
Urban sprawl and the cost of public services

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Abstract. One of the principle criticisms of urban sprawl is that it undermines the cost-effective provision of public services. In this paper the authors examine whether or not this is true through an exploratory analysis of the influence that alternative development patterns have on twelve measures of public expenditure: total direct, capital facilities, roadways, other transportation, sewerage, trash collection, housing and community development, police protection, fire protection, parks, education, and libraries. The objectives of the analysis are threefold. First, the authors, through a background discussion, provide a brief overview of previous research on the relationship between urban development patterns and the cost of public services. Second, through empirical analysis, they examine how the character of urban development affects per capita public outlays in a cross-section of 283 metropolitan counties during the 1982–92 time period. A separate equation is estimated for each measure of expenditure, providing substantive evidence on how density, the spatial extent of urbanized land area, property value, and political fragmentation affect the cost of services. Finally, the authors use the results of the empirical analysis to develop a set of policy recommendations and directions for future research.

1 Introduction

Over the last several decades there has been a sustained interest in measuring the relative costs of alternative forms of development in US metropolitan areas (Burchell, 1998; Frank, 1989; RERC, 1974). Throughout, a major emphasis has been on the question of whether or not urban sprawl—low-density, discontinuous, suburban-style development, often characterized as the result of rapid, unplanned, and/or uncoordinated growth (Nelson et al, 1995)—undermines the cost-effective provision of urban services. This issue is important because, unlike many other criticisms of sprawl, it provides a practical point of departure for debates over the role that governments should play in regulating the outcome of urban growth. In particular, the high service costs allegedly incurred through far-flung development patterns serve as a key source of leverage for urban planners and others advocating the use of growth management and ‘smart growth’ programs to promote more compact urban areas (for example, see Ewing, 1997). But despite claims that land-use regulation is necessary to maintain efficient service provision, the supporting evidence remains thin and inconclusive. How does the character of urban development affect the cost of services, and what does this imply for land-use planning and growth management efforts administered in the name of economic efficiency?

In this paper we respond to these questions with an exploratory analysis of the influence that alternative development patterns have on twelve measures of public expenditure: total direct, capital facilities, roadways, other transportation, sewerage, trash collection, housing and community development, police protection, fire protection, parks, education, and libraries. Our objectives are threefold. First, we provide a

brief overview of previous research on the relationship between urban form and the cost of public services. Second, we examine how the character of urban development affects per capita public outlays in a cross-section of 283 metropolitan counties during the 1982–92 time period. A separate equation is estimated for each measure of expenditure, providing substantive evidence on how density, the spatial extent of urbanized land area, property value, and political fragmentation affect the cost of services. Third, we use the results of the empirical analysis to develop a set of policy recommendations and directions for future research. We suggest that growth management programs may be justified from the standpoint of public finance and that development impact fees have significant potential for mitigating the fiscal effects of urban sprawl. Future research should focus on evaluating the cost of services by means of alternative measures of urban form, on determining whether or not the quality of service provision is affected by the physical character of development, and on evaluating the relative costs and benefits of political fragmentation, after taking into account its influence on urban sprawl.

The paper is organized into four sections. In section 2 we review previous research on the relationship between urban development and the cost of services in US metropolitan areas. In the section 3 we present the empirical analysis, including the research hypotheses, modeling framework, and estimation results. In section 4 we provide a discussion of the modeling results, focusing on policy recommendations and directions for future research. Finally, in section 5, we conclude the paper with a summary of the research findings.

2 Background

Widespread interest in evaluating the causes and consequences of alternative development patterns emerged in the 1960s, just following the first major postwar boom of suburban development in the United States. At the time, urban sprawl was a relatively new phenomenon, so much of the early research focused on defining its key characteristics and its relationship to newly evolving land markets (Bahl, 1968; Clawson, 1962). Although generally inconclusive about the costs and benefits of sprawl, these and other studies collectively characterized it as being composed of low-density, scattered, strip, and leapfrog development patterns and as being eminently associated with land speculation, suburbanization, and political fragmentation (Burchell, 1998; Downs, 1999). Since its initial rise, sprawl has come to represent the dominant mode of growth in most US metropolitan areas and, as a result, it continues to generate extensive debate over its desirability as a pattern of land use. On the one hand, proponents defend urban sprawl as a fulfillment of consumer preferences whereas, on the other hand, detractors fault it for contributing to numerous social and economic problems (Ewing, 1997; Gordon and Richardson, 1997).

Despite its intensity, this debate has been hampered by a failure on both sides to distinguish sprawl from general suburbanization and by a lack of criteria for establishing what constitutes an ideal urban form in the first place. Suburbanization often occurs at high densities—as the experiences of Las Vegas, Los Angeles, Phoenix, and many other western cities have shown—even though it is still considered sprawl. Meanwhile, in other instances, low-density suburbanization has produced many communities that present none of the problems, such as environmental degradation, socioeconomic segregation, and traffic congestion, that sprawl is commonly faulted for. Because of this dichotomy, density emerges as only part of the picture and can sometimes provide a misleading image of urban form. Placed in a broader context, the problem of sprawl in Los Angeles, for example, may stem more from the city's tremendous land area and extreme separation of land uses than density alone (Burchell et al, 1998). Even so,

density remains the most common measure used to describe urban form because of its intuitive appeal and the difficulty of obtaining data on alternative measures.

On a more pragmatic level, there remains the question of what constitutes an ideal urban form. Planning is a normative profession, responsible for shaping cities into what they 'ought' to be, but there are very few rigorous criteria for justifying one outcome over another (Talen and Ellis, 2002). But urban form matters in meaningful ways to people who live, work, and/or otherwise spend time in cities, so policies that aim to shape it should be guided by well-founded theory and have a clear set of objectives (Carruthers, 2002a). The physical outcome of urban development directly affects the livability, property values, transportation alternatives, and many other aspects of the urban environment and therefore is central to the planning process. This is expressed in one of the fundamental theories of urban form (Lynch, 1981), which suggests that cities may be evaluated on the basis of five dimensions (vitality, sense, fit, assess, and control) and two metacriteria (efficiency and justice). Together, these social use values describe how well a city serves the needs of its populace and promotes its quality of life. Ultimately, they suggest that an ideal urban form is one that is dynamic and responsive to the needs of its residents—in short, one that produces net benefits for the public at large and that may continually be adapted to minimize negative externalities.

Among the most tangible points of departure for evaluating urban form is urban planners' well-known contention that sprawl undermines the cost-effective provision of public services (Altshuler and Gómez-Ibáñez, 1993; Kaiser et al, 1995). In particular, it is argued that, for many services, the cost *per unit* of development rises as densities decrease (Kelly, 1993; Knaap and Nelson, 1992; Nelson et al, 1995; Porter, 1997). That is, low-density, spatially expansive development patterns lead to greater costs because of the large investments required to extend roadways and other types of infrastructure that transmit water, sewage, electricity, and other services long distances to reach relatively fewer numbers of people (Carruthers, 2002a). Urban sprawl may also undermine economies of scale for other services, including police protection and public education, by lowering the density of individual consumers. That public goods and services are priced according to their average as opposed to their marginal cost adds to the problem, as land developers have little motivation to help maintain a cost-effective urban form. The location of new development continues to be determined by land speculation and potential for profit instead of its impact on aggregate public welfare. As an outcome, growth commonly enjoys significant subsidies, as the costs it imposes end up being financed through collective property tax revenues (Bruekner, 2000; Lee, 1981).

The logic behind this reasoning is straightforward but the supporting evidence remains thin, and little is known about the actual relationship between urban form and the cost of services—if any exists at all. As a practical matter, site planners and engineers have investigated how alternative development patterns affect the cost of delivering physical infrastructure, including roads, schools, sewers, and other public facilities. Although many of these studies find that low-density developments are more expensive to support, they have produced few generalizable conclusions because of their site-specific focus and an overall lack of standardized measures of expenditure (for a thorough review, see Frank, 1989; for a recent analysis of this type, see Speir and Stephenson, 2002). The most well known of these was undertaken by the Real Estate Research Corporation (RERC, 1974), publishing its findings under the title *The Costs of Sprawl*. RERC attempted to use an 'internally consistent' set of estimates for the direct costs of alternative development patterns to illustrate that urban sprawl was approximately twice as expensive to serve as 'high-density planned' development patterns. But despite its extensive impact, the RERC study has also received significant criticism over the years for its methodology and failure to control for the influence of factors other

than density that affect the cost of service provision (Altshuler and Gómez-Ibáñez, 1993; Ladd, 1998).

More recently, a series of regression-based analyses conducted by Ladd and Yinger (1991) and Ladd (1992; 1994) suggests that greater densities are associated with higher, not lower, public service expenditures. Drawing on cross-sectional data and controlling for other determinants of spending, Ladd and Yinger found that the cost of services rises with density, contradicting the findings of earlier site-based analyses. Specifically, using a 'piecewise' regression procedure, Ladd (1992) illustrated that the relationship may be U-shaped, first declining as density increases but then increasing sharply, leading to average costs that exceed the minimum by as much as 43% in very dense counties. The implication is that urban services are subject to economies and diseconomies of scale—a finding that is explained in terms of the 'harshness' of high-density areas or, in other words, the increased traffic congestion, crime rates, and other conditions associated with urban environments (Ladd, 1998). If this is the case, urban sprawl may not be as costly as planners claim, undermining the rationale for policies aimed at shaping compact development patterns.

Despite the high quality and methodological rigor of these analyses, other evidence suggests that further research drawing on cross-sectional data is needed before the relationship between urban form and service expenditures is fully understood. For example, in an analysis of the 159 counties forming the 25 largest metropolitan areas in the United States, Pendall (1999) finds that public indebtedness is associated with urban sprawl. Although the direction of causation examined is the opposite of that examined here, the implication is that low-density development patterns require greater public expenditures to support them than do high-density development patterns. Moreover, in a cross-section of 283 metropolitan counties we have found that density has a negative influence on the cost of infrastructure, including roadways and sewers (Carruthers, 2000b; Carruthers and Ulfarsson, 2002). Unlike Ladd's (1992; 1994) expenditure model, in which indicator variables were used to partition the dataset categorically by density, we assumed a linear overall relationship and focused specifically on the interconnected influences of several characteristics of urban development. The results suggest that per capita spending on infrastructure declines at greater densities but increases with the spatial extent of urbanized land area and property values. It may therefore be the 'spread' of a metropolitan area and that relative strength of its property tax base, rather than its 'bulk', that leads to greater per capita service expenditure.

Finally, in addition to these and other characteristics of the built environment, urban sprawl has also been described in terms of the political structure of metropolitan regions (Burchell, 1998; Downs, 1994; 1999). In particular, new local governments and special districts are often formed in order to increase and/or maintain the quality of service provision in newly urbanizing areas (Foster, 1997; Lewis, 1996). This process is fundamental to the perpetuation of sprawl because new incorporations and service districts literally enable suburban development to proceed at the urban fringe (Carruthers, 2003; Carruthers and Ulfarsson, 2002). In turn, the 'fiscal zoning' and growth-control strategies often employed in these communities work to lower densities, virtually ensuring that metropolitan areas become more spread out over time. Even so, the thinking among many suburban residents is that the formation of small general and special purpose governments helps to secure the highest possible quality of public services for the lowest possible price. In this way, the process of political fragmentation compounds questions regarding the relationship between the character of urban development and service expenditures by simultaneously promoting the physical dimensions of urban sprawl and seeking to achieve greater cost-effectiveness in service delivery (Fischel, 1985).

In theoretical terms, the role that fragmentation plays in reducing the cost of public services may be understood through the Tiebout model of metropolitan governance. Specifically, the model suggests that, assuming a mobile population capable of ‘voting with their feet’, highly fragmented metropolitan areas should exhibit relatively lower per capita service expenditures as communities minimize their operating costs in order to attract and retain residents (Tiebout, 1956). This expectation has generally been reinforced by empirical research finding that the greater the number of jurisdictions, the lower their overall expenditure, but little is known about how spending on different *types* of services is affected (Dowding et al, 1994). The question is an important one because it has direct implications for the role of planning and growth management in many metropolitan regions, especially if the physical characteristics of development also make a difference.

In sum, the relationship between urban form and public service expenditure remains ambiguous and controversial. Early research developed a strong foundation for characterizing sprawl but remains inconclusive about the desirability of sprawl as a form of land use. Meanwhile, normative theory suggests that an ideal urban form is one that maximizes social use value by creating net benefits to the public at large and that may be adapted to minimize negative externalities. Within this context, public service expenditures represent a tangible point of departure for evaluating the impact of urban sprawl on aggregate public welfare. Site-based analyses have attempted to address the issue from a practical standpoint, estimating the infrastructure costs associated with alternative development patterns, but these have provided only limited insight because of their overemphasis on density as singular determinant of public spending. Regression-based analyses have produced conflicting evidence, partly because of methodological differences but also because of differences in the way the character of urban development is measured (an issue discussed in section 3.1). Adding to the complexity, the political structure of fragmented metropolitan regions may also affect service provision by promoting greater cost-effectiveness, even as it works to create low-density development patterns. Meanwhile, the alleged costs of sprawl continue to serve as leverage for growth management and ‘smart growth’ programs aimed at shaping compact, high-density urban areas in both academic and applied planning forums. Although it is impossible for any single analysis to account for all the relative costs and benefits of alternative development patterns, there is a clear need for more detailed testing of how the various physical and political dimensions of metropolitan areas affect public service expenditure.

3 Empirical analysis

In this section we present an empirical analysis of the relationship between alternative development patterns and expenditure on public services in a cross-section of 283 metropolitan counties, observed over the 1982–92 decade. The process is divided into three steps. In the first we provide a framework for measuring the physical and political characteristics of urban development (section 3.1). In the second we describe the data and specify the empirical model (section 3.2). In the third we deliver the estimation results for twelve different forms of expenditure: total direct, capital facilities, roadways, other transportation, sewerage, trash collection, housing and community development, police protection, fire protection, parks, education, and libraries (section 3.3).

3.1 Measuring the characteristics of urban development

Two key factors have detracted from analysts’ ability to estimate accurately the costs of alternative development patterns in the past: the interconnected influences of different physical characteristics of urban development, and the difficulty of obtaining appropriate measurements. First, most research has been narrowly focused on the question

of how density, as a singular measure of urban development, influences public service expenditure. This approach is problematic because although density may help to create economies of scale for certain urban services it does not unilaterally describe the character of urban areas. For example, many services are also subject to economies of geographic scope, which depend on the spatial extent of the area they provide for—especially where facilities are immobile and the cost of service delivery varies from location to location (Knaap and Nelson, 1992). Moreover, measurement of the influence of density in isolation may yield misleading results because dense urban areas also have high land values and therefore generate greater property taxes (Ewing, 1997). In this way, density may ‘pay for itself’, obscuring the actual costs that it generates. Where this is the case, density is likely to be positively correlated with the cost of service delivery, because of the greater spending through property tax revenues, not because of the physical form of the development itself.

Second, because of data limitations, analysts have until recently been limited to measuring the density of specific sites or, in the case of cross-sectional analyses, to using county land area as the spatial unit. As mentioned in section 2, the site-based approach has limitations because its findings do not necessarily apply beyond a localized area. The use of counties as the spatial unit of analysis is even more problematic because their large size obscures actual urban density. Counties are also ineffective spatial units for measuring changes in density through time—because the spatial unit remains fixed, any amount of population growth, by definition, leads to greater density. When measured this way, changes in county density over time more accurately represent changes in population than in the character of development occurring within.

In this analysis we address these two shortcomings by accounting simultaneously for the influence of density, the spatial extent of urbanized land area, and property value. Measurement of these dimensions is made possible by the National Resources Inventory (NRI), of the US Department of Agriculture (USDA), which records the number of acres of urbanized land and other major land-use categories at the county level every five years (USDA, 2002). Using these data: density is measured as the number of jobs and people per acre of urbanized land; the spatial extent of urbanized land area in a county is given by the total number of developed acres; and property value is expressed as the total locally assessed property value per acre of urbanized land. Employment plus population is used to calculate density, because the amount of developed land depends both on residential land use and on nonresidential land use. Also, in the case of property value, it is assumed that assessed land value corresponds primarily to urban development because the analysis focuses on metropolitan counties and it is impossible to separate the data according to land use. Together, the three measures provide a more realistic profile of the character of urban development within a county than is possible when the land area of the county itself is used. The approach has the added benefit of allowing the spatial unit to vary over time.

In addition to physical characteristics, in our empirical analysis we control for the effects of political fragmentation. Urban service expenditure is closely linked to the underlying political landscape—especially where land-use authority is distributed among numerous jurisdictions. In order to capture this effect, political structure is measured in terms of per capita municipalities and per capita special districts, with higher values corresponding to greater fragmentation. For example, a perfectly fragmented metropolitan area, with each person being his or her own mayor, would have a measure of 1 on an index of per capita municipalities. Note that measurement of political fragmentation in this way ‘double counts’ people, because total population is the denominator both in per capita municipalities and per capita special districts. This is appropriate because it is hypothesized that the ratio of *each* type of government to

the total population affects public service expenditure. In addition to these measures, because we make use of county-level data (described in section 3.2), an indicator variable is used to distinguish between central city and suburban counties; the two types of counties often have very different socioeconomic characteristics, so it is reasonable to expect that their spending patterns may vary systematically.

Finally, it is important to note the limitations and strengths of the analytical framework just described. At issue here is the scale at which the analysis is conducted. On the one hand, these measures—density, the spatial extent, or spread, of urbanized land, property value, and political fragmentation—are limited in the sense that they cannot capture the place-to-place variation in urban form that occurs within large metropolitan areas. It is quite possible, for example, to have ‘traditional’ urban neighborhoods imbedded in an overall pattern of urban sprawl. At a finer scale, urban form may be described in terms of centralization, concentration, connectivity, grain (which describes land-use mix), and numerous other measures that deal more directly with *patterns* of land use and that are capable of drawing out localized variation (Alberti, 1999; Galster et al, 2001). On the other hand, the measures incorporated in this analysis capture a great deal of variation in the *overall* character of metropolitan areas and provide a detailed basis for testing hypotheses regarding how alternative development patterns affect public service expenditures within an interregional framework. Although none of these variables measures sprawl directly, given previous interpretations in the planning literature, lower density, larger urbanized land area, greater fragmentation, and suburban county classification may generally be viewed as lying at that end of the spectrum.

3.2 Empirical model

In order to investigate the relationship between public service expenditures and the physical and political dimensions of sprawl, the variables described in section 3.1 are imbedded within an equation containing additional variables measuring sources of revenue:

$$e = f(\mathbf{B}, \mathbf{P}, \mathbf{R}, \mathbf{u}), \quad (1)$$

where expenditure, e , on a given public service is a function of: the characteristics of the built environment, including density, urbanized land area, and property value (\mathbf{B}); political characteristics, including per capita municipal governments, per capita special districts, and the indicator variable marking counties that contain a central city (\mathbf{P}); revenue, including local tax and intergovernmental sources (\mathbf{R}); and \mathbf{u} , a vector of unobserved effects. The two revenue variables are defined as the *total value* of locally assessed taxes—because communities rely on different combinations of property and sales taxes and tax rates—and state *plus* federal aid, respectively. These variables were originally tested in disaggregated form, including separate variables for property tax, state aid, and federal aid, but the detail added little to the results of the analysis: property tax alone was not an adequate explanatory variable, and state and federal aid were often collinear with one another.

In table 1 (see over) we provide a definition of each independent variable and summarize the effects that each is expected to have on the dependent variables. One variable that is conspicuously absent from the list is income, which plays a major role in shaping residents’ preferences for public services (Ladd, 1992; 1994). Income was tested in the model but competed with property value because of multicollinearity between the two variables—when income was added, property value would become insignificant and/or reverse its sign, and the density variable was also negatively affected. For this reason, income was discarded as an explanatory variable.

Table 1. Expected influence of the independent variables on public expenditure.

Variable	Expected effect	Variable definition
Built environment		
density	–	Average number of people plus jobs per acre of urbanized land
urbanized land	+	Total number of acres of urbanized land
property value	+	Average locally assessed property value per acre of urbanized land (US\$1000 per acre)
Political characteristics		
per capita municipal governments (thousands)	–	Number of municipal governments headquartered in county, divided by population
per capita special districts (thousands)	–	Number of special districts headquartered in county, divided by population
central city indicator	+	1 if the county contains a central city; 0 if not
Revenue		
per capita local tax revenue	+	Total value of locally assessed tax dollars within county, per person
per capita intergovernmental revenue	+	Total value of state plus federal aid (US\$) received by general purpose governments within county, per person

The functional relationship identified in equation (1) is specified as an econometric model with variables collected for 283 counties located in fourteen states at three points in time: 1982, 1987, and 1992. The dataset includes all metropolitan counties in Arizona, California, Colorado, Florida, Georgia, Idaho, Nevada, New Mexico, North Carolina, Oregon, Tennessee, Texas, Utah, and Washington (1998 Census definition). These states are similar in the sense that each ranks among the top twenty most rapidly growing states in the country, but they also capture significant geographic diversity. The widespread growth in the states makes them especially good locations for examining the relationship between urban development patterns and service expenditure because their cities are evolving rapidly, producing changes that may be traced through the longitudinal structure of the dataset. In figure 1 we show all counties included in the analysis (shaded dark gray), and in table 2 (see over) we list descriptive statistics and data sources for each dependent and independent variable used in the analysis.

Two accommodations are made in order to make the best use of the dataset within an econometric framework. First, because we employ cross-sectional and time-series data the model is specified by using a fixed-effects estimation method, adding constant terms for the years 1987 and 1992, and thirteen of the fourteen states—one from each group (1982 and Texas) is omitted in order to avoid perfect multicollinearity with the overall intercept. This controls for correlation across locations, because observations from all locations at a particular *time* are likely to share unobservable effects, and for correlation through time, because observations from a particular *location* are likely to share unobservable effects. The fixed-effects approach also helps us to minimize any omitted variable bias that may affect the parameter estimates. Ideally, location-specific fixed effects would be added for each county in the dataset, but this would require the addition of too many additional constant terms (282 instead of 13). The state-specific fixed effects represent a good compromise because they capture everything that sets a given state apart from the rest through time. Second, because the data are based on countywide aggregations, and because the counties are of different sizes, it is likely that the observations are heteroscedastic. Within an ordinary least squares (OLS) regression model, heteroscedasticity causes the estimates of the coefficients to become inefficient; although they remain unbiased and consistent, the usual estimate of the variance–covariance matrix becomes

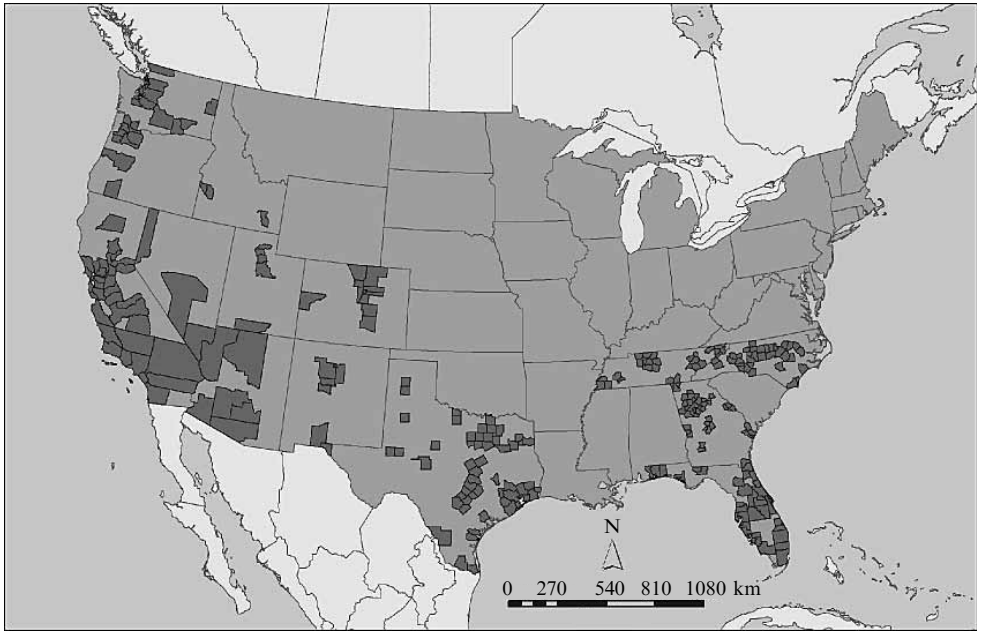


Figure 1. Counties included in the empirical analysis.

biased, thereby making it difficult to make statistical inferences about the coefficients. In order to avoid this problem, the model is estimated using White's heteroscedasticity-consistent estimator for the variance–covariance matrix. For a discussion of fixed effects and White's heteroscedasticity-consistent estimator, see Kennedy (1998).

As little is known about the exact nature (shape) of the relationship between urban development patterns and service expenditure, extensive sensitivity testing was conducted in order to achieve the best possible fit between the dependent and independent variables. As Ladd (1992) found, we also found that neither linear nor log–linear forms are appropriate; instead, a semilog form was adopted by taking the log of the dependent variable only. This allows the function itself to be nonlinear but still to preserve the *linear-in-parameters* assumption necessary to estimate an equation properly by using OLS. Because of the semilog form, the estimated coefficients were interpreted as percentages—that is, a unit change in the independent variable produces a percentage change in the dependent variable (Kennedy, 1998). The result is an econometric specification of equation (1), with the following functional form:

$$\ln e_{it} = \alpha + \lambda_j + \tau_t + \beta x_{it} + \varepsilon_{it}, \quad (2)$$

where i ranges over all counties; t ranges over the three time periods (1982, 1987, and 1992); j ranges over the fourteen states; α represents the overall constant; λ represents the locational fixed effects; τ represents the temporal fixed effects; β represents a vector of estimable coefficients; x represents the vector of independent variables given by equation (1); and ε represents the stochastic error term. As noted above, two of the fixed effects are restricted in each equation ($\tau_{1982} = 0$, and $\lambda_{\text{Texas}} = 0$) in order to avoid perfect multicollinearity with the overall intercept (α).

Table 2. Descriptive statistic and data sources for the dependent and independent variables.

	Mean	Median	Standard deviation	Data sources
Dependent variables				USCG, various years c; REIS, various years
per capita total expenditure (US\$)	1 463.31	1 348.74	984.48	
per capita spending (US\$) on				
capital facilities	188.56	144.56	258.66	
roadways	58.63	56.31	31.90	
other transportation	16.46	3.99	38.53	
sewerage	34.08	24.70	36.70	
trash collection	19.61	16.79	17.12	
housing	22.19	16.60	23.61	
police protection	59.93	55.82	27.65	
fire protection	29.03	26.98	21.12	
parks	26.22	19.62	24.27	
education	547.05	542.40	173.17	
libraries	7.63	6.11	6.51	
Built environment				
density (number of jobs and people per acre)	4.80	3.90	4.41	USDA, 2002; REIS, various years
urbanized land (acres)	68 677.64	45 900.00	96 784.27	USDA, 2002; REIS, various years
property value (US\$ thousands per acre)	67 258.69	42 003.99	96 784.27	USDA, 2002; USCG, various years b
Political characteristics				
per capita municipal governments (thousands), $t - 5$	0.07	0.04	0.09	USCG, various years a; REIS, various years
per capita special districts (thousands), $t - 5$	0.12	0.08	0.13	USCG, various years a; REIS, various years
Revenue				
per capita local tax revenue (US\$)	494.99	454.00	213.01	USCG, various years b; REIS, various years
per capita intergovernmental revenue (US\$)	408.88	376.23	195.21	USCG, various years b; REIS, various years

Note: $t - 5$, previous period.

3.3 Estimation results

By using data from the *Compendium of Governmental Finances* of the US Census of Government (USCG, various years c), we estimated twelve separate models for per capita spending on public services: total direct, capital facilities, roadways, other transportation, sewerage, trash collection, housing and community development, police protection, fire protection, parks, education, and libraries. In table 3 we provide a description of each dependent variable, as defined by the census survey form used to collect the data; the first two variables—per capita total direct expenditure and per capita spending on capital facilities—are aggregate measures, extending over all individual types of services. The results for each model are presented in table 4 (see over), showing the OLS estimates and *t*-statistics for all independent variables. The number of included observations varies slightly across equations because observations where the dependent variable was equal to zero were dropped. Because of the exploratory nature of the analysis, greater emphasis is placed on the hypothesis tests (the *t*-statistics) than the coefficients; although the coefficients are useful for judging the relative magnitude of the influence of a significant variable, they should not be interpreted literally.

The OLS estimates provide strong support for the hypothesis that public service expenditure is closely linked to the physical and political structure of metropolitan areas. First, the parameter estimates for *density* are negative and significant in several of the models, suggesting that it creates economies of scale for: public spending on the whole (total direct expenditure), capital facilities, roadways, police protection, and education. For each of these services, the per capita cost decreases as densities increase,

Table 3. Description of dependent variables (source: USCG, 2000).

Variable	Description
Per capita total direct expenditure	Sum of direct expenditure, including salaries and wages
Per capita spending on capital facilities	Sum of capital outlays, including new construction, the purchase of equipment, and outlays on land and existing structures
Per capita spending on roadways	Expenditure on the construction and maintenance of municipal streets, sidewalks, bridges and toll facilities, and street lighting, on snow removal, and on highway engineering, control, and safety
Per capita spending on other transportation	Expenditure on municipal airports, parking facilities, and sea and inland port facilities and subsidies to private transit facilities
Per capita spending on sewerage	Expenditure for the construction, maintenance, and operation of sanitary and storm sewer systems and sewage disposal plants
Per capita spending on trash collection	Expenditure on street cleaning and the collection and disposal of garbage
Per capita spending on housing and community development	Expenditure on urban renewal, slum clearance, and housing projects
Per capita spending on police protection	Expenditure on municipal police agencies, including coroners, medical examiners, vehicular inspection activities, and traffic control and safety activities
Per capita spending on fire protection	Expenditure incurred for firefighting and fire prevention, including contributions to volunteer fire units
Per capita spending on parks	Expenditure on parks and recreation, including playgrounds, golf courses, swimming pools, museums, marinas, community music, drama, celebrations, zoos, and other cultural activities
Per capita spending on education	Expenditure on local schools
Per capital spending on libraries	Expenditure on municipal and nongovernmental libraries

Table 4. Ordinary least squares estimates for expenditure equations: aggregate expenditure (total direct and on capital facilities) and expenditure on roadway, other transportation, sewerage, trash collection, housing and community development ('housing'), police protection, fire protection, parks and recreation, education and libraries.

	Total direct		Capital facilities		Roadways		Other transportation	
	coefficient	<i>t</i>	coefficient	<i>t</i>	coefficient	<i>t</i>	coefficient	<i>t</i>
Constant	6.07*	82.27	3.69*	27.75	3.29*	32.43	-1.82*	-5.48
Built environment								
density	-0.03*	-2.52	-0.03*	-1.86	-0.06*	-7.09	0.10*	3.41
urbanized land	2.84×10^{-7} *	1.55	6.03×10^{-7} *	1.82	3.12×10^{-7} *	1.30	2.66×10^{-6} *	3.62
property value	8.63×10^{-7} *	1.80	1.23×10^{-6} *	1.61	1.63×10^{-6} *	3.83	-3.80×10^{-6} *	-3.32
Political characteristics								
per capita municipal governments	-0.47*	-3.27	-0.51*	-1.54	0.62*	3.72	-0.90	-0.82
per capita special districts	-0.21	-0.85	-0.43	-1.28	-0.06	-0.31	-0.80*	-1.40
central city indicator	0.12*	4.78	0.09*	1.83	0.03	0.64	0.91*	6.56
Revenue								
per capita local tax revenue	1.27×10^{-3} *	6.90	1.67×10^{-3} *	5.70	1.07×10^{-3} *	4.27	3.97×10^{-3} *	8.48
per capita intergovernment revenue	1.30×10^{-3} *	9.26	1.02×10^{-3} *	5.00	4.58×10^{-4} *	3.40	2.21×10^{-3} *	4.00
Temporal effects								
1987	-0.02	-0.65	0.08*	1.54	0.07*	1.55	-0.11	-0.70
1992	-0.08*	-1.99	0.14*	2.00	-0.04	-0.95	-0.39*	-2.10
Locational effects								
Arizona	-0.04	-0.94	-0.37*	3.62	0.59*	9.02	-1.00*	-2.38
California	-0.21*	-3.36	-0.43*	-3.68	0.13*	1.63	-0.46*	-1.58
Colorado	0.09	1.12	0.27*	2.10	0.48*	5.60	-0.41*	-1.51
Florida	0.10*	2.70	0.27*	3.47	0.23*	4.87	0.75*	4.13
Georgia	0.07*	2.18	0.33*	3.40	-0.02	-0.42	-0.43*	-1.71
Idaho	0.01	0.12	0.29*	1.92	0.38*	4.36	1.54*	5.45
North Carolina	3.87×10^{-3}	0.07	-0.35*	-3.58	-1.09*	-10.31	-0.09	-0.38
New Mexico	0.01	0.08	0.27*	2.05	0.40*	3.27	0.49*	1.51
Nevada	0.10*	1.93	0.56*	2.61	0.64*	5.61	1.48*	2.57
Oregon	-0.01	-0.18	-0.20*	-1.96	0.15*	1.90	-0.36	-0.99
Tennessee	0.42*	7.55	0.09	0.96	0.44*	8.35	0.34	1.08
Utah	0.25*	3.79	0.38*	2.52	0.11*	1.45	0.40	0.88
Washington	0.14	1.27	0.31*	2.94	0.39*	4.33	1.33*	3.98
Number of observations	849		849		849		684	
Adjusted R^2	0.62		0.40		0.61		0.42	

Table 4 (continued).

	Sewerage		Trash collection		'Housing'		Police protection	
	coefficient	<i>t</i>	coefficient	<i>t</i>	coefficient	<i>t</i>	coefficient	<i>t</i>
Constant	1.76*	9.40	1.28*	7.07	1.31*	5.16	2.93*	35.11
Built environment								
density	0.03	1.12	-0.02	-0.71	0.01	0.31	-0.02*	-1.87
urbanized land	5.42×10^{-7}	1.08	7.30×10^{-7} *	1.89	6.86×10^{-7} *	1.88	3.20×10^{-7} *	2.25
property value	-1.46×10^{-6} *	-1.34	2.65×10^{-7}	0.24	5.98×10^{-7}	0.64	6.32×10^{-7} *	1.37
Political characteristics								
per capita municipal governments	-1.82*	-3.11	0.21	0.45	-2.54*	-3.21	-0.63*	-1.95
per capita special districts	-1.24*	-2.80	-1.39*	-2.69	-1.97*	-3.34	-0.46*	-1.83
central city indicator	0.18*	2.04	0.39*	4.48	0.52*	5.33	0.12*	4.82
Revenue								
per capita local tax revenue	2.28×10^{-3} *	7.82	1.36×10^{-3} *	5.66	8.28×10^{-4} *	2.51	1.47×10^{-3} *	9.43
per capita intergovernment revenue	1.38×10^{-3} *	4.42	1.80×10^{-3} *	5.51	2.05×10^{-3} *	4.89	7.33×10^{-4} *	4.97
Temporal effects								
1987	-0.07	-0.62	-0.17*	-1.97	-0.23*	-2.30	1.91×10^{-3}	0.07
1992	-0.12	-1.10	-0.02	-0.26	-0.29*	-2.37	-1.53×10^{-3}	-0.03
Locational effects								
Arizona	-0.17	-0.74	-0.11	-0.83	-0.16	-0.79	0.37*	7.67
California	0.08	0.45	-1.40*	-5.53	-0.16	-0.71	0.23*	3.59
Colorado	0.17	1.00	-1.62*	-4.04	0.43*	1.99	0.16*	2.37
Florida	-0.67*	-3.50	0.56*	6.03	-0.12	-0.82	0.38*	10.80
Georgia	-0.36*	-2.57	0.13*	1.44	0.20	1.29	0.10*	2.66
Idaho	0.81*	3.99	0.93*	5.67	1.25*	3.26	0.49*	5.87
North Carolina	-0.61*	-3.35	0.37*	4.46	0.30*	1.94	0.07*	1.62
New Mexico	-0.27	-0.73	-0.04	-0.20	-0.43*	-1.62	0.47*	6.56
Nevada	-0.48	-1.16	-2.82*	-7.40	0.40*	1.80	0.88*	7.40
Oregon	0.50*	3.26	-1.78*	-5.90	0.92*	4.48	0.04	0.80
Tennessee	0.24*	1.61	0.65*	5.41	0.85*	4.69	0.21*	4.18
Utah	0.49*	2.21	0.17	0.83	0.23	0.70	0.28*	1.56
Washington	0.59*	3.89	-0.17	-0.92	0.10	0.54	0.18*	2.97
Number of observations	753		839		849		849	
Adjusted R^2	0.34		0.41		0.32		0.70	

Table 4 (continued).

	Fire protection		Parks and recreation		Education		Libraries	
	coefficient	<i>t</i>	coefficient	<i>t</i>	coefficient	<i>t</i>	coefficient	<i>t</i>
Constant	1.58*	8.73	1.13	6.08	5.64*	74.03	0.33*	2.09
Built environment								
density	-0.02	-0.78	-4.86×10 ⁻³	-0.28	-0.04*	-4.48	-0.01	-0.49
urbanized land	3.94×10 ⁻⁷	1.16	6.11×10 ^{-7*}	1.50	-1.89×10 ^{-7*}	-1.36	572×10 ^{-7*}	1.68
property value	7.26×10 ⁻⁷	0.65	4.24×10 ⁻⁷	0.48	9.65×10 ^{-7*}	2.52	322×10 ⁻⁹	5.00×10 ⁻³
Political characteristics								
per capita municipal governments	-2.64*	-6.52	-2.10*	-3.64	0.03	0.18	-1.61*	-4.15
per capita special districts	-0.57	-1.24	-1.26*	-3.17	-0.34*	-1.32	-1.22*	-3.43
central city indicator	0.32*	5.96	0.39*	6.48	-0.03*	-1.38	0.18*	2.61
Revenue								
per capita local tax revenue	2.07×10 ^{-3*}	5.71	2.59×10 ^{-3*}	6.39	7.93×10 ^{-4*}	5.78	218×10 ^{-3*}	7.03
per capita intergovernment revenue	1.15×10 ^{-3*}	3.87	1.02×10 ^{-3*}	3.72	1.25×10 ^{-3*}	6.99	6.97×10 ^{-4*}	3.17
Temporal effects								
1987	-0.07	-0.91	-0.14*	-1.86	0.02	0.92	-0.02	-0.29
1992	-0.15*	-1.55	-0.28*	-2.88	-0.06	-1.19	-0.08	-0.95
Locational effects								
Arizona	0.31*	2.29	0.52*	4.23	-0.08*	-1.58	0.55*	3.68
California	0.24*	1.58	0.34*	2.05	-0.32*	-4.59	0.52*	3.97
Colorado	0.19	1.28	0.90*	5.77	-0.03	-0.53	0.59*	4.27
Florida	0.36*	4.96	0.60*	6.28	-0.10*	-3.73	0.31*	3.18
Georgia	-0.01	-0.11	0.02	0.18	-0.27*	-6.14	-0.57*	-4.93
Idaho	1.03*	7.89	0.92*	5.81	-0.08	-0.93	1.13*	8.05
North Carolina	0.14	1.21	0.23*	1.65	-0.12*	-4.01	0.46*	3.87
New Mexico	0.39*	2.17	0.81*	3.53	-0.17*	-2.63	0.77*	3.82
Nevada	0.95*	4.60	1.59*	8.41	-0.24*	-3.11	0.86*	5.52
Oregon	0.74*	6.33	0.32*	2.63	0.12*	1.99	0.64*	5.13
Tennessee	0.46*	3.79	0.26*	1.64	-0.17*	-3.34	-0.20*	-1.66
Utah	0.85*	3.81	1.52*	5.96	0.14*	2.13	1.22*	-7.82
Washington	0.71*	5.91	0.99*	6.21	-0.08*	-1.37	1.19*	7.38
Number of observations	846		843		849		827	
Adjusted <i>R</i> ²	0.53		0.58		0.55		0.54	

* Significant at $p < 0.10$.

Note: For units of measurement, see table 2.

with the greatest savings realized in areas with very high densities. An individual police officer patrolling a square mile in a dense urban area may provide protection to many more people than his or her counterpart in a suburban area. Likewise, fewer roads are needed in high-density areas, and school systems may be operated more efficiently—fewer (though larger) schools and less bussing of pupils are needed, for example. Among the rest of the models, density is insignificant and/or negative except in two logical instances: other transportation and sewerage. The positive coefficient in the equation for other transportation makes sense given the increased need for parking garages, public transit, and other facilities in high-density areas. Similarly, the positive correlation between density and sewerage is likely attributable to the use of private septic systems and lack of stormwater systems in low-density areas. Assuming a one-tailed hypothesis test in the opposite direction to that specified—positive instead of negative—the density coefficient in the sewerage equation is significant at an 85% confidence level. Overall, the models provide good evidence that density works to increase the cost-effectiveness of public service expenditure.

Second, the spatial extent of *urbanized land* is positive and significant in most of the models, indicating that the spread of a metropolitan area plays an important role in determining public service expenditure. As explained in the background discussion, urban sprawl requires roadways and sewer systems to be extended over long distances to reach relatively fewer people. Trash collection and street cleaning activities must cover larger areas and, similarly, police and fire protection are spread thin, requiring more patrols and, potentially, more station houses to achieve a given level of service. In the case of parks and libraries, a greater number of facilities must be built in order for people throughout the metropolitan area to enjoy equal access. In one instance—education—the urbanized land coefficient is significant and negative, but this effect is more likely to be a result of the overall size of the urban area than its spatial extent. The coefficient is positive and insignificant in the housing and community development equation, indicating that the spatial extent of urban development has little effect on spending on these services.

Third, *property value* is significant in five of the twelve equations and positively correlated with per capita spending for all services except for other transportation and sewerage. These findings illustrate the balancing effect that property value has in helping dense urban areas support themselves—and also how an examination of the influence of density in isolation may provide misleading results. As property values are generally the greatest in high-density areas, their contributions to public revenue through property taxes enable density to support itself. In the case of other transportation and sewerage, the negative coefficient is logical, because parking garages, sewerage treatment plants, and other locally undesirable facilities are less likely to be built in areas with high property values.

Fourth, the three political characteristics are significant in most of the equations, highlighting the role that political fragmentation plays in influencing patterns of public spending. Specifically, all of the coefficients for *per capita municipal governments* and *per capita special districts* carry negative signs, except in the roadways model, where municipal fragmentation has a positive influence, and in the trash collection and education models, where the respective variables are insignificant. These findings suggest that the formation of small general and special purpose governments may work to lower per capita spending, although it remains unclear just how this occurs. Although it is possible that greater efficiencies are achieved through competition among jurisdictions, some analysts have suggested that fragmentation may create fewer opportunities for budget maximization and/or may reduce communities' willingness to provide certain types of collective services (Dowding et al, 1994). In either case, further

research is needed in order to develop a better understanding of how fragmentation affects public service expenditures. Meanwhile, the *central city indicator* captures significant differences between the spending patterns of central city and suburban counties. In all cases except for education, the parameter estimates indicate that more money is spent on public services in central cities. This finding is realistic, as central cities commonly house facilities such as parks and museums that are used by the metropolitan area at large and are often where infrastructure systems converge. The negative sign on the education coefficient is interesting because it reinforces the notion that higher quality school systems are located in suburban areas.

Finally, the remaining control variables—revenue and the temporal and locational fixed effects—fulfill their expected role within the equations. Being perhaps the most important determinants of public spending, local tax revenue and intergovernmental revenue are significant and positive in all equations. The temporal fixed effects are only occasionally significant, indicating that little time-specific correlation exists among locations at the times of observation. The locational fixed effects, in contrast, are mostly significant, revealing important state-to-state differences in per capita spending patterns. Unfortunately, because the fixed effects capture an amalgamation of unobserved effects, they have no straightforward interpretation; instead, they highlight the need for further research aimed at uncovering state-level variables that affect local governments' spending patterns.

4 Discussion

The results of the empirical analysis (summarized in table 4) illustrate the numerous ways in which the characteristics of urban development affect public service expenditures. Collectively, they point to two overarching conclusions: (1) the physical pattern of development has a multidimensional effect, with density, urbanized land area, and property value all influencing the per capita value spent on service provision; and (2) one way or another, the political structure of metropolitan areas makes a difference, with greater fragmentation being associated with lower expenditure. Although the first of these findings is a well-known argument that is widely accepted among the planning community (Kaiser et al, 1995) there was little in the way of supporting evidence prior to this study. What follows are several policy-relevant insights and directions for future research.

By far the most salient finding of the analysis is that the per capita cost of most services declines with density (after controlling for property value) and rises with the spatial extent of urbanized land area. This reinforces planners' claim that urban sprawl undermines cost-effective service provision, and lends support to growth management and 'smart growth' programs aimed at increasing the density and contiguity of metropolitan areas—at least from the standpoint of public finance. In particular, the models show that there are savings to be gained in numerous areas, especially where both the density and the spread of the metropolitan area matter for the cost of service delivery. One important exception is sewerage, but further investigation is needed to determine whether the positive correlation is attributable to the increased *cost* or increased *use* of sanitary and stormwater sewage systems in high-density areas. In other words, the coefficient may reflect the greater reliance on septic tanks and above-ground stormwater drainage in low-density areas. The positive influence of the urbanized land area variable (though not quite significant within acceptable tolerances) suggests that this may be the case because it indicates that sewerage systems are more expensive when spread over greater areas. Although this evidence does not unilaterally justify growth management, it indicates that communities may wish to carefully evaluate whether or not greater efficiencies could be achieved through their urban form.

Empirical research on the effectiveness of state-based growth management programs suggests that they may help to reduce public expenditures through their influence on urban form. Specifically, programs that require local governments to produce plans that are consistent with state-defined goals and objectives and that incorporate urban growth boundaries (such as in Oregon) have been found to increase urban densities, which in turn affect the cost of public services. Programs that do not require consistency among jurisdictions' planning activities (such as in Georgia) and/or that rely on concurrency (such as in Florida) may inadvertently contribute to sprawl, thereby raising the cost of services (for an analysis demonstrating these results, see Carruthers, 2002b).

As an extension, the strong link between urban form and service expenditures reinforces the rationale for 'market-based' approaches to growth management, such as the use of development impact fees. As described in section 2, one of the principal complaints of urban sprawl is that it often ends up being financed by the public-at-large through average cost pricing mechanisms. Impact fees alter this situation by shifting some or all of the costs of growth to the private sector, forcing developers to consider more seriously the costs of alternative development patterns (Altshuler and Gómez-Ibáñez, 1993). As these costs are eventually passed on to homebuyers—making new housing more expensive—low-density development patterns may continue to be accommodated as long as market demand is sufficient to uphold the increase in price. Ultimately, the effect on the physical pattern of development rests on the elasticity of demand for low-density growth. Although it is probably unrealistic to assess impact fees for the ongoing costs of service provision, evidence suggests that it may be relatively easy to shift the costs of physical infrastructure to the private sector (Speir and Stephenson, 2002). It may therefore be worthwhile to compel new development to finance the roads, sewerage, schools, and other infrastructure that it requires. For example, in the average county in the dataset, capital facilities account for about 13% of total direct expenditure—a substantial proportion of their overall budgets. Density, urbanized land area, and property value are all highly significant in the capital facilities model, providing good evidence in favor of assessing impact fees at least for physical infrastructure. Even if growth continues to proceed at low densities, the increased price of housing and other development will strengthen the tax base, raising the amount of revenue available to support the ongoing costs of operation.

The results of this analysis point to several directions for future research. First, there is a need for additional work to incorporate alternative measures of urban form of the sort mentioned in section 3.1. For example, Galster et al (2001) have recently defined seven distinct dimensions of urban land-use patterns beyond density: centrality, clustering, concentration, contiguity, nuclearity, mixed use, and proximity. Each of these has been developed for and tested in thirteen metropolitan areas. Similarly, Alberti (1999) has emphasized the need to look beyond density and to include measures of centralization, connectivity, and grain in studies of urban form, especially with respect to its impact on the environment. Although the development of these types of measures for multiple metropolitan areas presents a considerable challenge, they hold much promise for offering further insight into the relationship between urban form and the cost of public services.

Second, given the potential savings to be gained through more compact urban development patterns, a major question that remains is whether or not the *quality* of service is affected. In this paper we have dealt with intermediate outputs but not the final outputs eventually consumed by the public. Future research should focus on evaluating how the character of urban development influences people's enjoyment of public services—congestion, for example, may overshadow the benefits of reduced cost

if it significantly lowers the accessibility of a given service. However, the increased property values of high-density areas may yield sufficient revenue to maintain a high enough level of service provision to offset the effects of congestion and/or to provide specialized forms of services that are unavailable in other areas. These issues are important because, ultimately, citizen support for growth management programs and for other policies aimed at shaping more compact development patterns is likely to rest heavily on how the outcome affects their quality of life.

Finally, the finding that fragmentation is associated with lower per capita spending suggests that there is a trade-off to be made between the physical and political structure of metropolitan areas. In particular, a number of studies have shown evidence that fragmentation contributes to urban sprawl in a physical sense by lowering densities and/or promoting growth at the urban fringe (Carruthers, 2002b; 2003; Carruthers and Ulfarsson, 2002; Lewis, 1996; Pendall, 1999; Shen, 1996). So, even if the lower costs are attributable to interjurisdictional competition, as the Tiebout model suggests, they may not offset the effects caused by the physical pattern of development. Likewise, if the correlation reflects the limitations of smaller tax bases, the creation of new municipalities and special districts may not be an advantageous approach to dealing with public services—no matter what the effect of the physical pattern of development. In any case, further applied research aimed at uncovering the nature of the relationship between fragmentation and service expenditures and at evaluating the relative costs and benefits of alternative political structures is needed before any substantive conclusions can be made.

5 Summary and conclusions

Over the last several decades there has been a sustained interest in evaluating the relative costs of alternative forms of development in US metropolitan areas. In this paper we examined this issue through an analysis of the relationship between the physical and political structure of metropolitan areas and twelve separate measures of public expenditure: total direct, capital facilities, roadways, other transportation, sewerage, trash collection, housing and community development, police protection, fire protection, parks, education, and libraries. Our primary contribution has been to provide empirical evidence of the widely held—but largely unfounded—belief among planners that urban sprawl raises the cost of providing public services. In this way, we have contributed to the sprawl–antisprawl debate in favor of more compact cities; although US metropolitan areas will continue to suburbanize, the results presented here suggest that they may maintain a more cost-effective urban form by doing so at higher densities and by consuming less land. Although public service expenditures represent just one aspect of urban performance, minimising the cost of such services to residents produces net benefits to the public at large, as long as the quality of those services remains unaffected. Talen and Ellis (2002) recently called for research to develop well-validated criteria for identifying desirable outcomes of urban development. The findings of this analysis represent substantive evidence that, at least from the standpoint of public finance, a more compact urban form is a desirable planning goal.

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