On the Effectiveness of Smart Growth Programs in Curbing Urban Sprawl [+]

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Abstract. According to research to date, sprawl negatively affects the lives of millions of Americans annually. Fortunately, in the U.S., several states have designed and enacted growth management programs to curb its expansion. But have they been effective? Following up on work by just a handful of other research teams, we control for land area, population, fuel cost, per capita income, passenger-miles of public transportation use, congestion, and crime rates as factors causing change in land area in a 1982-2005 panel data of 85 metropolitan areas. We examine so-called "smart growth" programs by state from their effective dates of implementation rather than their enactment dates. We find that anti-sprawl policies only in the State of Washington seem to curb sprawl. Additions to highway mileage induces sprawl in metropolitan areas regardless of the status of state smart growth programs. In contrast, additions to principal arterials roadways appear to increase sprawl only in states *without* smart growth programs. So transportation planners in smart growth states may be "damned if they do and damned if they don't" since not only does highway building cause sprawl but so does the non-build alternative since it results in greater congestion, which also seem to induce sprawl there. Finally, we find evidence that reducing central-city violent crime rates and increasing fuel costs also appear to most effective in reducing sprawl.

Introduction

The *Oxford English Dictionary* tells us that in the context of suburban development "sprawl" first appeared in a 1955 article within the *London Times* that disapproved of state of the city's periphery (Rybczynski, 2005). Sprawl was attacked for its lack of aesthetic charm, due to its mass culture and "middle brow" tastes (Mumford, 1961).[1] This lack of aesthetic and the ever-accelerating consumption of farm land and private open space by suburbs, in general, appear to

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[1] Of course, such suburban developments had been present for decades if not millennia. Bruegmann (2005), for example, notes that a not dissimilar urban extension was present in some of the earliest cities, such as Ur and Babylon. Typically cities expanded to include these "less tasteful" communities. Many such communities later became hot spots of urban activity—hardly the sprawling entities that they were once deemed.

remain the key thrusts of opposition to this “modern” human settlement pattern. Of the two sets of characteristics, the spatial spread explicit in the word “sprawl” is more readily measured. Indeed, opposition to sprawl, which has tended to be formalized into efforts cleverly labeled “smart growth” programs,[2] largely focuses upon increasing the density of the use of existing urban settlement areas and on setting explicit restrictions on the conversion of farm land and private open space to residential and commercial uses. Of course, such restrictions also implicitly mitigate marginal negative externalities of the intended uses, many of which may embody aesthetics.

Recently some states (at least Arizona, California, Idaho, Montana, Nevada, Oregon, and Washington)[3] have put forward laws that curb smart growth programs. Oregon Revised Statute 195.305 (better known as “Measure 37”), which was enacted in 2005 is a prime example. It allows property owners to file for compensation if they can make a valid claim that use of their property (and, hence, also its value) has been diminished due to environmental or other land use regulations established by state or local government. If the government does not compensate the claimant within a reasonable period (in Oregon, two years), restrictions on the property revert to those in place when the property was purchased. This revision “has teeth” because it is rooted in an interpretation of the U.S. Constitution which states “…nor shall private property be taken for public use, without just compensation.”[4]

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[2] This is because opponents must fight the moniker that they like growth that is the polar of “smart.”

[3] In the early 1990s, Florida, Texas, Louisiana, and Mississippi passed property-rights laws to protect landowners from pecuniary losses due to zoning ordinances. None of these laws was broadly written, so none of them really had much impact on local land-use regulation,

[4] In a special 2007 election, Oregon voters approved Ballot Measure 49, which modifies provisions of Measure 37. For the purposes of the present paper, Measure 49 does not much relax a need to evaluate the effectiveness of smart growth legislation. It appears limited to militating against large-scale developments (more than ten homes, malls, industrial complexes, and the like) See Boulanger (2008) for more information.

Of course there have been many arguments militating against laws such as Measure 37. A prime one has been that the legislation is deceptive, in that it coerces governments into altering land use laws/ordinances without a debate on the relative merits of the alternatives. This argument points out a need to measure the relative merits of smart growth programs. But what are they? The literature is unclear on this. The largest body of smart growth study has honed in on the effect of urban growth boundaries (UGBs) on property values. This is because economic theory (the monocentric city model of Alonso-Wingo) suggests that, after controlling for quantity of housing, restriction on the spatial expansion of development should cause land prices to rise per unit of property. Jun (2006) summarize this body of literature saying "empirical evidence on *housing* price effects of UGBs remains fragmented and weak." On the other hand, Cho, Chen, and Yen (2008) analyze the UGB in Knoxville, Tennessee, using the prices of new homes just inside and outside of the boundary, however, and confirm theoretical expectations. They find the prices of homes inside the boundary are slightly higher than those outside after controlling for various housing attributes (including distance from the city core), albeit the size of the price difference is similar to that obtained in some of the Portland studies. That is, although statistically significant, the difference is actually rather small. Indeed, empirical findings of Jun as well as Cho, Chen, and Yen concur with formal analysis by Wu (2006), who finds that structural, accessibility, and environmental amenities—all of which undoubtedly largely are embodied in prices within a housing market—tend to dominate human settlement patterns, at least more far so than UGBs. Of course, until a decline in value due to changes in the neighborhood aesthetics can be disentangled from the rest of the amenities, this literature provides fodder for arguments against Measure 37 rather than for it.

Naturally there is more to smart growth than UGBs. In fact, few states outside of Oregon, Tennessee, and Washington have established them. At the time of writing this paper (in late 2008) we counted a total of 14 states with laws that planners considered to be sufficiently comprehensive to label as "smart growth programs." It is difficult to measure the change in aesthetics avoided by the implementation of these laws. This is because it would require specifying exactly which developments are deemed "good" and which are deemed "bad" by society—such an undertaking would be a political quagmire, to say the least. As a result, very few researchers have focused upon measuring the effects of smart growth programs. Moreover, when they have, their analyses have focused on the ability of the programs to harness reductions in population density or the spatial expansion of the urbanized areas of metropolitan areas in the United States. For example, both Carruthers (2002) and Anthony (2004) find little evidence that state smart growth policies are effective in enhancing metropolitan population densities through 1997. Using a somewhat more sophisticated approach and a longer period of examination, Howell-Mulroney (2007) finds that, *ceteris paribus*, metropolitan areas in states with the most stringent smart growth programs tend to have lower rates of urban spatial expansion and higher population density increases (alternatively, changes in population density that are not so negative), but that weaker programs have no differential effect at all compared to metropolitan areas in states with no smart growth programs.

Our intention with the research presented in this paper is to extend the work of these previous studies by considering issues other than smart growth laws that could have intervening effects on the spatial expansion of the urbanized areas of metropolitan regions in the U.S. Also, Howell-Mulroney (2007) detailed when smart growth programs were passed in addition to identifying the effective relative intensities of the laws. We appreciate the novelty of this line of thinking, but opt instead to use the date that the laws were made operational. Combined, we believe our innovations should enable us to more clearly identify the effects of smart growth laws. In addition, compared to prior studies, we use a richer model in terms of urban areas covered and time span—expanding the analysis through to 2005.

The rest of this paper is organized as follows. It starts out with our reconnaissance into literature that identifies covariates of urban spatial growth. This leads our articulation of theory and a model for explaining urban sprawl at the metropolitan level. We also develop a model to predict what states adopt smart growth programs. We discuss the results and conclude with thoughts for further research.

Toward a Theory of the Spatial Expansion of Metropolitan Areas.

If the economics and planning literature is any gauge, sprawl is indeed undesirable. Researchers have shown that it increases congestion, environmental runoff (and flooding), the costs of public services (and, hence, taxes) (Wu, 2006). It also increases an individual's propensities to be obese, to show symptoms of asthma, to be apathetic, and to display antisocial behavior (Wu, 2006). Nonetheless, the notion of curbing urban sprawl has been hotly discussed during the last decade or so. Ewing (1997) and Gordon and Richardson (1997) provide a classic debate that hits at the core concerns underlying the anti-smart growth backlash represented by Measure 37. Gordon and Richardson suggest that new-urbanist growth-management policies interfere inefficiently with the land market and question whether the policies are worth their resulting changes in social and economic contributions, while Ewing waves the new-urbanists' banner.

To measure the value of anti-sprawl policies, we first need to have a better sense of what causes sprawl and what other measures could be applied to curb it. As was mentioned earlier, the Alonso-Wingo model has been a source of much of our knowledge about urban growth, which certainly is a source of sprawl. Derived largely from the work of von Thünen, this model shows why cities have lower densities at their urbanized peripheries. Assuming that workers prefer to live near their work place, the model shows that they are willing to live further away if rises in overall commuting costs are offset by lower land rents, especially if they are able to purchase more land. This highlights the importance to sprawl's growth of declining transportation costs—through new vehicle technology; secure low-cost fuel sources; and publicly subsidized infrastructure investments (Nechyba and Walsh, 2004).

Using the monocentric city model, Wheaton (1974) demonstrated how rising income levels can also reduce city densities. Margo (1992) finds that about half of the spatial spread from 1950 through 1980 was due to rises in income. Combining income and transportation in a single analysis, Su and DeSalvo (2008) show that urban areas expand with rises in their median household income and that public transit subsidies and automobile subsidies tend to, respectively, contract and expand the urban area. Meanwhile, Brueckner (2005) finds that, in net, transport subsidies incent the use of both highways and the automobile, while they disincent public transit. This suggests that in net federal transportation subsidies tend to support sprawl. Song and Zenou (2006) find that in net transportation subsidies increase individuals' travel distances, commuting times, and, hence, heighten congestion. Anas and Rhee (2006) concur that they increase daily personal travel (i.e., increase congestion), which both causes and is caused by sprawl. They conclude that congestion tolls, gasoline taxes, and parking taxes could help to curb casual road usage.

Inner-city crime has been cited as a driving force behind middle-class flight to the suburbs at least as early as Gibbs and Maynard (1976). Cullen and Levitt (1999), among others, find evidence to this effect. Since then researchers have suggested a return causal effect of suburbanization on crime rates (see, e.g., Jargowsky and Park, 2009). But the point remains that crime, particularly violent crime according to Liska, Logan, and Bellair (1998), instigates suburbanization.

In summary, this literature review suggests a myriad of factors other than smart growth programs that could either encourage sprawl or curb it. A paper by Nechyba and Walsh (2004) in the *Journal of Economic Perspectives* summarizes much of the pertinent literature on the causes of sprawl. We briefly cover material pertinent to our study[5] and both expand and update a bit the review by Nechyba and Walsh. We expand it by noting further articulations of the effect of transportation subsidies on sprawl, in particular that evidence suggests the availability of public transit will curb sprawl while increases in government provision for roadways motivate it. Further, Pigouvian taxes on road usage through tolls, parking taxes, and fuel taxes should reduce sprawl's expansion. We also point to specific literature that presents evidence on how high crime rates, particularly for violent crimes, enhances sprawl. This review sets the stage for the model that we test in the paper.

Modeling U.S. Sprawl at Metropolitan Level

We assert that the critical outcome to be explained is the change in urban land area at metropolitan level over time, i.e., sprawl is measured as the pressure to allocate urban land in each metropolitan area:

[5] We ignore large swaths of the Nechyba and Walsh (2004) review on Tiebout sorting, inner-city pollution levels, and the consumption of open space because credible, universal data by metropolitan are not readily available on these topics.

$$\text{Sprawl}_{i,t} \quad = \quad \ln\left(\frac{\text{Urban Land Area}_{i,t}}{\text{Urban Land Area}_{i,t\text{-}1}}\right)$$

for i=urban areas, and where t=1983,…,2005.[6] We use yearly data from the Texas Transportation Institute (TTI) *2007 Urban Mobility Study*, which has annual data on 85 metropolitan areas from 1982 to 2005. (Descriptive statistics for the data set are provided in appendix Tables A.1 through A.3.) This study provides data on urban land area (square miles), population (thousands), average fuel cost at state level ($/gallon), passengers-miles in public transportation per person (millions/thousand persons), highways lane length (thousand of lane-miles), principal arterials lane length (thousand of lane-miles), and a congestion index (travel time at rush hour over travel time at limit speed). The TTI collects and then adjust these data from the U.S. Federal Highway Administration's Highway Performance Monitoring System database with supporting information from various state and local agencies. We added data on local personal income (annual $ per person) from the U.S. Bureau of Economic Analysis and core-city violent crime rates (annual number of incidents per 100,000 inhabitants) from the FBI Uniform Crime Reports. The crime data is creates an unbalanced panel, i.e., on average over 25 percent of the observations are missing crime rates.

We include three binary variables to denote metropolitan areas with anti-sprawl programs. The first identifies states with a recognized and effective smart growth program. The second identifies those states that at least have some sort of smart growth legislation. Table 1

[6] We opted for the change in urbanized area since it takes into account a minimum threshold of population density to measure the change in spatial expanse. Other researchers (Carruthers, 2002; Anthony, 2004) have examined examining changes in density. This has the possible advantage of measuring any possible infill and multi-story building incentives in the smart growth laws, which should enhances densities at least close to the urban core. It could also detect any density declines—so-called “hollowing out”—at the core. Unfortunately TTI does not supply population data to match up its urbanized area estimates. Hence we were restricted to using urbanized area only. In this vein we are focusing only on the conversion of farm land and private open space to residential and commercial uses.

summarizes the information of the year of initial enacted smart growth legislation and the year of initial effective of smart growth program by state. We also include a third binary variable that indicates whether the metropolitan area is affected by a strong urban containment policy. These data are provided by Wassmer (2006, Table 1).

Prior studies assume that the dates of enactment of smart growth programs are the effective starting dates of smart growth programs. For states like New Jersey and Florida, however, the effective date is the date a set of administrative rules was adopted (Florida, in 1986) or the date a state plan was adopted (New Jersey, in 1992). Here we start from Gray's (2007, Exhibit 1) lists of smart growth legislation by state, which we embellish in Table 1. We have updated it somewhat and add a column that refers to the effective year of the smart growth program.

What Evokes Smart Growth Legislation?

In analyzing the effect of smart growth laws on sprawl, Howell-Moroney (2007, p. 2168) split his data set into two segments, acknowledging that states are heteroskedastic on the causes sprawl. Speaking less technically, he suggests that smart growth and non-smart growth states have sprawl that emanates from somewhat different foundations. In fact, it is quite intuitive that non-smart growth states do not have programs to regulate sprawl simply because they have less development pressure than do their smart growth equivalents.[7] Thus, most of them have little reason to implement any smart growth-oriented policies.

[7] As the reader shall see later, states that have enacted smart growth laws tend to be those with metropolitan areas with incomes per capita that are higher than average among the 85 metropolitan areas in the TTI data base.

Table 1. Smart Growth Programs by State

State	Legislation Year	Effective Year	Law and Sources
Arizona	1998	-	- Growing Smarter Act - Not considered effective smart growth policies because of lack of regional cooperation and enforcement
Delaware	2001	-	- Comprehensive Plans and Annexation Law (H.B. 255) - Planning Coordination (S.B. 105) among others
Florida	1985	1986	- Omnibus Growth Management Act enacted in 1985 - Implementing rule 9J-5, FAC has an effective in 1986 (Pelham (2007, p. 10))
Georgia	1989	-	- Coordinated Planning Legislation (O.C.G.A. 50-8-1 et seq.) - It does not have a clear State mandate
Hawaii	1978	1978	- Hawaii State Plan of 1978 - Hawaii Land Use Land was enacted in 1961
Maryland	1992	1998	- Economic Growth, Resource Protection and Planning Act of 1992 - Smart Growth Areas Act of 1997 - Priority Funding Areas Act went into effect on October 1, 1997, but the effective dates for counties to comply was postponed until October 1, 1998 (Dierwechter (2008, p. 36))
Maine	1988	1998	- Comprehensive Planning and Land Use Regulation Act (30 M.R.S.A. Sec. 4960)
New Hampshire	2000	-	- Smart Growth Bill (H.B. 1259)
New Jersey	1986	1992	- State Planning Act (NJSA 52-18A-196 *et* seq.) of 1986 - New Jersey State Planning Act (N.J. Rev. Stat. §§ 52:18A-196-52:18A-207) and Fair Housing Act (N.J. Rev. Stat. §§ 52:27D-301 to 52:27D-329)
Oregon	1973	1973	- Land Conservation and Development Act (S.B. 100, Oregon Stats. 197)
Rhode Island	1988	1988	- Comprehensive Planning and Land Use Regulation Act (Rhode Island General Laws, Ch. 45-22)
Tennessee	1998	1998	Growth Policy Law (Public Chapter 1101)
Vermont	1988	1988	Growth Management Act (Act 200, 24 Vermont Stats. 117)
Washington	1990	1994	- Growth Management Act of 1990 (Sub. House Bill 2929) - Amendments to Growth Management Act of 1994 as shown by Piro (1999, p. 99)
Wisconsin	1999	-	Growth Management Law (A.B. 133)

We decided to probe the rationale for splitting the data set on smart growth legislation, a action taken by Howell-Mulroney (2007) but not fully elaborated. To do so, we employed a random-effects panel probit model to identify what makes states more or less likely to adopt such programs. All 85 metropolitan areas from both smart growth and non-smart growth states in the TTI data set were used. (Note that metropolitan areas in neither Maine nor Vermont are included in the TTI data set that we use here.) We created two variables for later purposes, and added them together to form the binary dependent for the present analysis. The first, is the binary variable *Smart Growth*$_{i,t}$, which takes the value of 1.0 when *t* is a year in which the state's smart growth program is effectively implemented. We added to this the binary variable *Some Legislation*$_{i,t}$, a binary variable takes the value 1.0 in years during and after the laws were enacted (and the effective year does not exist yet). For the sake of the analysis, we assimilate both Baltimore and Washington, DC, into Maryland, as well as both New York City and Philadelphia into New Jersey. We realize that because of this the smart growth binary variables for these metropolitan areas are "contaminated." But it was do this or lose these two large observations and two leading smart-growth states (Maryland and New Jersey) altogether. We estimate two models—with and without crime rates.

Both models in Table 2 show that declining urbanized-area population density is an important trigger for states' decisions to commit to a smart growth program. In both cases, higher income per capita also encourages states to adopt smart growth program. Presumably, this is not only because the factor promulgates sprawl but also because it is a proxy for a rising standard of living and quality of life, which adjust peoples tastes so that they actively militate against sprawl. Central-city violent crime rates do not appear to factor into such decisions, even indirectly. For this reason, we are more prone to accept the results of the model that excludes crime: it is more robust since the panel is balanced and includes 25 percent more observations. The percentage change in the urbanized area (change in sprawl) does not factor into the decision to "go" smart growth when crime is excluded. But when crime in included as a factor, we obtain the unexpected finding that low rates of expansion in urbanized areas enhance the probability that a state will adopt a smart growth program. Of course, this may result because good number of metropolitan areas in California and the Northeast—areas where smart growth programs tend to be in place—are almost fully urbanized. When crime is not modeled, higher fuel costs appear to reduce the probability a state will adopt a smart growth program: Of course, raising fuel costs via taxes has long been suggested as a "best" way to curb sprawl. But also in the absence of crime as a potential factor, high congestion does appear to be a key in inducing states to legislate smart growth programs.

Table 2. Probit Model for State Legislation of Smart Growth Laws

	Crime Included			**Crime Not Included**		
	Coeff	**SE**	**z**	**Coeff**	**SE**	**Z**
Urban area, *t*-1	-0.202	-0.76	0.45	-0.718***	-3.35	0.00
Urban area (change in), *t*-1 over *t*-2	-14.057**	-2.09	0.04	-5.141	-1.07	0.28
Density, *t*-1	-9.161***	-2.59	0.01	-7.727***	-2.82	0.01
Fuel cost (change in), *t*-1 over *t*-2	-0.593	-0.78	0.44	-1.419**	-2.34	0.02
Per capita income (change in), *t*-1 over *t*-2	3.931***	6.14	0.00	4.041***	7.45	0.00
Congestion (change in), *t*-1 over *t*-2	0.202	0.05	0.96	6.148*	1.92	0.06
Strong urban containment, *t*-1	2.118***	3.58	0.00	1.774***	3.60	0.00
Violent crime rate in cities, *t*-1	-0.093	-0.23	0.82	n/a	n/a	n/a
Intercept	-29.683***	-3.74	0.00	-30.151***	-5.06	0.00
Statistics						
Wald chi^2 (8) and Wald chi^2 (7) respectively	94			119		
Log likelihood	-137			-179		

Note: In Tables 2 to 4, we use the following usual notation:
* denotes significant at 0.1 p-value level,
** denotes significant at 0.05 p-value level, and
*** denotes significant at 0.01 p-value level

Modeling Sprawl

Given the heteroskedasticity issue demonstrated above, we follow Howell-Moroney's (2007) approach and split the data into two segments. The first segment contains data of 23 metropolitan areas that belong only to states that have enacted smart growth legislation, as shown in Table 1 and analyzed in the previous section. The second segment contains data of 56 metropolitan areas from the 27 non-smart growth states in our data set.[8]

A total of four models are specified, with the following characteristics:

i. Smart growth states, crime rates included

ii. Smart growth states, crime rates excluded

iii. No smart growth states, crime rates included

iv. No smart growth states, crime rates excluded

Models i and ii use the first segment of the data set, and models iii and iv use the second segment of the data set. Models i and iii contain data about crime rates in core cities of metro areas. Nonetheless, the panels including the crime variable are unbalanced because over 25 percent of the crime data is missing in some years. In contrast, Models ii and iv do not contain data on crime rates and, hence, are balanced. The time-series, cross-sectional analysis inherent to panel data removes the risk of endogeneity in the explanatory variables.

We expected that increases in the length of mileage for both highways and principal arterials cause urban areas to expand. We also expected that higher crime rates in core cities, congestion, and personal income also would cause urban areas to expand, and we expected that higher fuel costs and expansions in transit services would curb sprawl. Due to results from prior

[8] Alaska, Alabama, Arkansas, California, Colorado, Connecticut, Illinois, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Missouri, North Carolina, Nebraska, New Mexico, Nevada, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Texas, Utah, and Virginia.

studies, we were, however, skeptical detecting the ability of smart growth programs to curb sprawl.

We opted to use an unweighted feasible generalized least squares (FGLS) random-effects panel regression model. All variables but dummies are measured in natural logarithmic form. This allowed us to interpret regression coefficients as sprawl elasticities for the “average” metropolitan area in the sample. We apply a one-year lag of the dependent variable as an independent variable. This supports the notion that a good predictor of change this year is the prior year’s level. We add a five-year lag to both the lengths in miles of highways and principal arterial roadways constructed. This construct enables us to assert Granger causality in the cases where those variables are found to be significantly associated with the dependent variable.

By design, a random effects model account for panel-specific heteroskedasticity and first-order autocorrelation (AR1) in disturbances. Homoskedasticity can be tested through a likelihood ratio test between the estimates with and without a panel-level correction for heteroskedasticity. In all models, homoskedasticity was rejected with 99 percent significance. As a result, we specified all of the estimates using panel-level heteroskedasticity. This is important because the resulting parameters were somewhat larger when homoskedasticity was assumed.

Non-autocorrelation of first order in panel data can be tested through a Wooldridge test as described in Drukker (2003). In all models, non-autocorrelation was rejected with 95 percent significance. For those balanced models (ii and iv) we specified panel-level first-order autocorrelation. For those unbalanced models (i and iii) we were forced to specify no autocorrelation because autocorrelation do not work with missing values.

Discussion of the Results for Smart Growth States

Table 3 shows results including smart growth states[9]. Thus, during the entire study period and in both models, sprawl's rate of expansion was fairly uniform across other smart growth states across the study period, 1982-2005. The interaction terms of smart growth policies and state suggest that only smart growth programs in Washington (model ii) curbs sprawl. That is, after smart growth laws were in effect, urbanization rates declined in the state of Washington. The implementation of smart growth policies does not seem to have made much of a difference in other states. The presence of a strong urban containment policy appears to have induced sprawl significantly (models i and ii) in those smart growth states.

The second column of Table 3 shows that after controlling for crime rates, additional highways mileage has no appreciable effect on sprawl in smart growth states, but expansion of principal arterials may help to curb sprawl. In contrast, the fifth column of Table 3 shows that additional highways do induce sprawl in smart growth states. Higher crime rates in core cities of metropolitan areas also seem to induce sprawl. Contrary to expectations, population change does not seem to induce sprawl.[10] Higher fuel costs emerges as a solid remedy for reducing sprawl (both models) as expected and, after controlling for crime rates, greater congestion induces sprawl (model ii) as per expectations. Surprisingly, changes in personal income per capita do not seem to make a difference.[11] More passenger-miles allocated public transportation has the apparent perverse effect of inducing sprawl (crime model only). We suspect this is because the

[9] We include all of the dummies and interaction variables but we show only the significant ones at 0.1.

[10] Of course, governments typically do not build roads in anticipation of stagnant population growth. Thus, while we did not find the correlation between the various lane-miles variables and population growth to be sufficiently strong to eliminate one or the other variable from the regression, the existing correlation between these two independent variables may well explain a lack of finding here.

[11] This lack of finding may be strictly because of the bifurcation of the analysis by state on the presence of smart growth legislation since income per capita weighs heavily on its adoption.

passenger-miles are typically added at the fringe of the metropolitan areas, although this still does not explain why the finding does not comport with that found by others using public finance data. The spatial extent of the urban area has no apparent effect on sprawl (both models). Meanwhile the population size of metropolitan areas on average reduces the propensity for sprawl's expansion after controlling for crime rates (model i). This suggests that more densely populated cities have suburbs that are expanding less rapidly into their surrounding countrysides.

If the magnitudes of the regression coefficients are reliable, a 1.0 percent lane-mile increase in the expansion of highways causes a 0.014 percentage point annual rise in sprawl's spread five years later (model without crime). A 1.0 percent lane-mile increase in the expansion of principal arterials causes a 0.025 percentage point annual rise in sprawl's spread five years later (model with crime). A 10 percent rise in fuel cost, reduces the spread of sprawl in smart growth states by between 0.11 and 0.15 percentage points annually. Each year of so-called smart growth policies in Washington appears to curb the rate of sprawl by an average of 0.6 percentage points annually.[12] Interestingly, urban containment policies have similar sprawl-inducing effects but they are moderated somewhat when crime is excluded (in the order of 0.6 to 0.7 percentage points in both models). The sprawl-inducing effects of urban containment in the presence of crime are particularly surprising since violent crime's effect has the expected statistically significant sprawl-inducing effect, albeit the effect is generally relatively small—a 1.0 percent change in the violent crime rate transforms into a 0.007 percent higher spread of the urbanized area in the following year.

[12] Given the range of values for coefficients of binary dependent variables examined here renders Halvorsen and Palmquist's (1980) value adjustment

Table 3. Determinants of Sprawl Change in Smart Growth States (Models i and ii)

	Crime Included			Crime Not Included		
	Coeff	**SE**	**z**	**Coeff**	**SE**	**z**
Urban area, *t*-1	0.009	1.45	0.15	-0.006	-0.81	0.42
Population, *t*-1	-0.014***	-2.65	0.01	0.005	0.74	0.46
Fuel cost (change in), *t*-1 to *t*-2	-0.015**	-1.98	0.05	-0.011**	-2.55	0.01
Population (change in), *t*-1 to *t*-2	0.025	0.35	0.73	0.040	0.96	0.34
Per capita income (change in), *t*-1 to *t*-2	-0.043	-1.08	0.28	0.007	0.30	0.77
Passengers-miles per person (change in), *t*-1 to *t*-6	0.008*	1.88	0.06	0.004	1.32	0.19
Highways lane length (change in), *t*-1 to *t*-6	-0.017	-1.53	0.13	0.014**	2.52	0.01
Arterials lane length (change in), *t*-1 to *t*-6	-0.025*	-1.70	0.09	-0.009	-0.89	0.38
Congestion (change in), *t*-1 to *t*-2	-0.012	-0.13	0.89	0.121**	2.48	0.01
Violent crime rate in cities, *t*-1	0.010***	4.13	0.00			
Strong urban containment, *t*-1	0.007*	1.81	0.07	0.006**	2.28	0.02
Smart growth x Washington	-0.006	0.01	-1.01	-0.010**	-2.24	0.03
Intercept	-0.009	-0.49	0.62	0.015	0.99	0.32
Statistics						
Wald chi^2 (28) and Wald chi^2 (28) respectively	192			178		
Log likelihood	778			1308		

Note: In this FGLS run, we employed binary variables for all states as well as their interactions with one denoting the presence of Smart Growth laws. For ease of reading (and to save space), we supply only those that are statistically significant.

In Tables 2 to 4, we use the following usual notation:
* denotes significant at 0.1 p-value level,
** denotes significant at 0.05 p-value level, and
*** denotes significant at 0.01 p-value level

Discussion of the Results in Non-smart Growth States

Table 4 shows that additional roadway mileage (highways and principal arterials) induces sprawl in non-smart growth states (models iii and iv). Higher crime rates in core cities of metropolitan areas induce sprawl too. Recall that this result was found for smart growth states as well. But change in population clearly is associated statistically to have higher rates in the spread of sprawl in non-smart growth states (model without crime), one of the surprising “nonfindings” in the case of smart growth states. Changes in fuel costs, passenger-miles in public transportation, personal income per capita, and strong urban containment policies have no appreciable effect on the rate of sprawl in non-smart growth states. Increases in congestion seem to induce sprawl in non-smart growth states (models with crime). The amount of urbanized metropolitan area is both significant and a negative in effects on sprawl (model iv), while metropolitan population size apparently does not have no appreciable effect on the rate of sprawl in non-smart growth states (models iii and iv). Thus metropolitan areas that are in states lacking smart growth laws and that have more densely packed urbanized areas are more likely to have greater rates of sprawl. This also was the case for metropolitan areas in smart growth states.

As shown in Table 4, in non-smart growth states, a 1 percent increase in lane-miles of roadways (either highways or principal arterials) induces between a 0.023 to 0.036 percentage point premium on the annual percentage change in sprawl five years down the line. A 1 percent increase in population induces accelerates sprawl up 0.12 percent in non-smart growth states (model iv). Compared to its effect in smart growth states, violent crime's effect is somewhat more moderate in smart growth states—a 1 percent rise in the violent crime rate causes sprawl's rate of change to rise by only about 0.003 of a percentage point.

Table 4. Determinants of Sprawl Change in Non-smart Growth States (Models iii and iv)

	Crime Included			Crime Not Included		
	Coeff	**SE**	**z**	**Coeff**	**SE**	**Z**
Urban area, *t*-1	-0.002	-1.26	0.21	-0.004*	-1.94	0.05
Population, *t*-1	0.000	0.17	0.86	0.002	1.40	0.16
Fuel cost (change in), *t*-1 to *t*-2	-0.003	-0.67	0.51	-0.002	-0.88	0.38
Population (change in), *t*-1 to *t*-2	0.000	0.19	0.85	0.116***	3.94	0.00
Per capita income (change in), *t*-1 to *t*-2	-0.001	-0.06	0.96	0.008	0.61	0.54
Passengers-miles per person (change in), *t*-1 to *t*-6	0.000	0.23	0.82	0.001	0.32	0.75
Highways lane length (change in), *t*-1 to *t*-6	0.031***	5.64	0.00	0.026***	4.81	0.00
Arterials lane length (change in), *t*-1 to *t*-6	0.036***	3.83	0.00	0.023**	2.32	0.02
Congestion (change in), *t*-1 to *t*-2	0.123**	2.43	0.02	0.013	0.44	0.66
Violent crime rate in cities, *t*-1	0.003**	2.22	0.03			
Strong urban containment, *t*-1	-0.001	-0.49	0.63	-0.001	-0.91	0.36
Intercept	0.000	0.00	1.00	0.014	2.67	0.01
Statistics						
Wald chi^2 (11) and Wald chi^2 (10) respectively	71			61		
Log likelihood	2,027			3,013		

Note: In Tables 2 to 4, we use the following usual notation:
* denotes significant at 0.1 p-value level,
** denotes significant at 0.05 p-value level, and
*** denotes significant at 0.01 p-value level

Conclusions

Our analysis shows that smart growth programs curb sprawl only in the State of Washington and do not seem to make a difference in other states. These results are fairly consistent with previous studies, although Howell-Moroney (2007) confirms not only minor effectiveness for the smart growth program of the State of Washington but also those in Florida and Oregon. We found no such anti-sprawl effect at all in the two latter states. We find that urban containment programs even appear to spur sprawl slightly in states with smart growth programs.

In as far as highway subsidies are concerned, we find support that additions to highway mileage induces sprawl, although additions to principal arterials mileage may curb sprawl in states with smart growth programs. We also find that worsening levels of congestion tend to induce sprawl in all states. This leaves transportation departments in smart growth states in a "damned if you do damned if you don't position."*:* That is, if with the hope of reducing sprawl they scale back highway construction efforts, they will achieve sprawl instead via enhanced congestion, and perhaps even more immediately.

New residents of metropolitan areas tend to demand new land for urban development in states without smart growth programs. Increases in fuel cost seem to reduce sprawl only in smart growth states, and changes in personal income per capita surprisingly do not seem to make a difference in general at metropolitan area level. At we note in the probit analysis, however, rising incomes do appear to induce states to pass smart growth laws. Surprisingly (or not), increases in passenger-miles in public transportation might induce sprawl in smart growth states (as shown only if controlling for crime rates). This may be because such expansions are invested at the fringes of urbanized areas rather than within the cores. Higher crime rates also seem to induce sprawl.

Higher per capita incomes (as noted earlier), and the presence of strong urban containment policies improve the likelihood that a state will legislate smart-growth laws. Higher population densities and higher fuel costs reduce this probability, while states with metropolitan areas that have increasingly higher levels of congestion tend to support such legislation. High violent crime rates appear to have no effect on the passing of smart growth laws at the state level.

Given the general effect of violent crime on sprawl's growth, it would clearly be useful to have a fully balanced panel. To achieve such a panel would, however, require a procedure that estimates the missing values we encountered. If available, not only would the ideal model include crime rates but it would be robustly specified with respect to autocorrelation.

There has been increasing attention to the effects of metropolitan fragmentation and the way property taxes are levied as potential sprawl-inducing factors. Both are rather complex and require special attention and measurement. How should metropolitan fragmentation be measured? Should property actual or effective property tax rates be used? How should a metropolitan wide property tax be measured when property taxes are levied for jurisdictions as small as or smaller than counties? Both issues would undoubtedly be tedious, arduous, and expensive undertakings. Nonetheless, could prove to be fruitful and would certainly move the purposes of the present analysis to a more comprehensive conclusion.

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APPENDIX: DESCRIPTIVE STATISTICS

Table A.1. Descriptive Statistics for 85 US. Metro Areas

Variable	Obs	Mean	Std. Dev.	Min	Max
Urban area (square miles)	2040	626.03	631.87	20.00	4780.00
Population (thousands)	2040	1,546.61	2,338.30	80.00	17,775.00
Urban density (thousands/sq miles)	2040	2,255.09	896.25	1,000.00	5,625.00
Fuel cost ($/gallon)	2040	1.32	0.32	0.93	2.63
Per capita income (annual $/capita)	2040	23,094.98	8,269.85	6,023.00	67,269.00
Passengers-miles per person (Millions/thousand persons)	2040	449.61	1849.26	1.00	18,989.99
Highways lane length (thousand of lane-miles)	2040	851.48	989.98	20.00	7200.00
Arterials lane length (thousand of lane-miles)	2040	2,19.05	3,101.56	155.00	20,754.99
Congestion (travel time at rush hr/travel time at speed limit)	2040	1.13	0.09	1.01	1.50
Violent crime rate in cities (number of incidents/100K inhabitants)	1758	1,191.21	759.001	198.85	19,563.79
Strong urban containment dummy	2040	0.18	0.39	0.00	1.00
Smart growth dummy	2040	0.17	0.38	0.00	1.00
Some legislation dummy	2040	0.02	0.14	0.00	1.00

Table A.2. Descriptive Statistics for U.S. Metropolitan Areas in Smart Growth States

	In Smart Growth States				
Variable	Obs	Mean	Std. Dev.	Min	Max
Urban area (square miles)	600	788.80	830.69	70.00	4780.00
Population (thousands)	600	2,016.05	3,186.49	160.00	17,775.00
Urban density (thousands/sq miles)	600	2,267.55	982.61	1,000.00	5,111.00
Fuel cost ($/gallon)	600	1.34	0.33	0.93	2.63
Per capita income (annual $/capita)	600	23,300.22	7,748.69	10,022.00	48,697.00
Passengers-miles per person (Millions/thousand persons)	600	944.91	3,230.15	5.00	18,989.99
Highways lane length (thousand of lane-miles)	600	940.41	1264.03	30.00	7200.00
Arterials lane length (thousand of lane-miles)	600	2,974.37	3,486.57	220.00	19,010.00
Congestion (travel time at rush hr/travel time at speed limit)	600	1.16	0.09	1.02	1.39
Violent crime rate in cities (number of incidents/100K inhabitants)	513	1,333.397	783.924	222.173	4,085.358
Strong urban containment dummy	600	0.41	0.49	0.00	1.00
Smart growth dummy	600	0.59	0.49	0.00	1.00
Some legislation dummy	600	0.07	0.25	0.00	1.00

Table A.3. Descriptive Statistics for U.S. Metropolitan Areas in Non-Smart Growth States

Variable	In Non Smart Growth States				
	Obs	Mean	Std. Dev.	Min	Max
Urban area (square miles)	1440	558.20	512.68	20.00	2800.00
Population (thousands)	1440	1,351.00	1,841.37	80.00	1,2540.00
Urban density (thousands/sq miles)	1440	2,249.90	858.01	1,107.00	5,625.00
Fuel cost ($/gallon)	1440	1.31	0.32	0.95	2.62
Per capita income (annual $/capita)	1440	23,009.46	8,478.69	6,023.00	67,269.00
Passengers-miles per person (Millions/thousand persons)	1440	243.24	597.97	1.00	3873.00
Highways lane length (thousand of lane-miles)	1440	814.43	847.91	20.00	5870.00
Arterials lane length (thousand of lane-miles)	1440	2,329.33	2,906.55	155.00	20,754.99
Congestion (travel time at rush hr/travel time at speed limit)	1440	1.12	0.09	1.01	1.50
Violent crime rate in cities (number of incidents/100K inhabitants)	1245	1,132.62	740.91	198.85	19,563.79
Strong urban containment dummy	1440	0.09	0.28	0.00	1.00
Smart growth dummy	1440	0	0	0	0
Some legislation dummy	1440	0	0	0	0