Density and Urban Sprawl

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Richard B. Peiser

A fundamental criticism of urban sprawl is that it leads to inefficient and costly patterns of development. The burden of proving that urban sprawl is not inefficient has fallen on those who, by virtue of not attacking urban sprawl, have been placed in the position of defending it.

The term "sprawl" has a variety of definitions. I use the one that Mills (1981) adopted from Clawson (1962, 99), who characterized sprawl as "the lack of continuity in expansion." While an area is developing, sprawl patterns imply that the urbanized area is larger than it otherwise would be because undeveloped tracts remain interspersed among developed subdivisions.

Urban sprawl is called inefficient because it generates low density development that is "sprawled" over the landscape. A primary justification for interfering in the land market is a presumption that the public good is served by reducing urban sprawl through policies aimed at preventing discontinuous development. This paper argues that, contrary to conventional wisdom, a freely functioning urban land market with discontinuous patterns of development inherently promotes higher density development.

This is not a new notion. Other authors, notably Ottensmann (1977), Schmid (1968), and Ohls and Pines (1975) have also suggested that discontinuous development leads to higher densities than would occur if discontinuous development were prevented. This paper presents additional theoretical arguments and some empirical evidence that lend support to their theses.

The impact of discontinuous development on density is important because uniformly low-density urban development is inefficient. It increases transportation costs, consumes excessive amounts of land, and adds to the cost of providing and operating public utilities and public services. However, if discontinuous development patterns in fact promote higher density, as argued here, then public policies aimed at preventing discontinuous development may be misguided. Policies that encourage sequential or continuous development may lead to development patterns in which densities will be lower than they would be in the absence of such a policy.[1]

I test empirically the theoretical arguments using three geographic areas: Dallas, Texas; Montgomery County, Maryland (north of Washington, D.C.), and Fairfax County, Virginia (south of Washington, D.C.). Lot sizes and residential densities are examined over time along major growth corridors emanating from central Washington, D.C. and central Dallas. The arguments suggest that lots should be smaller (i.e., densities should increase) the later they are developed, after controlling for house size and distance from the central business district (CBD). I investigate three separate areas because jurisdictional attitudes and policies toward growth would be expected to influence development patterns for infill development.

The paper concludes that if higher densi-

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[1] Sequential development policies pose the major obstacle to higher densities. Policies which focus on attaining target densities are not subject to the same criticism as those that focus on sequential development unless the targets are site specific rather than area wide.

ties closer to the CBD are desired then cities should avoid policies which require sequential development. Furthermore, they should let the land market seek its natural level of densities, at least within the limits that existing road, utility and other infrastructure will support. A competitive land market will achieve the desired result of higher density precisely by the process associated with urban sprawl—namely, discontinuous development followed by later infill.

I. BACKGROUND

Most recent research on urban sprawl has focused on the cost of sprawl. *The Costs of Sprawl* (Real Estate Research Corporation [RERC] 1974) concluded that urban sprawl leads to significantly higher overall costs than would be found in more carefully planned communities with higher residential densities and contiguous development. Windsor (1979) criticized the RERC study because it failed to isolate the effects of density and planning from other sources of variation in development costs, and therefore it failed to prove the thesis that the costs of sprawl were significantly higher than planned development. More recently, Peiser (1984) concluded that the added costs of sprawl were lower than one might expect (approximately 3 percent higher than planned development) for the case where gross densities were constrained to be the same between sprawl and planned communities.

The relationship between sprawl and density has been addressed directly by Ottensmann (1977), and Ohls and Pines (1975). Ottensmann hypothesized that faster growing cities, while having more sprawl, would be denser in those areas which were actually developed. "When expectations about future development potential are high, more land will be withheld from development, land values will be higher, and the densities in developed areas will be higher" (p. 392). Ohls and Pines present evidence that discontinuous urban development may be consistent with efficient allocation of resources. They show that in "the expansion of a rapidly growing city [it] may sometimes be efficient to skip over relatively centrally located land early in the development process in order to build low density dwellings in suburban locations" (Ohls and Pines 1975, 233).

Discontinuous development occurs as a natural product of the land development process because of a number of market imperfections. Land becomes available for development at different times. Developers' preferences for sites are distorted by capital immobility—it is not costless to convert low density housing to high density housing. They face uneven information, imperfect public pricing, different levels of taxes and externalities.[2] Discontinuous development may be more efficient than continuous development under certain conditions of market imperfection. Because higher land prices lead to higher densities, land which is not developed initially may, because of higher prices, result in higher long run density. Therefore, land use controls that restrict discontinuous development may reduce efficiency in the land market and lead to lower rather than higher overall urban density.

II. EMPIRICAL ANALYSIS

Despite the early theoretical work, there has been little empirical work on the relationship between discontinuous development and density. Ohls and Pines demonstrated that discontinuous development may be desirable if density increases in those locations that were initially passed over. In this section, I demonstrate that such development patterns in fact take place.

Developers' opportunities to increase densities depend on prevailing zoning and growth policies which vary from city to city. I collected data from three different sample areas based on the following criteria:

1. Dallas and Washington were selected because both cities have experienced rapid growth since 1950.

[2] A referee suggested many of these points as a concise statement of longer arguments made in an earlier version of the paper.

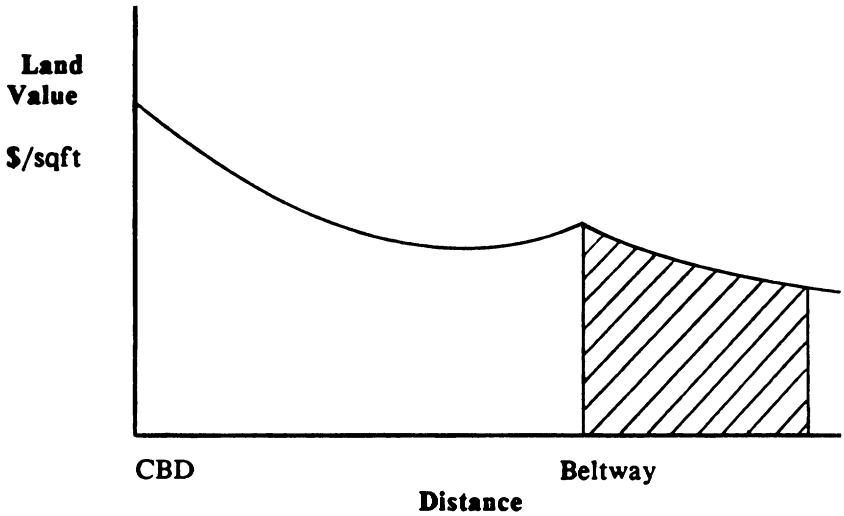

FIGURE 1
LAND VALUES AND DISTANCE FROM THE CENTRAL BUSINESS DISTRICT

2. Dominant growth corridors were selected from each city along radial roads which emanated from the CBD.
3. The corridors measured approximately one mile wide and six miles long starting from the beltway loop and extending away from the CBD.
4. The corridors were all substantially undeveloped before 1950 and approached full development by 1987.
5. The corridors were located in sectors of middle and upper-income growth, with houses ranging in price from approximately $80,000 to $300,000.

The shape and location of the corridors were carefully chosen to follow major radial roads. Each corridor begins at the beltway loop where accessibility is best; accessibility declines as one moves out along the corridor away from the beltway. Since land values theoretically decrease as accessibility worsens, land values in the corridors would be expected to follow the standard declining rent gradient pattern shown in the hatched area of Figure 1. I avoided corridors that were crisscrossed by expressways because land values tend to be higher around freeway intersections. Major cross-highways make it harder to rank land values with respect to location.

Because the data had to be assembled by hand, house lots were sampled from subdivisions in each of the study corridors. Every subdivision within the study area boundaries with platted lots was sampled. Average lot sizes and filing dates for each subdivision were taken from plat maps and zoning plat records. Lots were sampled from the middle of street blocks in an effort to find typical lots with respect to size and shape. If the subdivision contained more than one standard lot size, separate observations were taken for each representative lot.[3]

[3] Developers usually subdivide land around one or two basic lot shapes that represent the dominant lot form in a subdivision. Standard lot sizes are located in the middle of blocks. Corner lots, cul-de-sac lots and lots on curves are atypical though they, too, must meet minimum lot standards for the subdivision. For example, within the same subdivision, a developer may have lots that measure 75 × 120 for larger homes, and 60 × 120 for smaller homes (O'Mara 1978). Both lot sizes would be included in the sample. A possible bias, introduced by the sampling procedure, is that the number of lots sampled in one subdivision may be greater proportionately than in another. An attempt was made to sample evenly with respect to geographic area but some smaller subdivisions may be overrepresented numerically in relation to larger subdivisions.

The data included only individually platted, single family and townhouse lots. It would, of course, have been preferable to include multi-family developments since apartments would be expected to manifest the same density/price characteristics. Unfortunately, density information for apartments and condominiums was not readily available.[4]

Another factor affecting land price is physical terrain. Attractive features such as hills, trees and creeks may tend to reduce land prices because development costs are high. Nevertheless, such terrain often carries higher prices because wealthier homebuyers outbid others for special homesites. For the purposes of this study, the hypothesis that land prices decline as distance increases from the beltway assumes that land is physically homogeneous. While an on-site inspection of each subdivision would be desirable, individual site inspections were not performed. Thus, land values and densities may be affected by physical factors which are not included in the regression analysis. This should not bias the regression results unless there are major differences in the physical terrain within a study area.[5] Tax and impact fee data, which also affect development economics, were excluded without harming the results because observations within each corridor were located in the same jurisdiction.

Different Planning Environments

The planning environments for the three areas are very different. Expecting the hypothesis to apply more readily in areas which are permissive toward higher density infill zoning, I attempted to find a way to measure these local attitudes. Based on interviews with local planners and developers, I found that Montgomery County, Maryland is clearly more restrictive than either Fairfax County, Virginia or Dallas, Texas.

Montgomery County zoned the study area for low density housing in the 1950s, and plats for new subdivisions had to conform. A revised master plan adopted in 1981 allowed increased densities around commercial nodes but retained the low density on undeveloped parcels in areas with existing half-acre lots along the New Hampshire Avenue corridor (Maryland-National Capital Park and Planning Commission 1982, 74). The county has a record of not allowing developers to increase densities.[6] Unless they can prove that an error was made in the master plan, it is impossible for them to upzone the property.[7] Also, the county has an "adequate facilities" test for new development. The planning board has said that if the capital program does not give road and utility relief, they will not grant a zoning change (Porter 1986).

Fairfax County, Virginia has allowed higher densities in infill areas where infrastructure would support it.[8] The county adopted a comprehensive plan in 1958 which permitted zoning of three to four units per acre in areas previously zoned for one-acre lots, and developers were allowed to upzone new subdivisions to conform to the comprehensive plan. In 1975, a major plan revision was adopted which permitted still higher single family densities, based on the theory that people should live closer to where they work. Also, higher densities were considered appropriate near commercial uses. Upzoning for higher density has

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[4]The absence of multi-family sites from the sample may introduce another bias. A city which frequently zones individual patio and townhouse lots will appear to have more higher density housing than one which zones multi-family or planned unit development without individual lots simply because it has more high density housing in the sample.

[5]Densities in individual subdivisions will be influenced by physical terrain factors, especially flood plain areas. However, such factors rarely affect all lots in a subdivision. The impact of physical terrain on density is mitigated by selecting sample lots that are representative of the majority of lots in each subdivision.

[6]Interview with Doug Alexander, Chief of Urban Design for the Montgomery County Planning Office of the Maryland National Capital Park and Planning Commission (December 1987).

[7]Interview with Clarence Kettler, Montgomery County residential land developer (December 1987).

[8]Interview with Wayne Pumphrey, Deputy Director of Comprehensive Planning, Fairfax County (December 1987).

been approved 100 percent of the time where it was in accord with the comprehensive plan.

Dallas has also been generally sympathetic to rezoning for higher density patio homes and townhouses. The study area (following the Hillcrest Road corridor north of LBJ Freeway) was developed "at a period of time when higher density zoning was thought to be the thing to do."[9] Developers have enjoyed a 70 to 80 percent success rate in rezoning infill parcels from the "standard residential zoning" of 4.5 units per acre to 6–9 units per acre.[10] The city's willingness depends on units per acre and amenities the developer is offering: "6 to 9 units per acre is okay but 20 units is not."[11]

Regression Model

By examining growth patterns over time, it is possible to test the hypothesis that discontinuous development leads to higher densities in subdivisions built in the same locality and price range as earlier subdivisions. The driving force behind the hypothesis is that land values on vacant infill parcels increase faster than land values at the urban fringe, and therefore developers must build at higher densities to achieve the same level of return. Land values increase on infill sites because they incorporate agglomeration benefits of residents who bought homes earlier in the "sprawled" developments farther from town. Also, development risk is lower because infill sites have better, more established locations than sites at the urban fringe where the direction and extent of future growth has greater uncertainty.[12]

To formulate a testable model for the hypothesis, let us begin by positing a direct relationship between density and land value:

$$DENS = f(R) \quad [1]$$

Density (*DENS*) should increase as land value per square foot (*R*) increases.[13] Figure 2 illustrates the relationship between density and accessibility as measured by distance to the point of maximum accessibility. Curves t_1 and t_2 represent density as a function of distance at two points in time. Of course, time is a continuum but a two-period example illustrates the relationships. Consider four subdivisions: *A*, *B*, *C* and *D*. Subdivisions *A* and *B* are platted at the same time, t_1. *C* and *D* are platted later, at time t_2. *A* and *C* are adjacent to one another and have comparable accessibility. Similarly, *B* and *D* are located next to one another at a greater distance from 0, the point of maximum accessibility. The hypothesis suggests the following: (1) controlling for location, subdivision *C* will have higher density than *A*, and *D* will have higher density than *B* because *C* and *D* are platted later in time, and (2) controlling for time, subdivision *A* will have higher density than *B*, and *C* will have higher density than *D* because *A* and *C* have superior locations. These relationships suggest the following equation:

$$DENS = f(R) = f[R(D, T), H] \quad [2]$$

where $R[D, T]$ = land value per square foot at distance *d* and time *t*, and H = house size. We include *H* because homebuyers will purchase more land for larger houses. *H* may be interpreted as an income effect on lot size.

While we do not know the true functional form, let us assume an exponential relationship between house size and density. As house size increases, density should decrease. Similarly, density should decrease with subdivision age (*T*) and with

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[9] Interview with James Schroeder, Development Coordinator for the City of Dallas (December 1987).

[10] Interview with Elias Martinez, Urban Planner for the City of Dallas (December 1987).

[11] Martinez interview.

[12] As noted by a reviewer, lower development risk translates into higher land rents as long as the regulatory environment permits higher densities. Changes should be greater in a more market-oriented system, where land prices should reflect the increased probabilities of higher density zoning.

[13] A positive relationship between density and land value is easily demonstrated using a simple valuation model. See the Appendix.

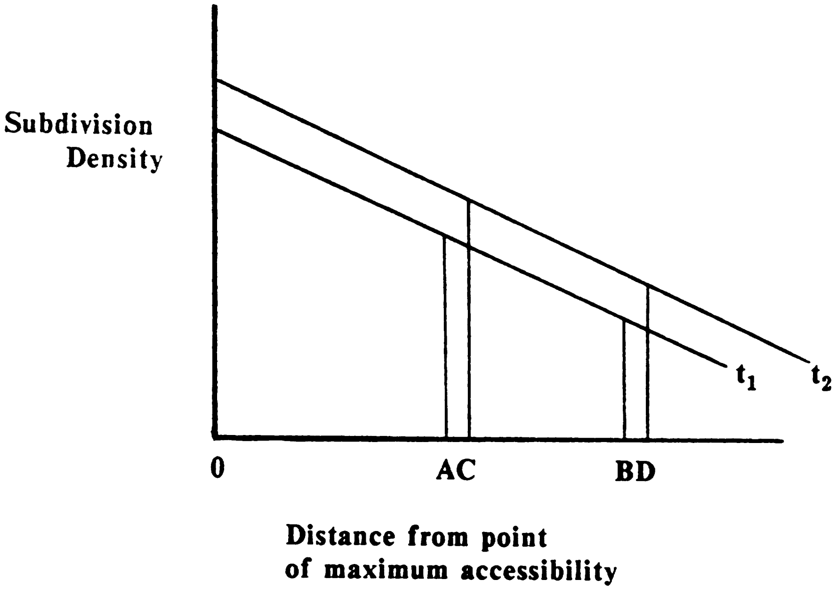

FIGURE 2
RELATIONSHIP BETWEEN DENSITY, LOCATION, AND TIME OF DEVELOPMENT

distance from the city center (*D*):

$$DENS = f[R(D, T), H] = R_0 e^{-aD} e^{-bT} H^{-\alpha} \quad [3]$$

where R_0 = land value today, and a, b and α are parameters for distance, age and house size.

In the regressions that follow, lot size (*SQFT*) rather than density is used as the dependent variable. Since lot size is inversely related to density, we have

$$DENS = \frac{C_0}{SQFT} = R_0 e^{-aD} e^{-bT} H^{-\alpha} \quad [4]$$

where C_0 is a constant (43,560 square feet per acre). Inverting equation [4], we obtain

$$SQFT = \frac{C_0}{R_0} e^{aD} e^{bT} H^{\alpha} \quad [5]$$

Equation [5] can be estimated by taking the log of both sides:

$$\ln SQFT = \ln C_0 - \ln R_0 + aD + bT + \alpha \ln H \quad [6]$$

Since C_0 and R_0 are constants, they become part of the constant term in the regression. From equation [6] we expect to find that lot size increases with house size (*H*), age of the subdivision (*A*), and distance (*D*) from the city center.

For the regressions, *T* is represented by *AGE*, the number of years since the developer platted the subdivision. If the subdivision was later replatted, I use the last plat recording date. *D* is measured by two variables: *DLOOP*, the distance to the point of greatest accessibility as measured along the nearest radial arterial to the subdivision, and *DCROSS*, the lateral distance from the subdivision to the arterial. *H* is measured by *CENVAL*, the median house value of the subdivision based on 1980 census block data.[14] The dependent variable is average square footage of lots in the subdivision (*SQFT*):

[14] House size was not available so I used house value as a proxy. This raises potential multicollinearity problems. Further testing indicated that correlation between distance and house value did not appear to bias the results.

$$\ln SQFT = b_0 + b_1\, DLOOP + b_2\, DCROSS + b_3\, AGE + b_4 \ln CENVAL + \varepsilon \quad [7]$$

In equation [7], $b_1 \ldots b_4$ are the estimated parameters for a, b and α in equation [6], and ε is the error term.

If discontinuous development in fact promotes higher densities, lot size should decrease (density should increase) for newer subdivisions and for infill locations closer to the CBD, after controlling for house value.[15] Specifically, among subdivisions platted at the same time, densities should be higher where accessibility is better; among subdivisions of comparable accessibility, densities should be higher the later a subdivision is developed.

Regression Results

Regression results are shown in Table 1. We would expect the explanatory power of the regression equation to be best for those areas with the most flexible regulatory environment, namely Fairfax County and Dallas. Fairfax County shows the highest R^2. In equation [T2] all variables have the expected signs and are significant. Lot size increases with distance from the beltway (*DLOOP*), age of the subdivision (*AGE*) and home value (*CENVAL*). Lateral distance to the radial artery (*DCROSS*) was tested for each area but was not significant in any equation.

The equations for both Montgomery County, Maryland and Dallas, Texas show less explanatory power. Subdivision age is significant and positive in both sets of equations, indicating that densities increase for more recent subdivisions. Distance from the beltway, however, is insignificant and house value (*CENVAL*) is significant only for Montgomery County.

In light of Montgomery County's strict policy against upzoning, its results are not surprising. If higher densities have not been permitted on infill sites, we should not expect to find a correlation between accessibility and density. The results for Dallas, however, are surprising, since Dallas has had a more positive attitude toward upzoning. One possible explanation is that "when the study area was developing, not many parcels were left out to begin with."[16] Also some of the land closest to the beltway has remained undeveloped because of flood plain problems.

To verify the results for Dallas, cross sectional analysis was performed by examining average subdivision lot size and 1980 median house values. Table 2 presents results for average lot size grouped by distance from the beltway and year in which the subdivision was platted. Data along the diagonal in Table 2 illustrate how the fringe of development moved farther out for each time period. For example, subdivisions 1–3 miles from the Beltway were first developed in the 1960s while subdivisions 5–6 miles away were first developed in the latter half of the 1970s. Within each distance zone, average lot sizes decline for almost every succeeding time period. The exceptions, such as cell 0–1 miles, 1970–74, are marked by more expensive houses where we would expect to find larger lots. The table, however, does not support the corollary hypothesis—that lot size increases with distance from the beltway—except for the period 1980–83. The analysis is complicated by the fact that the highest income areas of the sample are located nearer to the beltway. A closer look at lot size for subdivisions grouped according to median house price for the period 1970–79 shows some evidence that lot size increases with distance, but the data are not conclusive.[17]

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[15] Because lot size is positively correlated with house price, differences attributable to house prices must be standardized in order to examine the issue of density. For example, we would expect to find more expensive housing on infill sites in cities where zoning precludes higher densities. As an estimate of subdivision quality, data was collected on median house value for census blocks (1980 Census) in which sampled lots were located. In addition, appraised values in Fairfax County, Virginia were also collected. Somewhat surprisingly, median census values for the block in which sample lots were located proved to be more reliable predictors of density than actual appraised values for individual lots.

[16] Schroeder interview.

[17] The pattern is stronger for higher priced houses than lower priced houses. Lot size increases with dis-

TABLE 1
REGRESSION RESULTS
LOT SIZE AS A FUNCTION OF DISTANCE FROM THE BELTWAY, SUBDIVISION AGE, AND HOUSEHOLD INCOME

DALLAS:

$$\ln SQFT = \underset{(2.7)^{a}}{5.47} + \underset{(.52)}{.02\,DLOOP} + \underset{(4.5)}{.032\,AGE} + \underset{(1.74)}{.278 \ln CENVAL} \quad [T1]$$

$R^2 = .30 \qquad F = 11.81 \qquad N = 99$

VIRGINIA:

$$\ln SQFT = \underset{(1.2)}{-2.42} + \underset{(4.4)}{.08\,DLOOP} + \underset{(8.7)}{.028\,AGE} + \underset{(5.3)}{.278 \ln CENVAL} \quad [T2]$$

$R^2 = .65 \qquad F = 50.4 \qquad N = 93$

MARYLAND:

$$\ln SQFT = \underset{(.16)}{1.50} - \underset{(.98)}{.07\,DLOOP} + \underset{(5.7)}{.028\,AGE} + \underset{(5.3)}{.674 \ln CENVAL} \quad [T3]$$

$R^2 = .40 \qquad F = 12.12 \qquad N = 111$

COMBINED DATA SAMPLE:

$$\ln SQFT = \underset{(2.2)}{3.47} + \underset{(1.4)}{.049\,DLOOP} + \underset{(5.5)}{.034\,AGE} + \underset{(3.5)}{.436 \ln CENVAL} \quad [T4]$$

$$+ \underset{(0.3)}{.062\,DUM_{VA}} + \underset{(3.4)}{.84\,DUM_{MD}} + \underset{(1.3)}{.06\,DUMDLOOP_{VA}}$$

$$- \underset{(0.8)}{.12\,DUMDLOOP_{MD}} - \underset{(0.8)}{.006\,DUMAGE_{VA}} - \underset{(1.7)}{.006\,DUMAGE_{MD}}$$

$R^2 = .60 \qquad F = 39.28 \qquad N = 303$

$$\ln SQFT = \underset{(1.98)}{2.43} + \underset{(3.76)}{.066\,DLOOP} + \underset{(11.74)}{.030\,AGE} + \underset{(5.19)}{.523 \ln CENVAL} \quad [T5]$$

$$+ \underset{(3.74)}{.24\,DUM_{VA}} + \underset{(7.49)}{.55\,DUM_{MD}}$$

$R^2 = .59 \qquad F = 67.11 \qquad N = 303$

$$\ln SQFT = \underset{(3.96)}{4.81} + \underset{(2.13)}{.039\,DLOOP} + \underset{(14.15)}{.037\,AGE} + \underset{(3.34)}{.337 \ln CENVAL} \quad [T6]$$

$R^2 = .49 \qquad F = 75.23 \qquad N = 303$

[a] *t*-values are in parentheses.

The results of the pooled data sample are shown in equations [T4], [T5] and [T6]. There are problems in pooling the data because we are likely to find different lot sizes in different cities. Standard densities may differ simply for historical reasons or because a certain house style and lot shape became popular. To allow for both absolute differences and different rates of change in lot size between cities, equation [T4] has both dummy intercept variables (DUM_{VA} and DUM_{MD}) and dummy slope variables ($DUMDLOOP_{VA}$, $DUMDLOOP_{MD}$, $DUMAGE_{VA}$ and $DUMAGE_{MD}$). *DUMDLOOP* and *DUMAGE* are slope variables for distance from the beltway (*DLOOP*) and age of the subdivision (*AGE*). The coefficients of the dummy variables give differences between Fairfax County and Montgomery County relative to Dallas, which is omitted from the equation. The slope dummy variables take the form $\beta(D_t Y_t)$ where β is the regression coefficient, Y is the variable for city t and D is a bivariate (0,1) dummy vari-

tance (density decreases) in 6 out of 9 income/distance cells for homes above \$200,000 and homes \$137,500–\$200,000. Among houses valued \$70,000–\$121,000, average lot size shows little variation regardless of distance from the beltway.

TABLE 2
LOT SIZE BY YEAR PLATTED AND DISTANCE FROM BELTWAY (LBJ FREEWAY) FOR DALLAS

MILES FROM BELTWAY	1949–59	1960–69	1970–74	1975–79	1980–83	TOTAL
0–1	19,167 $178,571[a]	15,125 $158,300	23,805 $240,800	9,833 $220,300	4,700 $201,300	14,526 $199,854
1–2		19,517 $185,661	16,250 $223,500	14,583 $217,533		16,783 $208,898
2–3		11,340 $129,440	12,325 $142,066	9,824 $161,383	6,000 $144,296	9,872 $144,296
3–4			7,068 $174,220	9,347 $182,705		8,208 $178,463
4–5	14,400 $84,200		10,052 $165,225	10,898 $146,136	5,435 $84,200	10,196 $119,940
5–6				9,050 $115,957	8,100 $120,900	8,575 $118,429
6+					8,900 $70,000	8,900 $70,000
TOTAL	11,189 $87,590	11,496 $118,350	11,583 $157,635	9,076 $149,145	6,627 $124,139	9,633 $148,554

[a] 1980 median house value for census tract in which subdivision is located.

able. The slope term is zero except for data in city *t*.

None of the slope terms is significant in equation [T4] indicating that the rate of change in the impact of distance and age on density does not differ significantly among the three study areas. Equation [T5] gives the most plausible results, with all variables significant and correctly signed. The dummy terms indicate that average lot sizes are approximately 27 percent larger in Fairfax County and 73 percent larger in Montgomery County than those in Dallas.[18] The coefficient for *DLOOP* indicates that average lot sizes increase 6.8 percent per mile from the beltway. The coefficient for *AGE* suggests that densities have doubled in the last 33 years.

III. IMPLICATIONS

The regressions indicate that for cities which allow higher densities on infill parcels, discontinuous development may lead to higher densities than are likely to occur where discontinuous development is prevented. If so, then the implications have far-reaching consequences.

Public policies designed to prevent urban sprawl by reducing discontinuous development may have the unintended effect of increasing low density development. These policies may take a variety of forms which have impact on either the sequencing of development or the supply of developable land. They include zoning and land use controls, urban growth boundaries, provision of utilities, and infrastructure financing.

In many communities, large areas of undeveloped land are zoned for low density development. Where zoning and land use controls restrict land to low density development, then the flexibility required to achieve higher densities is obviously removed. Similarly, where municipalities use zoning approvals to restrict new development to parcels adjacent to existing development, discontinuous growth may be forestalled.

Urban growth boundaries are a successful tool in preventing urban incursions into

[18] Percentage changes are evaluated for a typical 8000-square-foot lot. This equates to a density of 4 units per acre when streets and alley rights-of-way are taken into account.

agricultural areas (Knapp 1985, Nelson 1986). However, if the boundaries are drawn too tightly, then the supply of developable land is reduced, causing prices to rise while reducing the opportunities for later infill development. As demonstrated previously, higher land prices will encourage higher density development unless it is prevented by zoning or other land use restrictions.

Methods of infrastructure financing directly affect the availability of urban services, especially water and sewer utilities. As a practical matter, extending utility services more than a mile or so from the end of existing lines is not economically feasible except for the largest developments. Policies that require developers to pay for these extensions have the effect of constraining development to within a one-mile radius or so of existing water and sewer lines.

Where leapfrogging is prevented, land prices at the urban fringe are higher because monopoly pricing opportunities are available to owners whose property is next in line for development. Even where leapfrogging is not prevented, the cost of extending utilities to parcels beyond the fringe may be prohibitive, effectively reducing the supply of land that is immediately developable. On the other hand, when utilities are available to fringe areas and development controls are unrestrictive, then land supply is increased and prices are more competitive (Peiser 1983).

How do local policies toward discontinuous development affect the overall level of development? If one assumes that demand for space is unaffected by urban form, then one might argue that total built space will be the same, regardless of continuous or discontinuous development. Local policies would then affect how much land area is consumed (i.e., density) to accommodate a fixed demand. The more interesting question is how do different methods of controlling sprawl affect long-run densities? The present paper only suggests that the regulatory environment makes a difference. Future research should address the questions of how much and in what way.

Caveats

While urban sprawl appears to contribute to higher densities, I have not evaluated other consequences associated with urban sprawl such as inefficient resource allocation for public facilities, increased transportation costs, and removal of agricultural land. How to reduce these negative aspects of sprawl—rather than prevent sprawl itself—should be the thrust of public policy with respect to urban fringe growth.

New residents should bear their fair share of costs associated with urban growth (Snyder and Stegman 1986). However, as long as prices reflect the full cost of growth in new areas, then attempts to interfere with a freely functioning land market may lead to higher land prices due to a restricted supply of land.

Regulatory constraints that reduce the supply of developable land cause land prices to rise and could thus contribute indirectly to higher density.[19] A policy designed to limit urban fringe growth without inhibiting higher density infill could, in fact, lead to higher overall density. However, where regulatory constraints at the urban fringe are combined with low density zoning on infill sites, the result may be doubly harmful. First, by preventing discontinuous development at the urban fringe, the supply of developable land is reduced causing higher prices on the remaining land. Second, low density zoning prevents higher density development which otherwise would help equalize the cost of reduced land supply. The net result is that prices are higher on all developable land. In particular, the least expensive lots are more costly

[19]Douglas Porter of the Urban Land Institute raised this issue as a question of causation: To the extent that regulatory constraints on developable land raise land prices, could regulation rather than the market be responsible for higher density? Is regulation thus a cause or a cure? Regulation that reduces the supply of developable land acts as a form of tax. Whether the benefits of the regulation outweigh the costs is a separate issue which may have the unintended side benefit of also raising density. However, where the regulation on supply is coupled with regulations controlling density, then the potential benefits are lost.

than they would have been without a policy to restrict sprawl because the same low density development occurs on a reduced supply of land.

The notion that clear sighted planning can solve the density problem is seductive. Given perfect foresight about future growth, planners could mandate densities that reflect the ideal long run outcome. There would be no loss of future density increases if cities required developers to build new areas at higher densities than the current market indicates. Stronger planning/regulatory environments in countries such as England, Japan and Canada give planners the authority to do so, if not the foresight. They still face the problem of how to estimate future growth, not to mention the short run loss of benefit that homebuyers incur because their homes are built on smaller lots than they would prefer.

While unconstrained land markets may lead to higher densities precisely by the process associated with sprawl, many factors may contribute to urban sprawl that do not serve the purpose of promoting higher densities. For example, municipalities may use restrictive zoning or other development restrictions to keep out higher density development, causing development to spread over a larger area without the opportunity for later higher density infill. Indeed, future demand for more intensive land use may be very small compared to the vacant pockets of land available for infill development. In that case, the negative aspects of sprawl, such as excessive investment in infrastructure and transportation, may outweigh potential benefits from lower land cost at the urban fringe coupled with higher density infill.

IV. CONCLUSION

This paper provides evidence that sprawl patterns of urban growth characterized by discontinuous development lead to higher densities in areas skipped over. This phenomenon, as shown by Ohls and Pines, Schmid, and Ottensmann, may be more efficient than policy-prescribed continuous urban development.

The case studies from Dallas and Montgomery and Fairfax Counties demonstrate how the local planning/regulatory environment affects the relationship between sprawl and density. Subdivision data from Fairfax County, which is more flexible in its rezoning and land use policies than Montgomery County, provides convincing evidence that density increases as accessibility improves. Controlling for location, density increases for infill subdivisions developed later in time. Dallas, which also has relatively pro-growth attitudes, does not show statistically significant higher densities for infill development. Nevertheless, cross sectional analysis indicates that densities do increase over time in almost every distance zone.

While sprawl may be unjustly maligned for generating low density development, the potential benefits of discontinuous growth nevertheless depend on the full-cost pricing of development. If discontinuous development is subsidized by utility companies, highway programs, or municipal contributions, sprawl patterns of development may be spread over so large an area that inefficiencies associated with sprawl would outweigh any potential benefits from higher density infill development. A delicate balance must be struck between policies which control or reduce sprawl and policies that inadvertently increase sprawl by mispricing costs of development at the urban fringe. Future research should address the normative question of how much discontinuous development is optimal and how much becomes excessive.

Much remains to be understood about urban land markets, in general, and consumption of urban fringe land, in particular. This paper has attempted to reinforce the case made by others that the impact of discontinuous urban development on density is very likely positive rather than negative. The correct answer has critical implications for urban policy.

APPENDIX

This appendix utilizes a simple valuation model (Brueggeman and Stone 1981) to demonstrate the positive impact that land value has on density. Equation [A1] represents the return to land or land rent (r) from a building of size (B), and rent per square foot or per dwelling unit (R):

$$BR - (k_b + \alpha)BP_b = r \quad \text{[A1]}$$

where P_b = development costs per square foot of improvements, k_b = return on investment, and α = premium for building depreciation, operating costs and risk. Developers also require a market return on land (k_r), so we have

$$\frac{r}{LP_L} = k_r \quad \text{[A2]}$$

where L = land area, P_L = land price per square foot and LP_L is land value. We want to find B/L, which is the ratio of building area to land area (i.e., density).

Substituting for r in equation [A1], we have

$$BR - (k_b + \alpha)BP_b = k_rLP_L. \quad \text{[A3]}$$

Rearranging, we obtain an expression for building density,

$$B/L = k_rP_L[R - (k_b + \alpha)P_b]^{-1}. \quad \text{[A4]}$$

Differentiating, we have

$$\frac{d(B/L)}{dP_L} = k_r[R - (k_b + \alpha)P_b]^{-1} > 0 \quad \text{[A5]}$$

$d(B/L)/dP_L$ is greater than zero since we know that

$$R - (k_b + \alpha)P_b > 0 \quad \text{[A6]}$$

from equation [A1]. The latter follows from the fact that $[R - (k_b + \alpha)P_b]$ must be greater than zero in order for the return on land (k_r) to be positive. Equation [A5] proves that as the price of land increases, building size (i.e., density) also increases.

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