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The Impact of Population Density on Municipal Government Expenditures

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Data from 487 municipal governments with populations greater than 50,000 are examined to see the relationship between population density and per capita government expenditures. There is no statistically significant relationship between per capita total government expenditures and operational expenditures for cities smaller than 500,000, and for larger cities, higher population density is associated with higher per capita government expenditures. Infrastructure expenditures tend to decline with increases in population density for cities smaller than 500,000, whereas expenditures on services tend to increase with population density for cities larger than 500,000. The relationship between per capita total expenditures and population density has policy relevance because it indicates that when all government expenditures are taken into account, policies that increase population density will not reduce per capita government expenditures and, in larger cities, will lead to higher per capita government expenditures.

Keywords: *municipal expenditures; urban sprawl; population density; local government finance*

1. Introduction

In the past several decades, government land use policies have become increasingly oriented toward preventing the proliferation of urban sprawl by implementing policies that encourage urban infill and that increase population density in already-developed areas. One of the motivations for

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promoting more compact urban development is the conclusion that "'sprawl' is the most expensive form of residential development" and that "this cost difference is particularly significant for that portion of total costs which is likely to be borne by local governments" (Real Estate Research Corporation 1974, 7). Real Estate Research Corporation (1974, 8) went on to conclude that "planned development is likely to decrease the total capital cost burden to local government by as much as one-third" but that "the on-going operating and maintenance costs of most public or semi-public services—education, recreation, sewage treatment, water supply, general government, police and fire protection—are largely based on population rather than development pattern or even housing type."

Subsequent studies on the cost of sprawl support the idea that sprawling development increases government costs relative to more compact urban development. Burchell et al. (2002, 10) concluded that controlled growth, as opposed to sprawl, could save 13.4 percent on roadway costs and about 3 percent on other infrastructure costs.[1] This study examines that proposition by looking at the impact of population density on the cost of providing government services. "Density, or more specifically, *low density,* is one of the cardinal defining characteristics of sprawl. But density has to be set in context.... Sprawl is not simply development at less-than-maximum density; rather, it refers to development ... at a low *relative* density, and one that may be too costly to maintain" (Burchell et al. 1998, 6). The relationship between population density and sprawl is, first, that sprawling development is low-density development, and second, that policies to reduce sprawl are almost always policies that increase population density. However, sprawl and population density are not the same thing, and the work presented here looks at the effects of population density on the cost of government services and so looks at the issue of sprawl only indirectly.[2]

Many things can affect population density besides government land use policy, including housing prices and geographical constraints, so the conclusions of this study do not directly apply to particular land use policies. At the same time, policies intended to limit sprawl do so by encouraging higher population density in already-developed areas, so while these conclusions apply narrowly only to the effects of population density on government costs, they do have implications for public policies that attempt to increase population density. The general conclusion is that for communities larger than 50,000, where most of the concern for sprawl is centered, higher population density does not reduce the per capita expenditures for providing government services.

Relatively little academic work has been done looking directly at this question. Ladd (1992) looked at the relationship between population density and growth on the cost of county government expenditures and found that higher population density is associated with higher per capita government costs. Several public policy institutes have issued studies examining the relationship between population density and government cost, or sprawl and government cost, including Cox and Utt (2004), who called into question cost savings from discouraging sprawl, and Litman (2004), who criticized Cox and Utt's methodology and found cost savings from higher-density development. Burchell and Mukherji (2003) used a simulation model to conclude that sprawled growth adds 10 percent to the cost of government relative to managed growth. This article looks directly at data on government expenditures to see the relationship between population density and government expenditures.

2. The Data

This study looks at municipal government expenditures reported in the Historical Finance Database from the U.S. Bureau of the Census. The database contains observations on 3,489 local governments for the year 2000 and 6,771 for 1990. All other data are from the 2000 U.S. census except for 1990 population (to calculate population growth from 1990 to 2000) and 1990 density, which are from the 1990 census. Limiting the data set to cities with populations greater than 50,000 yields 553 cities, and matching that set of cities with those that could be matched with local governments from 1990 reduces the data set to 487 observations for which matching pairs were available.

3. Population Density and Total Government Expenditures

The correlation coefficient between population and population density in municipalities is .35, so one factor that should be held constant in the analysis is the total population within the government's jurisdiction. For example, if within a jurisdiction with a fixed geographic area, the population were twice as large, two things could be occurring that might affect the cost of government. First, the population density would double, which is the effect this article is trying to analyze, and second, twice as many people would be provided government services within the jurisdiction.

The effect of the larger population should be removed from the analysis to focus purely on the impact of density because the total population within a jurisdiction could affect government expenditures independently of the population density if there are economies or diseconomies of scale in the production of government services. The idea is to see whether, holding total population within the jurisdiction constant, an increase in population density has any impact on government expenditures.

To examine this issue, a two-stage least squares regression model was run with per capita total municipal expenditures as the dependent variable and population density segmented by total population as the key independent variable. The results appear in table 1. A two-stage model was run because there may be a concern about the direction of causality between density and government expenditures. If higher government expenditures make an attractive jurisdiction, creating population infill, then it may be that the level of government expenditures has some causal effect on density. To deal with this issue, a two-stage least squares regression model was used in which population density was instrumented using population density from 1990 and total per capita government expenditures from 1990 as instruments. Using density and expenditures from 1990 as instruments removes the question of causality because expenditures in 2000 could not have a causal impact on population density and expenditures a decade earlier.

Because of the variation in city size, there is some heteroskedasticity in the data; therefore, robust standard errors were estimated for all variables to adjust for heteroskedasticity. These changes were made to guard against two potential econometric problems, but the results in table 1 are nearly identical to those made just by running an ordinary least squares regression on the original data. Therefore, while it is worthwhile to incorporate these adjustments to guard against potential econometric problems, the adjustments turn out to have no effect, and the results are robust to whether or not these changes are incorporated into the empirical specification.

The effects of total population are separated from the effects of population density by dividing cities into four population groups and using dummy variables to estimate the effect of density separately within each group. The population groups are cities with populations between 50,000 and 100,000 (group 1, of which there are 282), cities with populations between 100,000 and 250,000 (group 2, of which there are 153), cities with populations between 250,000 and 500,000 (group 3, of which there are 31), and cities with populations greater than 500,000 (group 4, of which there are 21). Table 1 shows regression results with cities grouped this way,

Table 1
The Effect of Population Density on Per Capita Total Municipal Expenditures: Two-Stage Least Squares with Robust Standard Errors (Dependent Variable: Per Capita Total Expenditures)

Independent Variable	1
Constant	–4.78
	(–3.14)
Population1	1.12e–06
	(.62)
Population2	2.41e–07
	(.27)
Population3	6.30e–07
	(.99)
Population4	–6.48e–08
	(–.34)
Density1	–.00003
	(–1.26)
Density2	1.19e–06
	(.05)
Density3	4.03e–06
	(.10)
Density4	.0002
	(3.05)
Commute	.003
	(.25)
Popgrowth	–.01
	(–.44)
%inCollege	.001
	(.35)
%inLaborForce	.04
	(3.77)
Poverty	.08
	(6.22)
MedianHvalue	1.95e–06
	(2.10)
MedianIncome	6.81
	(.93)
MedianAge	.07
	(3.95)
%inSchool	–.007
	(–.66)
State	Yes
R^2	.61

Note: *t*-statistics are in parenthesis.

using per capita total municipal expenditures as the dependent variable. Population is the city's actual population multiplied by 1 if the city is in that population group and 0 otherwise. By assigning dummy variables this way, one can see whether, within that population group, a higher population is associated with higher or lower per capita expenditures.

When the specification in table 1 is run without dividing cities into population groups this way, the coefficient on population is positive and statistically significant, with a *t*-statistic of 7.16, suggesting that larger cities have higher per capita expenditures, but as the results in table 1 show, when cities are divided into population groups, none of the population coefficients are statistically significant.[3] The specification in table 1 was also run with the dummy variables alone rather than interacting them with population, but again those population dummies were not statistically significant. The results show that within each population group, there are no statistically significant economies or diseconomies of scale.

The main variables of interest are the density variables. The coefficients in table 1 show a positive but insignificant effect on cities with less than 500,000 populations and a highly significant positive effect in cities with populations greater than 500,000. Increased population density has no statistically significant effect on government expenditures in cities with populations from 50,000 to 500,000, and higher population density is associated with higher government expenditures for cities larger than 500,000. Whatever the other merits of policies designed to increase population density, these results indicate that increases in population density will not lead to lower municipal per capita government expenditures.

Other independent variables are included to hold the demographic characteristics of the municipalities constant, and it is worth noting that higher labor force participation, higher poverty rates, higher median home values, and a higher median age are all positively related to the level of government expenditures. Average commuting times were included as an independent variable with the idea that some cities may mainly be residential communities where residents have relatively long commutes to other jurisdictions where jobs are located, whereas communities with shorter commute times would be more likely to have their own job base, perhaps with different expenditure structures that would affect per capita expenditures. However, this variable was not statistically significant.

Another population-related factor that might influence the per capita cost of government is population growth (popgrowth). Popgrowth measures the percentage growth in the jurisdiction's population from 1990 to 2000, but the results in table 1 indicate that higher population growth is not associated with higher per capita total expenditures. The regression also includes a set of state dummy variables to take account of any differences across states that can affect municipal expenditures. For example, in some states, public schools are provided by municipal governments, and so K-12 school expenditures are a part of their budgets, whereas in other states, school districts are independent governments whose budgets are separate from the budgets of the municipalities they serve. If the state dummies are left out of the regressions, the coefficients on the remaining independent variables do not change much; however, the R^2s are lower without them.

Table 2 looks at total per capita operating expenditures of local governments using the same set of cities and the same set of independent variables. The same general relationship between population density and expenditures holds. Population density has a positive and statistically significant effect on operating expenditures for cities with populations larger than 500,000. It is not statistically significant for smaller cities but shows a negative coefficient for cities with populations between 50,000 and 100,000. Population density only has a statistically significant effect on the largest cities, and its effect there is to raise total per capita expenditures and per capita operating expenditures. Whether one is looking at total per capita municipal expenditures or per capita operating expenditures, the results show that higher population density is not associated with lower government expenditures, and among the largest cities, those with higher population densities have higher per capita expenditures.

4. Population Density and Infrastructure Expenditures

If one is concerned about the impact of population density on government expenditures, then the most important measure would be total government expenditures, or perhaps operational expenditures, as examined in tables 1 and 2. However, the components of total expenditures might be differentially affected, and this section examines some components in more detail. One claim frequently heard about higher-density development is that it reduces infrastructure costs because infrastructure does not have to be extended as far to service a given number of people. This implies that higher population density should reduce per capita infrastructure expenditures. This section examines that claim by looking at highway, sewer, and water expenditures using the same group of local governments as the previous section. Table 3 shows some regression results. The

Table 2
The Effect of Population Density on Per Capita Current Operational Municipal Expenditures: Two-Stage Least Squares with Robust Standard Errors (Dependent Variable: Per Capita Current Operational Expenditures)

Independent Variable	1
Constant	–3.88
	(–3.09)
Population1	9.78e–07
	(.68)
Population2	3.68e–08
	(.05)
Population3	6.73e–08
	(.14)
Population4	–1.12e–07
	(–.75)
Density1	–.00002
	(–1.23)
Density2	6.38e–06
	(.34)
Density3	4.35e–06
	(.13)
Density4	.0001
	(2.35)
Commute	.001
	(.12)
Popgrowth	–.03
	(–1.29)
%inCollege	–.0002
	(–.08)
%inLaborForce	.03
	(3.63)
Poverty	.06
	(6.25)
MedianHvalue	1.69e–06
	(2.28)
MedianIncome	2.56e–06
	(.43)
MedianAge	.06
	(4.07)
%inSchool	–.005
	(–.59)
State	Yes
R^2	.61

Note: *t*-statistics are in parenthesis.

Table 3
The Effect of Population Density on Components of Municipal Government Expenditures: Two-Stage Least Squares with Robust Standard Errors

Independent Variable	Infrastructure			Services	
	Highway	Water	Sewer	Police	Fire
	1	2	3	4	5
Density1	–3.35e–06	–2.92e–06	–5.82e–06	–7.57e–07	–2.33e–06
	(–2.58)	(–1.36)	(–3.27)	(–.48)	(–1.85)
Density2	–3.09e–06	–1.61e–06	–6.14e–06	1.42e–06	3.51
	(–2.30)	(–.38)	(–2.34)	(.77)	(.26)
Density3	–2.16e–06	–7.83e–06	–.00001	4.49e–06	1.44e–06
	(–.71)	(–1.36)	(–2.44)	(1.31)	(.74)
Density4	5.21e–06	7.55e–06	6.67e–06	.00002	4.07e–06
	(1.76)	(1.12)	(1.80)	(6.59)	(1.70)
Popgrowth	.016	–.005	–.005	–.01	–.001
	(4.78)	(–1.91)	(–2.48)	(–1.52)	(–.81)
R^2	.34	.29	.31	.55	.48

Note: *t*-statistics are in parenthesis.

variables of primary interest are the density variables, so to conserve space, table 3 reports only the coefficients and *t*-statistics for the density variables plus population growth, along with each regression's R^2. The actual regressions were run exactly as those reported in tables 1 and 2, with all of the same variables.

The first regression is identical to those in tables 1 and 2 except that the dependent variable is per capita highway expenditures. For municipalities with populations less than 250,000, represented by Density1 and Density2, there is a significant negative relationship between population density and highway expenditures, showing that higher population density does lead to lower expenditures in that category for cities with populations less than 250,000. The coefficient is negative but insignificant on Density3 and positive but insignificant (at the .05 level) for Density4. This suggests the possibility of a weakly positive relationship between population density and highway expenditures for the largest cities. Overall, however, highways is the category that shows the strongest negative relationship between population density and per capita expenditures, although the relationship goes away for the largest cities. Note also the positive and significant coefficient on population growth. One might conjecture that population growth leads to a demand for expanding highway infrastructure, leading to greater expenditures, and the data appear to support this conjecture.

The second regression shows the density coefficients for water, and although three of the four signs are negative, there are no statistically significant density coefficients. It appears that population density has little to do with per capita water costs. The coefficient on population growth is negative and significant at nearly the .05 level, indicating that population growth may lower per capita water expenditures. This would make sense if the existing infrastructure could be used to supply water to new residents. Note that Kim (1987) and Renzetti (1999) suggested that there are economies of scale in municipal water production, but those conclusions apply to extending service to a larger number of residents rather than a higher population density. This distinction illustrates why it is useful to separate out the effects of population from the effects of population density. It may be that there are economies of scale in water production but no economies associated with increased population density.

The third regression shows the coefficients for sewer expenditures, and the first three density coefficients (for municipalities with populations less than 500,000) are all negative and statistically significant. The positive coefficient on Density4 falls just short of statistical significance at the .05 level. These results indicate a strong negative relationship between per capita sewer expenditures and population density. Also note the negative and significant coefficient on population growth, which indicates that higher growth leads to lower per capita expenditures. Hanke and Wentworth (1981) found economies of scale in sewer expenditures, and if their (now rather old) results hold, it appears that both higher population and higher population density can lower per capita sewer expenditures.

The first three regressions taken together provide some indication of how population density affects infrastructure expenditures. Density does not appear to have much effect on water expenditures, but for both sewer and highway expenditures, higher population density is associated with lower per capita expenditures for municipalities with populations less than 250,000, and perhaps 500,000. While the coefficients are positive for cities larger than 500,000, none are statistically significant at the .05 level, which lends support to the idea that higher population density can reduce infrastructure expenditures except in the largest cities. From a policy perspective, one of the claims from those who support policies that increase population density is that higher density can lower expenditures on infrastructure, and the evidence here supports that claim.

The signs on the population growth variable are also interesting, as population growth tends to increase per capita highway expenditures but reduce other infrastructure expenditures. This makes intuitive sense if there is excess capacity (or a public good nature) in sewer and water infrastructure, but highways are more likely to face capacity constraints and require expansion in response to population growth.

5. Population Density and Expenditures on Services

The last two columns in table 3 examine the relationship between population density and expenditures on two government services: police and fire protection. Column 4 looks at police expenditures. Only Density4 is significant at better than the .05 level, suggesting that for cities with populations greater than 500,000, there is a strong positive relationship between density and police expenditures. Fire protection exhibits a weak U-shaped relationship in column 5 of table 3. For municipalities with populations less than 100,000, there is a negative relationship. That negative relationship becomes positive as population size goes up, but the *t*-statistics never become significant at the .05 level.

The relationship between population density and per capita expenditures is quite different for police and fire services. Higher population densities tend to increase per capita police costs in the largest cities, consistent with the findings of Gyimah-Brempong (1987), perhaps because it is more difficult to insulate oneself from the effects of others when population density is higher, whereas higher population densities may lower fire expenditures in smaller cities but may raise them in larger ones, although the coefficients are not statistically significant.

6. Conclusion

This study shows that higher population density does not bring with it lower levels of per capita municipal government expenditures, as has been suggested by some antisprawl advocates. When looking at per capita total expenditures and per capita current operational expenditures, there is a positive and statistically significant relationship between population density and per capita expenditures for cities with populations larger than 500,000 and no statistically significant relationship between population density and total or operational expenditures for smaller cities. This suggests that increasing population density will not lead to lower per capita government expenditures, and for larger cities, it is likely to lead to higher expenditures.

When looking at infrastructure expenditures in isolation, the results are different. For smaller cities, higher population density is associated with lower per capita expenditures on highways and sewers, but this relationship does not hold for larger cities. The results are the opposite for services. Police expenditures per capita are higher for cities with higher population densities in larger cities, but there is no statistically significant effect for smaller cities. There is a weak relationship at best between density and fire expenditures. Overall, except for the smallest cities, services exhibit expenditure increases as population density rises. An examination of the components of municipal government expenditures is interesting as a guide to seeing how the components relate to the whole, but the effect on total expenditures is more important. The key finding here is that higher population density is not associated with lower levels of total per capita municipal government expenditures.

A second finding worth mentioning is that population growth does not have a statistically significant effect on total per capita expenditures or on per capita current operating expenditures. There is some conjecture that growing municipalities must raise expenditures to pay for growth, and while total expenditures surely do need to increase, the tax base increases along with expenditures in growing jurisdictions. These results show that per capita total expenditures are not higher, on average, in faster-growing municipalities. There is a positive and statistically significant coefficient on population growth when highway expenditures is the dependent variable and a negative and statistically significant coefficient on police expenditures. While this relationship is worth exploring in more detail, it is tangential to the relationship between population density and expenditures because growth is a transitory phenomenon whereas higher density has been suggested as a potentially desirable policy goal. Increasing density will create more short-run population growth within a jurisdiction, for example, but once the target density is reached, the growth will cease, but the population density will remain. Thus, for policy purposes, the effects of growth and the effects of density on government expenditures are distinct issues.[4]

Many observers have the idea that sprawling development is more costly for governments to service than compact urban development (for example, Burchell et al. 1998, 2002), and the findings here have an indirect relevance to that idea. More compact urban development implies higher population densities, and while the data do indicate that higher population densities are generally associated with lower expenditures on infrastructure, for larger cities, total government expenditures tend to be higher in areas of higher population density, so it appears that on net, higher population density leads to a higher level of government expenditures and therefore higher taxes to support that higher-density development.

One factor that must be emphasized is that this study looks at the level of municipal government expenditures, which is the cost of providing government services to residents, but it does not contain any measure of the amount of services provided, so it does not measure the cost per unit output of government services. It may be, for example, that it becomes more expensive per unit to provide government services to citizens as population and population density grow but that larger municipalities with higher population densities provide fewer services, so the total per capita expenditures go up even though the unit cost goes down. Both Trejo (1991) and Valletta (1989) suggested that there are economies of scale in public-sector unionization, which raises labor costs in larger cities. This could be a factor that could cause unit cost to rise as population rises, in which case higher expenditures would reflect higher labor costs, at least in part.

From a feasibility standpoint, it is difficult to measure the quantity of government services. How would one measure the quantity of fire protection, or sewer services, provided by a municipal government? More to the point, however, is that the quantity of such services supplied may well be a function of population density, so that higher population densities naturally bring with them the demand for more of some services and less of others. For example, one would expect that higher-population-density areas would have less lawn area that homeowners would water, leading to a lower quantity of water per capita demanded. Similarly, higher-density areas would have taller buildings, which may require more expensive firefighting equipment than would low-rise construction. Thus, it is not unreasonable to look at the total cost of providing government services, independent of the quantity of services provided, when the quantity will be systematically related to population density, which is the independent variable of primary interest.

The relationship between population density and urban sprawl is ambiguous, partly because exactly what constitutes sprawl is ambiguous. However, policies to fight sprawl typically have as a component an increase in population density, so from a public policy perspective, there is some relationship between population density and sprawl. The data examined here indicate that there are not potential savings in the form of lower government expenditures for higher-density development, so any claim that policies that promote higher densities will bring the benefit of lower per capita government expenditures should be viewed with skepticism.

Notes

1. Of course, there are other costs and benefits associated with sprawling development, and because this article looks only at the relationship between density and government expenditures, these other costs, discussed by Ewing (1997), are beyond the scope of this more narrow article that examines only this public finance issue.

2. See Eidlin (2005), for example, who analyzes Los Angeles as among the highest-density cities in the United States, but with some of the worst features associated with sprawl. Ewing, Pendall, and Chen (2002) and Galster et al. (2001) are two attempts to quantify the concept of sprawl. As the current article makes no attempt to identify sprawl per se, it only examines the relationship between population density and government expenditures.

3. The reason population is not significant in table 1 is that the effects are picked up by the density groups. If a regression is run with a single population variable but density is segmented by population group, the t-statistic on population drops to 0.70. In other words, if the same specification as in table 1 is run, but with a single population variable and a single density variable, the t-statistic on population would be 7.16, but leaving a single population variable, if density is segmented by population, the t-statistic on population falls to 0.70, meaning that the apparent statistical significance of population is the result of the positive correlation between population and density.

4. Of course, some municipalities have population growth as a goal as well, often in conjunction with attracting good jobs as a benefit. For such municipalities, it may be even more important to decide whether they want to plan for sprawling growth by growing out and not increasing population density, or whether they want to restrict their boundaries so that population growth also increases population density. Still, population growth and population density remain distinct issues.

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