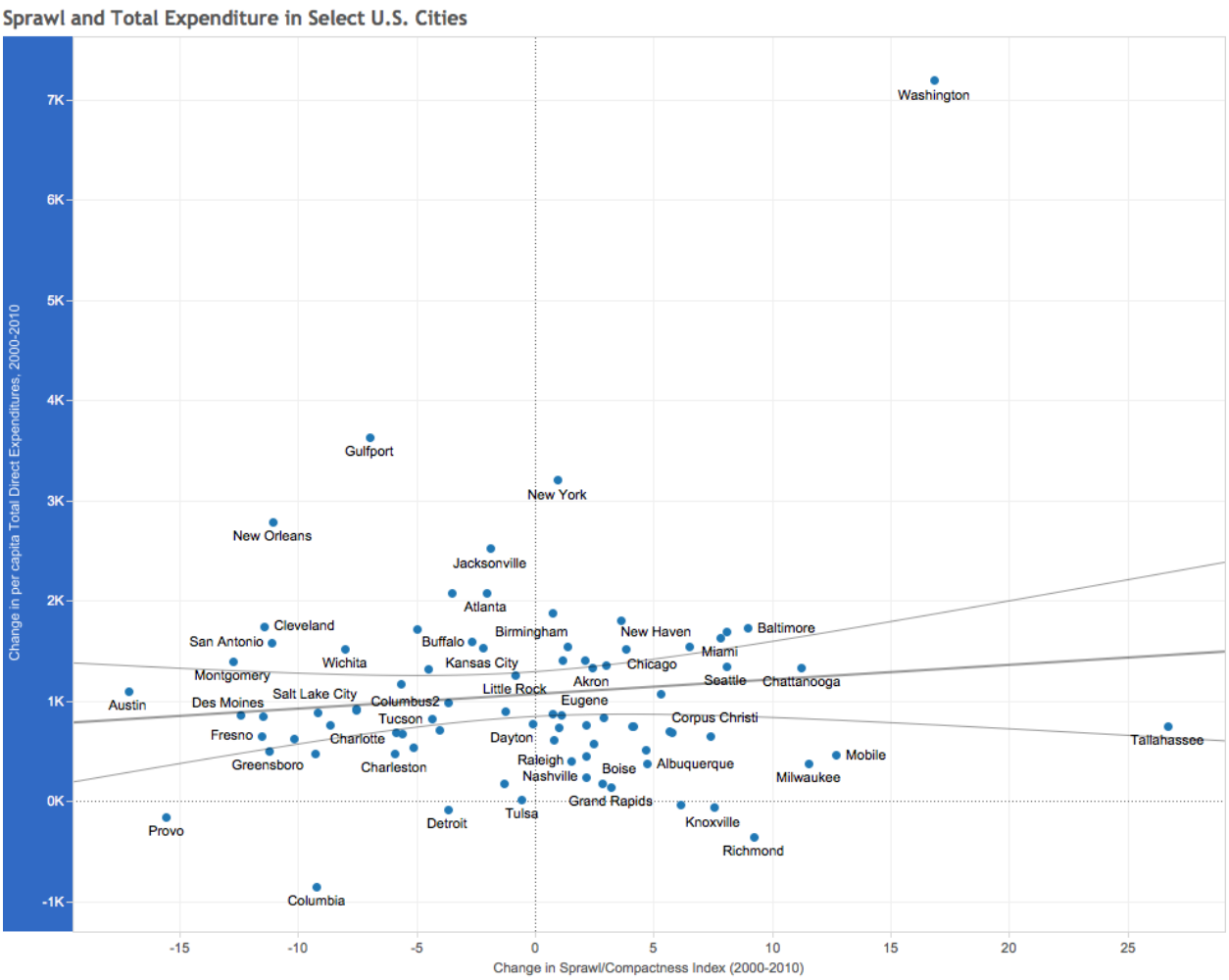

FIGURE 5. SCATTERPLOT OF RELATIONSHIP BETWEEN SPRAWL INDEX AND PER CAPITA DIRECT EXPENDITURES (2000-2010)

Figure 5 presents the summarized regression results for select expenditure models. Of the 23 regression models, 10 models were statistically insignificant and inconclusive, with very low F-stat values (less than 1.68), and therefore not included in the summary. The sprawl index variable was statistically significant and negative in one of the models, as a predictor of capital outlay. More specifically, the coefficient of -17.18 signifies that for every one percent increase in the sprawl/compactness index (the city is becoming less sprawling), per capita capital outlay decreases by 17%. In all other models, the sprawl index had no statistically significant impact on the dependent financial variables.

Variable	Predictors of Total Direct Expenditures	Predictors of Education Expenditures	Predictors of Transportation Expenditures	Predictors of Highway Expenditures	Predictors of Police Expenditures	Predictors of Fire Protection Expenditures
Sprawl Index	(4.90)	4.33	(0.177)	2.36	0.42	(0.128)
Population	(0.002)	0.001	0.0002	(0.000001)	(0.0002)	**(0.0002)***
Median Age of Structures	(5.82)	**39.87*****	(10.60)	(1.34)	0.32	**(2.90)***
Median House Value	**0.005***	(0.001)	**0.001***	0.0004	0.000006	**0.0002***
Median Household Income	0.023	0.015	0.003	0.006	0.000005	**(0.003)***
Total Land Area	(3.13)	0.24	**(3.78)***	(0.301)	0.423	0.229
Tax Revenue	**1.79*****	**0.53*****	0.16	**0.196*****	**0.10*****	**0.069*****
F	7.24	4.20	3.60	5.86	2.25	2.98
Adj. R^2	0.35	0.21	0.18	0.30	0.09	0.15
N	82	82	82	82	82	82

Variable	Predictors of Parks and Rec Expenditures	Predictors of Housing & Comm. Dev. Expenditures	Predictors of Solid Waste Mgmt Expenditures	Predictors of Interest on Debt	Predictors of Transit Expenditures	Predictors of Capital Outlay	Predictors of Debt Outstanding
Sprawl Index	(1.77)	(2.46)	(0.136)	(2.69)	(0.96)	**(17.18)****	(13.845)
Population	0.0003	**(0.001)****	0.00003	**(0.001)****	(0.0001)	0.0015	**(0.0095)***
Median Age of Structures	**(7.29)****	(5.96)	0.774	(3.37)	(1.02)	13.67	(38.35)
Median House Value	0.0003	**0.001***	**0.0002***	(0.0002)	**0.0012*****	**0.0032****	0.009
Median Household Income	0.001	**0.011***	0.0003	**(0.008)***	**(0.007)***	0.025	**(0.168)***
Total Land Area	(1.69)	0.95	0.004	0.776	(0.065)	**(7.97)***	(1.08)
Tax Revenue	0.028	**0.195****	0.021	**0.229*****	0.036	(0.002)	**3.826*****
F	2.42	4.77	1.92	2.55	3.53	4.51	2.41
Adj. R^2	0.11	0.25	0.07	0.12	0.18	0.23	0.11
N	82	82	82	82	82	82	82

FIGURE 6. SUMMARY OF THE REGRESSION RESULTS IN THE 13 SIGNIFICANT MODELS. *, **, AND * SIGNIFIES SIGNIFICANCE AT THE 90%, 95%, AND 99% CONFIDENCE LEVEL.**

Among the confounding variables, tax revenue was the most consistently significant variable. In eight of the models (expenditures on total direct, education, highway, police, fire, housing and community development, interest on debt, and debt outstanding) tax revenue was significant and positive. Increases in tax revenue were associated with increases in spending. Median house value for all owner-occupied units was significant and positive in seven of the models (total direct, transportation, fire protection, housing and community development, transit, and capital outlay expenditures). Population was significant and negative in four models

(debt outstanding, interest on debt, housing and community development, and fire protection expenditures), meaning that as population increases, per capita spending and debt decreases. The median household income was also significant and negative in four models (fire protection, interest on debt, transit and debt outstanding). As median household income increases, expenditures in the four areas decreases. Total land area was significant and negative in two of the models, transportation expenditures and capital outlay.

The remaining variable, median age of structure (a proxy of the age of the city), was significant and positive for predicting education expenditures, but significant and negative in the fire protection and parks and recreation models. This suggests that more aging cities spend more on educational services, however they spend less on fire protection and parks and recreation.

VI. Discussion

The regression models found only one significant relationship between sprawl and municipal expenditures, as a predictor of capital outlay. In line with what the literature and theoretical models would suggest, as cities become less sprawling and more compact, their capital outlay decreases. Capital outlay includes spending on the construction or purchase of any fixed asset or asset upgrade. This can include the acquisition of property, the construction of buildings and infrastructure, or the completion of any permanent public works or improvement projects, such as street improvements. The magnitude of this relationship is important, as well. For every one point increase in "compactness", there is a 17% decrease in *per capita* capital outlay. This can translate into significant savings when taken across the entire population, especially considering the cities in this study have a median population of more than 295,000.

The other regression models found no significant relationship, positive or negative, between sprawl and municipal finances, despite strong suggestions in the literature of a negative relationship. However, most of the theoretical models that have been developed regarding this issue focus on the general costs of sprawl compared to traditional development patterns. The results of this research are not able to completely contradict this claim, as this paper only examined the cost burden to the authority providing the service, such as the municipality, school district, water board, etc. It is possible that the additional financial costs of sprawl are being absorbed by another entity, such as developers or consumers. Additional research is needed to determine if other parties are bearing additional financial burdens as a result of sprawl.

Tax revenue was one factor that did consistently predict spending across categories. Not surprisingly, higher tax revenues are associated with increased spending. However, many factors

influence tax revenues, including income, political affiliation, and even development. Further research should be conducted to examine the relationship between development patterns and tax revenues. It is also important to consider that this paper only examined the actual realized financial costs (in spending or debt) of sprawl, and none of the environmental or social costs that have been thoroughly documented in existing literature.

This research found the primary costs of sprawling development patterns to be embedded in constructing new assets and infrastructure and improving existing infrastructure (capital outlay). The results suggest that there is no significant difference in the costs of administering and maintaining existing services between sprawling and compact cities, despite what existing literature would suggest. However, cities of all kinds are building and acquiring new assets regularly. Even after controlling for population growth, the age of the city, and total land area, capital outlay in more sprawling areas is significantly higher. In other words, even as compact cities build and acquire new assets and infrastructure, it costs significantly less.

These findings emphasize the importance of investing in compactness and accessibility. While reversing the trend of low-density, poorly planned suburbanization is complex and will require significant investments, they can be offset by savings in capital outlay over time. Urban form and infrastructure are very rigid elements of any city. A typical freeway lifespan is in excess of 50 years. Once a sprawling, poorly connected subdivision is built, it is very difficult to change. Investments in infrastructure and urban form have the capability to “lock-in” cities for decades, in terms of physical space, population, livability, carbon emissions, and financial obligations. Therefore, these investments should be planned very carefully, with all of their implications fully

considered. Cities that choose to invest in development that continues the process of urban sprawl will be forced to live with the increased financial obligations of more costly capital outlay, in addition to the numerous increased environmental and social costs, decades into the future. However, cities that choose to invest in compact, accessible development can expect significantly less capital outlay expenditures for decades to come, in addition to a healthier, more livable community. At a time when municipal budgets are severely strained, potential savings of any kind should be seriously considered, especially when the savings offer co-benefits of improved accessibility, higher social capital, and increased environmental protection.

This research only begins to uncover the extreme complexity of municipal fiscal patterns. The regression analysis shows that no one factor can explain municipal finances, rather many variables influence spending, debt, and capital outlay of cities and other authorities responsible for providing services; this analysis only scratched the surface. Exogenous factors such as natural disasters, economic influencers, and failing infrastructure certainly play a role in municipal finances, and may overshadow the costs inflicted by sprawl or compact development. Furthermore, factors can influence various categories of spending in different, sometimes opposing, ways. This research also focused broadly on general expenditures, that included the administrative and daily functioning expenses. However, the one significant variable was capital outlay – the actual construction or purchase of real assets across all categories – and did not include any administrative costs. Future research should analyze the impacts of sprawl on individual categories of capital outlay, such as sewerage, waste management, highways, and education, in order to better understand this relationship.

While this research does strongly support denser, mixed-use, more accessible development, it does not advocate for any one kind of compact urban form that cities should design and build. There is no one prescriptive compact urban form that is right for all cities. Compactness and sustainable urban form looks different everywhere, depending on local context and citizens' desires and preferences. However, this research shows that it does matter significantly to cities' finances. Urban form and land use patterns have serious financial implications that cities must begin to consider in order to remain fiscally and financially healthy.

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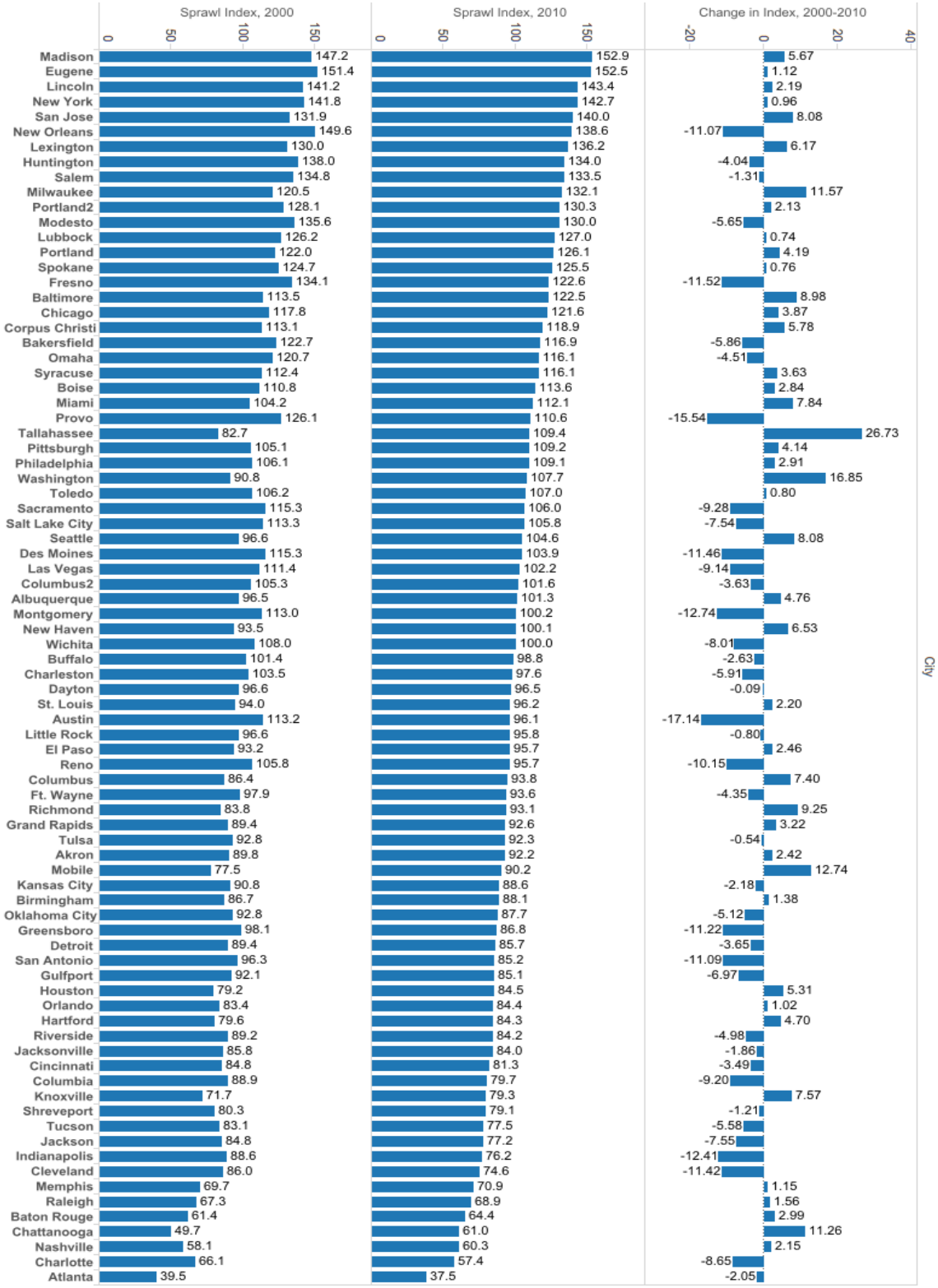
APPENDIX

APPENDIX A. SPRAWL INDEX CALCULATIONS FOR THE 82 SELECTED CITIES.



APPENDIX B. KEY FINANCIAL DATA FOR SELECT CITIES