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Urban Growth Externalities and Neighborhood Incentives

Another Cause of Urban Sprawl?

Matthias Cinyabuguma and Virginia McConnell

1616 P St. NW
Washington, DC 20036
202-328-5000 www.rff.org



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Abstract

This paper suggests a cause of low density in urban development or urban sprawl that has not been given much attention in the literature. There have been a number of arguments put forward for market failures that may account for urban sprawl, including incomplete pricing of infrastructure, environmental externalities, and unpriced congestion. The problem analyzed here is that urban growth creates benefits for an entire urban area, but the costs of growth are borne by individual neighborhoods. An externality problem arises because existing residents perceive the costs associated with the new residents locating in their neighborhoods, but not the full benefits of new entrants which accrue to the city as a whole. The result is that existing residents have an incentive to block new residents to their neighborhoods, resulting in cities that are less dense than is optimal, or too spread out. The paper models several different types of urban growth, and examines the optimal and local choice outcomes under each type. In the first model, population growth is endogenous and the physical limits of the city are fixed. The second model examines the case in which population growth in the region is given, but the city boundary is allowed to vary. We show that in both cases the city will tend to be larger and less dense than is optimal. In each, we examine the sensitivity of the model to the number of neighborhoods and to the size of infrastructure and transportation costs. Finally, we examine optimal subsidies and see how they compare to current policies such as impact fees on new development.

Key Words: externalities, urban growth, optimality, policies, taxation

JEL Classification Numbers: H23, R11, D60, R28, H2

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Urban Growth Externalities and Neighborhood Incentives: Another Cause of Urban Sprawl?

Matthias Cinyabuguma and Virginia McConnell¹

1 Introduction:

This paper addresses an important externality in urban development that has received little attention in the urban growth literature. There have been a number of arguments put forward about how market failures may contribute to urban sprawl, including incomplete pricing of infrastructure, unpriced congestion, (Brueckner, 2001, Wheaton, 1998), environmental externalities, (Wu, 2006), and property taxes (Brueckner and Kim, 2003).² The problem examined in this paper is that growth often creates benefits for an entire urban area, but the costs of that growth are born primarily by residents of the neighborhoods where new development occurs. An externality problem arises because existing residents perceive the local costs associated with admitting new residents, but not the full benefits which accrue to the city as a whole. The result is that existing residents have an incentive to block new residents to their neighborhoods, resulting in cities that are less dense or too spread out than is optimal.

The tendency of local neighborhoods to attempt to block or reduce the density of new development in their own areas is ubiquitous in cities, but it has been given scant attention in the economics literature. There is a fairly large literature addressing related issues having to do with the provision of public goods, and the use of zoning to limit development. For example, the Tiebout model (Tiebout, 1956) and many of its extensions examine neighborhood outcomes where individual preferences over public goods are heterogenous and individuals can move costlessly among neighborhoods. The focus is on equilibrium models of location choice and the optimal provision of public goods across neighborhoods. Another related literature examines the NIMBY problem: “not in my backyard”. The NIMBY issue is similar to the one we address in this paper because there is both a public good to the city as a whole and a perceived private or local bad. Analysis of NIMBY problems has tended to focus on the siting of noxious facilities (Mitchell and Carson, 1986, and Feinerman, Finkelshtain and Kan, 2004), whereas the focus in this paper is on the behavior of existing neighborhoods to allow new development and the effects on overall urban size and urban density.

In a study of development projects in the San Francisco region, Pendall (1999) finds that the reasons for opposition to new infill residential development range from concerns over increased traffic,

¹Matthias Cinyabuguma is Assistant Professor of Economics at UMBC. Virginia McConnell is a Senior Fellow at RFF and Professor of Economics at UMBC. We would like to thank K.E. McConnell, Paul Gottlieb, Arthur O’Sullivan, Marlon Boarnet, and anonymous referees for valuable comments.

²There has also been recent work that finds conditions under which aggregate sprawl might be more efficient (Anas and Rhee, 2007 and Anas and Pines, 2008).

new infrastructure requirements, and environmental concerns. Opposition to new development occurs across all income levels, not just in high income areas, and anti-growth sentiment tends to be higher in slower growing communities. Fischel (2001) argues that such opposition is a rational response to the uncertainty about the potential adverse effects of infill development – homeowners are trying to prevent the small probability of large losses in the absence of insurance against such losses.³

Local residents are often successful at blocking new development in their neighborhood. As regions develop, single family residents can become major players in local land-use decisions, along with urban planners, and developers (Fischel, 1978). Regions may have comprehensive plans for the density and location of new development, but increasingly local residents are able to block or reduce the density of that development (Downs, 2005 and Johnston, et al. 1991). Also, smaller county or city jurisdictions that are part of a larger metropolitan area may want to have less density in their boundaries than may be optimal from the larger regional perspective.

This paper sets up a model to examine the costs and benefits of new development in existing neighborhoods or jurisdictions. We assume that new residents want to move into the city, and we focus on the decision of local communities to admit them, and on where those new residents will be located – in existing neighborhoods or in the periphery of the city. Previous economic models of cities and urban growth have focused on the choices of individual agents who choose locations to maximize their own welfare (Nechyba and Walsh, 2004). We do not model the behavior of new residents, and for simplicity, we abstract from individual utility maximization choices. Instead of a general equilibrium model of the urban area that would include effects on land and housing prices, and endogenous transportation costs (e.g. Glaeser, 2005; Mills, 1972; Brueckner, 2001; Knaap et al, 1999, and Epple and Seig, 1999), we model the residents in existing neighborhoods and focus on their decisions about whether to admit new residents.⁴

Our focus is on growing urban areas where population increases are likely to create city-wide benefits. Wassmer and Boarnet (2001) summarize the benefits of population growth in urban areas, finding that ‘growth generates new jobs, income, and tax revenue, and raises property values, offering residents more choices and diversity.’ More specifically, economic historians have documented the strong positive correlation between growth and geographic agglomeration of economic activities (Quah, 2002).

³A number of studies have attempted to empirically identify the effect of what such losses or gains might be on local property values. The evidence is mixed, with some recent studies finding small positive effects, and one study of suburban infill development finding a small negative effect on surrounding single family homes. The effects tend to be larger the larger the size of the development and to decay with distance from the infill location. See McConnell and Wiley (2012) for a review of the literature.

⁴A general equilibrium modelling approach would be a useful extension to this work, and might have implications for the extent and magnitude of effects shown here. For example, if land values change in response to changes in new development, this might influence the decision to admit new residents.

Baldwin and Martin (2004) and Martin and Ottaviano (2001) present a model linking growth and agglomeration of economic activities and discuss conditions under which growth and agglomeration are mutually self-reinforcing processes. In an empirical analysis of cities in the U.S., Germany and China, Bettencourt et al (2007) find that wages and R&D expenditures are higher in larger cities, whereas Simon and Love (1990) find that for most goods, economic cost decreases rather than increases with urban growth. Based on this evidence, we concern ourselves only with growing cities, and assume population growth provides benefits to all residents, whether it is in the form of higher wages, more employment opportunities, or higher levels of amenities.

There are a range of possible assumptions that we consider using the model below. We first assume that the physical limits of the city are fixed. Population growth is endogenous, and determined by the willingness of existing residents to allow new neighbors to enter their neighborhoods. Next we take another case where population growth is given but the city boundary is allowed to vary. That is, it is possible for new residents to move into the city, either into existing neighborhoods or to the periphery. We find in both types of cities density will be lower than is optimal. We then examine how changes in certain parameters affect the results. We look at the effects of more neighborhoods, of greater infrastructure costs, and of higher transportation costs in the periphery. Finally we consider possible solutions to the externality problem, including optimal fees and the more common impact fees which are often used to pay for infrastructure costs of new development (Ihlanfeldt, and Shaughnessy, 2002). We find that there is an optimal subsidy that could induce existing residents to admit the optimal number of new residents to their neighborhoods. Our results indicate, however, that in most cases an impact fee instrument used by itself does not result in the efficient solution. But, if the impact fee and a subsidy to existing neighborhoods are jointly used then the optimal development outcome will be achieved.

2 City 1: Fixed boundary and population endogenous

We first assume a simple urban area where the urban boundaries are fixed and the population growth is endogenous. There are constant benefits, b ,⁵ to the city for each new resident admitted to any of the \bar{n} neighborhoods in the city. Further, we assume that these benefits accrue to all the existing residents of the city, for example in the form of higher wages, more services, or other amenities. However, smaller neighborhoods bear many of the costs. Neighborhoods are defined by the size of the jurisdiction which has effective control over development within its boundaries. These neighborhoods or jurisdictions

⁵This assumption of constant marginal benefits can be modified with no changes to the results below – benefits could be either diminishing with the number of residents or increasing if there are agglomeration economies.

could be small urban neighborhoods that try to exert control over external zoning regulations through neighborhood associations or just by public pressure. They will try to block development within their boundaries, or at least try to reduce its density because they perceive the costs. We might see the same behavior from larger areas such as cities or even counties that are part of metropolitan areas that may also try to reduce the amount of development, not wanting the associated costs. We refer to “neighborhoods” in the remaining sections of the paper as any of these existing areas that are considering whether to take in new development.

We assume there are infrastructure costs, \bar{c} , associated with each new resident who locates in an existing neighborhood. These costs can include utilities such as sewer lines, and road extensions, or other services such as schools and fire or police protection. In addition, new residents impose costs on the existing residents in any given neighborhood, in the form of congestion costs and other perceived costs that affect the quality of life in the neighborhood. The cost c_i to each neighborhood i is increasing in the number of new people admitted, k_i . We assume this congestion function is increasing at an increasing rate with the number of new residents admitted. When there are \bar{n} total neighborhoods, we assume that the congestion costs to each of the existing neighborhoods of allowing more residents to enter is:

$$c_i = c(k_i, \bar{n}), \tag{2.0.1}$$

where we assume that $\partial c_i / \partial k_i > 0$, $\partial^2 c_i / \partial k_i^2 > 0$, and $\partial c_i / \partial k_i \equiv c'(k_i, \bar{n})$.⁶

2.1 City 1: The planner’s outcome

Assume the planning authority can costlessly determine the optimal number of new residents that maximize net benefits to the city with a given number of neighborhoods \bar{n} . The planner would admit new residents, k , so that total benefits net of total costs to the city are maximized. The total benefits are the constant marginal benefit per person, b , times the number of new residents ($\beta = b \sum_i^{\bar{n}} k_i$). Total costs, C , are the summation of the costs across all of the neighborhoods where residents are admitted, including the congestion costs and infrastructure costs for all k new residents. The problem is to choose the number of new residents to be located in each neighborhood, k_i , that maximizes the total net benefits to existing neighborhoods, that is

$$Max_{k_i} (\beta - C) = b \sum_i^{\bar{n}} k_i - \left(\sum_i^{\bar{n}} (c(k_i, \bar{n}) + \bar{c}k_i) \right). \tag{2.1.1}$$

⁶The cost of new development is likely quite uncertain in most neighborhoods – will there be more traffic, would higher density bring more crime, will property values fall? etc. We have simplified the cost function in our model here, but it is likely that uncertainty and risk aversion would result in incentives to block new development that are even greater than those we see here.

In each neighborhood, the optimal number of residents, k_i^* , is defined by an implicit equation obtained from the first order conditions:

$$\frac{\partial(\beta - C)}{\partial k_i} \equiv H(k_i^*; \bar{c}, \bar{n}, b) = b - c'(k_i^*, \bar{n}) - \bar{c} = 0, \quad i = 1, \dots, \bar{n}, \quad (2.1.2)$$

or where the marginal benefit of one more new resident to the city equals the marginal cost in each of the \bar{n} neighborhoods, that is

$$b = c'(k_i^*, \bar{n}) + \bar{c}, \quad i = 1, \dots, \bar{n}. \quad (2.1.3)$$

In each neighborhood there will be k_i^* new residents, and the total new population in the city will be $\sum_i^{\bar{n}} k_i^*$.

2.2 City 1: Outcome with neighborhood choice

When local jurisdictions are able to determine the number of allowed new residents, whether it is county level government or local neighborhood associations, the outcome is likely to be different from the optimum. This is because of the externality problem discussed above. Although there is a benefit to all of those in the city when each neighborhood admits another resident, the existing residents of that neighborhood are not likely to perceive the full benefit.⁷ It is difficult to know how the existing residents might perceive their potential benefits; in fact they may have no understanding about the benefits of growth or believe that some other neighborhood would take newcomers, in which case they will block new development in their own neighborhood completely. Here, we take one simple but representative case with \bar{n} neighborhoods in the city, and where a single neighborhood believes that it will receive a proportional share of the benefits of admitting another resident, or b/\bar{n} .

We assume that the infrastructure costs, \bar{c} , for each new resident coming into a neighborhood are born by all residents of that neighborhood, for example in the form of higher taxes.⁸ The problem faced by each neighborhood is then to maximize neighborhood's total benefits ($\beta_i \equiv \left(\frac{b}{\bar{n}}\right) k_i$) net of total cost ($C_i \equiv c(k_i, \bar{n}) + \bar{c}k_i$), or:⁹

$$\text{Max}_{k_i} (\beta_i - C_i) = \left(\frac{b}{\bar{n}}\right) k_i - c(k_i, \bar{n}) - \bar{c}k_i, \quad (2.2.1)$$

where,

$$\frac{\partial(\beta_i - C_i)}{\partial k_i} \equiv G(k_i; b, \bar{n}, \bar{c}) = (b/\bar{n}) - c'(k_i, \bar{n}) - \bar{c} = 0, \quad i = 1, \dots, \bar{n}. \quad (2.2.2)$$

⁷An alternative way of modelling the neighborhood choices is through a game theoretic approach, which could be useful if one is interested in strategic interactions between neighborhoods about admitting new residents. We do account for interactions between neighborhoods in City 2 models.

⁸We will explore various policy options later in the paper.

⁹The approach we use here examines each neighborhood's choices as independent of other neighborhoods. We consider more interaction between neighborhoods in City 2 below.

or equivalently,

$$b/\bar{n} = c'(k_i, \bar{n}) + \bar{c}, \quad i = 1, \dots, \bar{n}. \quad (2.2.3)$$

That is, each neighborhood will admit residents up to the point where the value to the neighborhood, b/\bar{n} , is just equal to the marginal cost to the existing neighborhood residents, including new infrastructure costs and congestion costs, $c'(k_i, \bar{n}) + \bar{c}$.

Comparing the outcomes under the planner's optimum above and this neighborhood choice case, we find that the city admits fewer new residents when the decision is under neighborhood control, since $b > b/\bar{n}$. In this case, the city will have smaller population and development will be less dense than under the optimum case.

2.2.1 The effects of changes in the number of neighborhoods

We examine what happens to the number of new residents admitted as the number of neighborhoods changes, comparing the social optimum to the outcome under neighborhood choice. We assume that the congestion function is increasing with the number of neighborhoods, that is

$$\frac{\partial c_i}{\partial \bar{n}} > 0, \quad \frac{\partial^2 c_i}{\partial \bar{n}^2} > 0. \quad (2.2.4)$$

This is because in a city of a given physical size, as the number of neighborhoods or jurisdictions goes up, the spatial size of each neighborhood decreases. Therefore, for a given number of new incoming residents, the congestion effects of those residents will be greater the smaller the size of the neighborhoods they are entering.¹⁰ With greater number of neighborhoods, \bar{n} , we find that in both the planner's case and the neighborhood choice case, the number of residents admitted to each neighborhood, k_i , decreases as the number of neighborhoods increases, as in Figure 1.¹¹

But we are interested in the relative effects of increasing \bar{n} on the two outcomes. As \bar{n} increases the difference between the planner's outcome and the local choice is:

$$\frac{\partial}{\partial \bar{n}} \left(\frac{-b}{\bar{n}^2 c''_{k_i}(k_i, \bar{n})} \right) = \frac{b \left(2\bar{n} c''_{k_i}(k_i, \bar{n}) + \bar{n}^2 \frac{\partial (c''_{k_i}(k_i, \bar{n}))}{\partial \bar{n}} \right)}{\left(\bar{n}^2 c''_{k_i}(k_i, \bar{n}) \right)^2} > 0.$$

¹⁰We are assuming that the costs are increasing with the ratio of new residents to existing residents. There are different possible costs that the new residents might impose on the local community. We have focused on one of the most prevalent – congestion costs.

¹¹To see the effect of increasing \bar{n} on the outcome when there is neighborhood choice, we take the derivative of the first order condition, equation 2.2.2, with respect to the number of neighborhoods, \bar{n} , we find that the number of residents admitted to each neighborhood, k_i , decreases. Similarly, to see the effect of increasing \bar{n} on the outcome when there is a planner choice, we take the derivative of the first order condition of the social planner problem with respect to the number of neighborhood, \bar{n} , and we also find that k_i decreases.

Therefore as \bar{n} increases the additional population admitted to each neighborhood will be smaller under the neighborhood outcome than under the planner outcome. This suggests the population under the neighborhood outcome will be even smaller relative to the optimum when the number of neighborhoods increases. We show this result in Figure 1.

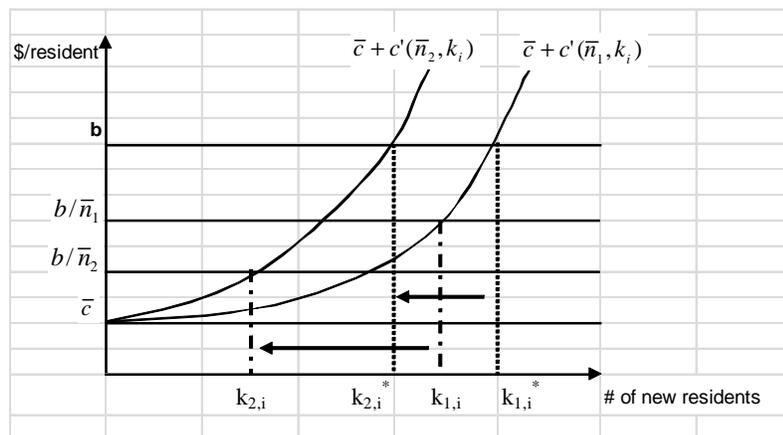


Figure 1: City 1: Cost and benefit for neighborhood i of admitting new residents when the # of neighborhoods changes.

For each neighborhood i , the optimal number of residents to admit with the initial number of neighborhoods \bar{n}_1 is shown as $k_{1,i}^*$, and with the larger number of neighborhoods \bar{n}_2 , it is shown as $k_{2,i}^*$. Likewise, for the case of neighborhood choice, the number of residents admitted will be $k_{1,i}$ when the number of neighborhoods is \bar{n}_1 , and $k_{2,i}$ when there are more neighborhoods. It is clear that as the number of neighborhoods increases, the cost function shifts from $c(\bar{n}_1)$ to $c(\bar{n}_2)$, and there is a greater decrease in the admitted population when local neighborhoods can choose.

Thus, given the type of congestion cost function we have specified here for incoming residents, cities where small local areas have control over the amount of development allowed within their boundaries are likely to be less dense and more spread out than is optimal. In contrast, cities with just a small number of larger neighborhoods will be more likely to be closer to optimal population size. In the extreme, one jurisdiction that has control over growth in the entire city will have the incentive to allow the optimal amount of population growth.

2.2.2 The effects of changes in the infrastructure costs

We next examine how the number of residents admitted in each neighborhood changes when there are higher infrastructure costs for new residents. In both the planner's and neighborhood choice cases, the number of new residents will be lower as infrastructure costs go up.¹² However, the outcome when

¹²The partial changes in the numbers of new residents (equations 2.1.2 and 2.2.2) with respect to the cost of infrastructure for both the planner case and the neighborhood choice case are negative and, respectively, given by $-1/c''(k_i)$ and $-k_i/c''(k_i)$.

there is local control is that the number of new residents will fall by more than under the case where the planner is making decisions. We can see this in Figure 2 below. The initial optimum number of new residents admitted under the planner's solution is $k_{3,i}^*$, while in the neighborhood choice case, the solution is $k_{3,i}$. When infrastructure costs increase from \bar{c}_1 to \bar{c}_2 , the optimal number admitted falls to $k_{4,i}^*$, and to $k_{4,i}$ for the neighborhood choice. The reduction is greater under neighborhood choice conditions. Again, as infrastructure costs go up, the neighborhood outcome deviates relatively more from the optimal level.

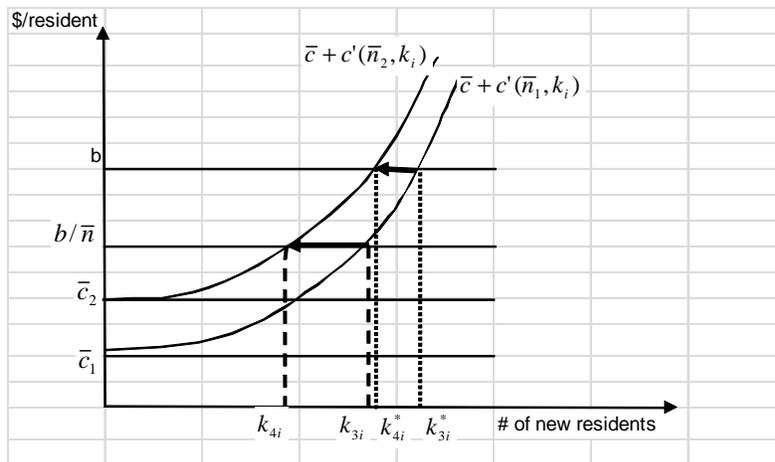


Figure 2: City 1: Costs and benefits of admitting new residents as infrastructure costs increase

We can summarize the results for city 1. Under the planner's solution, the city is more densely developed with greater population than if control over growth is influenced by local neighborhoods. The extent to which this is true depends on how existing residents see the benefits of admitting new residents to their own neighborhoods. The larger the number of neighborhoods, or the smaller is each area that has control over land use, the more the optimal outcome will be different from the neighborhood choice model. And, the higher the infrastructure costs, the fewer new residents are admitted in both planner and neighborhood control.

3 City 2: Fixed population growth and boundary variable

An alternative way to model a growing city is to assume there is an exogenous increase in population, and if in-coming residents are not located in the existing neighborhoods, they can be located at the periphery. In this case the growth in population is given, and we examine the differences between densities and physical city size in the optimal and neighborhoods outcomes. Therefore, we must consider the costs to locating new residents at the outer edge of the city. We assume these include the costs of a new system of infrastructure, such as sewers and roads. There is mixed evidence about

whether the cost of infrastructure is higher in outlying regions of urban areas. Much of the planning literature has argued that the costs of infrastructure for new development are higher for urban areas that grow with more dispersed density patterns (Brueckner, 1997, and RERC, 1998). There is some evidence from economics, however, that the issue is more nuanced. Ladd (1992) and Frank (1989) find that in some cases, infrastructure costs for new residents in existing urban areas can be higher than for outlying areas. Given the mixed evidence, we use the simple assumption that infrastructure costs for adding new residents to the city will be the same, whether they are located in the existing neighborhoods of the city, or in the outlying areas. However, there is an important way costs are likely to be different for new residents locating in the periphery, and that is they must pay higher transportation costs because of the more distant location. As a result they would prefer to live in the existing neighborhoods where we assume they do not have to pay transportation costs.

Again we compare the planner's and the neighborhood's outcomes as regards the decision to admit new residents. The social planner will allocate residents to maximize the benefits of new residents to the entire city. In the case where there is neighborhood choice, new residents can choose where to locate, but existing neighborhoods are allowed to choose the number of new residents they will accept. First, we assume that the existing neighborhoods know that the new neighbors are going to locate somewhere, and that they will benefit from the population growth in the city no matter where the growth occurs (*City 2A*). Then, we assume that existing neighborhoods might be uncertain whether new residents will be allowed to locate in some part of the city; or they may feel that they have some obligation to admit some new residents to their neighborhoods (*City 2B*). We choose these two scenarios to show the range of possible outcomes.

3.1 City 2: The planner's outcome.

The planner knows the growth in population, and the question becomes where to locate the residents: in the existing neighborhoods or in the peripheral areas. We assume that the costs of locating a new resident in the periphery is the fixed infrastructure cost, \bar{c} , and the transportation costs, \bar{c}^T .

The problem faced by the planner is to choose k_i^{e*} to be admitted in each existing neighborhood i , $i = 1, \dots, n$, and k^{p*} to be admitted in the periphery in order to maximize total net benefits to the city. Because the new population to be admitted is given, and the new residents can go somewhere, solving the maximization problem in this case is equivalent to minimizing the total costs of allowing the \bar{k} new residents into the urban area, allocating them to existing neighborhoods and the periphery. Therefore, the planner will minimize the costs of admitting new residents into the existing neighborhoods, by

choosing k_i^{e*} which minimizes the following equation:

$$\text{Min}_{k_i^e} \left(\sum_i^{\bar{n}} (c(k_i^e, \bar{n}) + \bar{c}k_i^e) \right) + (\bar{c} + \bar{c}^T) \left(\bar{k} - \sum_i^{\bar{n}} k_i^e \right)$$

Given the fact that $\bar{k} = k^p + \sum_i^{\bar{n}} k_i^e$, the planner will choose the number of new residents, k_i^{e*} , in each existing neighborhood according to the following first order conditions:

$$V(k_i^{e*}, \bar{c}, \bar{c}^T, \bar{n}) \equiv c'(k_i^{e*}, \bar{n}) + \bar{c} - (\bar{c} + \bar{c}^T) = 0, \quad i = 1, \dots, \bar{n}. \quad (3.1.1)$$

At equilibrium, the planner will locate new residents in each existing neighborhood up to the point where the fixed cost of a resident in the periphery, $(\bar{c} + \bar{c}^T)$, is equated to the marginal cost of locating an additional resident in an existing neighborhood i , $c'(k_i^{e*}, \bar{n}) + \bar{c}$. We show this result in Figure 3 below. We designate the optimal number of new residents in each existing neighborhood as k_i^{e*} and the optimal number of new residents at the periphery as $\bar{k} - k_i^{e*}$, or k^{p*} . Given that total population growth is known, we define the maximum surplus to the city from growth as $b\bar{k} = b \left(k^{p*} + \sum_i^{\bar{n}} k_i^{e*} \right)$.

3.2 City 2: Outcome with neighborhood choice

We now look at the neighborhood choice outcome for City 2 when there is a fixed population growth but the boundary of the city can vary. New residents can be admitted to existing neighborhoods by city residents, or they are able to move into the peripheral areas. As described above, we take two possible ways the existing residents perceive the effects of the new residents to the city: City 2A and City 2B. In City 2A: existing neighborhoods know new residents will go somewhere in the city or in the periphery and yield to the city a benefit of b per person admitted regardless of where they locate. In City 2B: existing neighborhoods think they will get some benefit from new residents, which we assume is b/\bar{n} for each new resident admitted. We assume that new residents who locate in the periphery must pay their own infrastructure costs and that existing neighborhoods pay all infrastructure costs for each new resident they admit in. In the next section we explore the use of impact fees, which require new residents to pay for all of their own infrastructure costs.

Under City 2A, because existing residents are aware that they will benefit without having to admit any new residents to their own neighborhood, they will block the new-comers completely. All new residents will be located in the periphery, that is, $k_i^e = 0$, $i = 1, \dots, \bar{n}$, and $k^p = \bar{k}$. Consequently, the city physical size will be larger with a lower density than was the case under the social planner.

Under City 2B, however, we assume that existing residents perceive some benefits from admitting new residents, b/\bar{n} . Hence, the maximization problem is similar to that of the neighborhood-controlled

choice in City 1 (see equations 2.2.1–2.2.3). The solution for the existing neighborhoods for City 2B is

$$k_i^e : \frac{b}{\bar{n}} = c'(k_i^e, \bar{n}) + \bar{c}. \quad (3.2.1)$$

Recall from above, equation (3.1.1), that the optimal solution is given by

$$k_i^{e*} : c'(k_i^{e*}, \bar{n}) = \bar{c}^T. \quad (3.2.2)$$

Therefore, if $\frac{b}{\bar{n}} - \bar{c} < \bar{c}^T$, or the perceived benefit of another resident net of the infrastructure costs are less than the transportation costs, more new residents will be admitted under the optimal case than under neighborhood choice.¹³ If the number of neighborhoods, \bar{n} , is relatively large or if the transportation costs, \bar{c}^T , are high, then this is likely to be true. (See Figure 3: the number admitted to existing neighborhoods is higher in the planner's case). The opposite result is possible, however. If $b/\bar{n} - \bar{c}$ is greater than \bar{c}^T , the planner outcome will be a more dispersed city than the city under neighborhood choice.

We now examine the effects of changes in some of the key assumptions for City 2B. These include 1) higher transportation costs; 2) a larger number of neighborhoods; and 3) higher infrastructure costs for new residents.

3.2.1 The effects of changes in transportation costs

If transportation costs are higher for new residents who must locate in the periphery, then under the social planner outcome each existing neighborhood will take more new residents.¹⁴ This is because overall costs will be minimized when more residents are located in the existing city. Fewer new residents will locate in the periphery and the city will be more densely developed and less spread out.

Under either of the neighborhood cases described above, the number of new residents admitted into existing neighborhoods will be unchanged when transportation costs go up. In the case where existing neighborhoods do not take any new residents (City 2A), clearly transportation cost changes will not matter. In the case where existing neighborhoods admit residents because they believe their benefits will be b/\bar{n} (City 2B), then transportation cost changes to new residents in the periphery also do not matter in their decisions, because we assume these costs are paid by the incoming residents.

However, under the optimal case, higher transportation costs will tend to make the optimal city small and more dense. Overall, the higher are the transportation costs from the periphery, the greater

¹³Note that if the perceived benefits of a new resident to existing neighborhood, $\frac{b}{\bar{n}}$, is less than \bar{c} , the infrastructure costs, then no new residents will be admitted.

¹⁴From the social planner optimum, equation (3.1.1), we obtain that the partial derivatives of k_i^{e*} with respect \bar{c}^T is positive and equals $1/c''_{kk}(k_i^{e*}, \bar{n})$. Hence, if transportation costs increase, more new residents will be admitted to each existing neighborhood, and fewer new residents will locate in the periphery.

will be the difference between the social optimum and the market outcome.

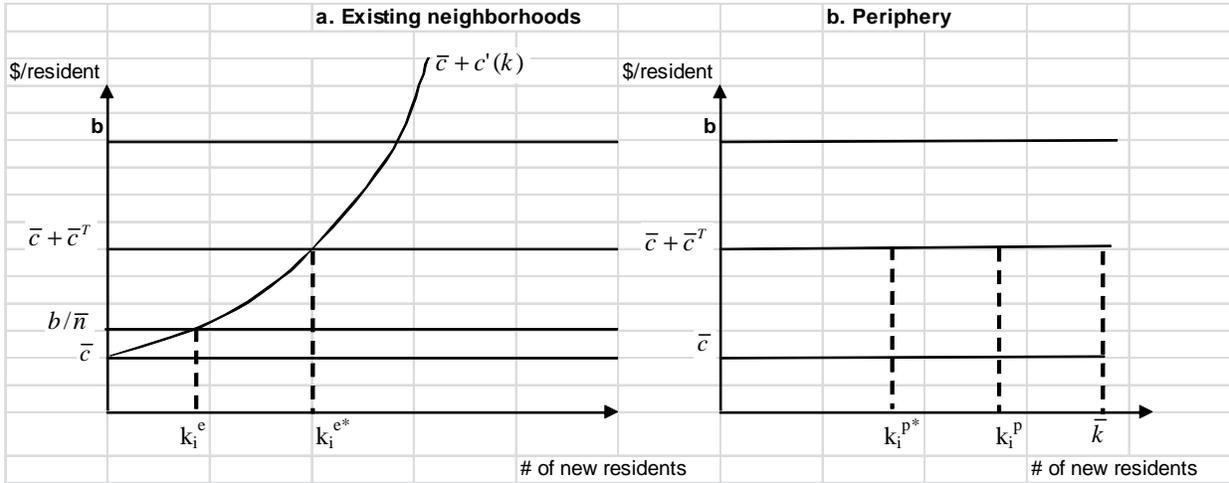


Figure 3. City 2B: Optimal & neighborhood outcomes in existing neighborhoods and periphery

3.2.2 The effects of changes in the number of neighborhoods

We next examine changes in the number of neighborhoods. As in our analysis of City 1 above, we assume that when there are more neighborhoods, (\bar{n} is larger), then each neighborhood is smaller in size. Therefore, the congestion costs of admitting any given number of new residents will be greater (see equation 2.2.4). For the planner case, we find the partial derivative of k_i^{*e} with respect to \bar{n} to be negative and given by $\partial k_i^{*e} / \partial \bar{n} = -c''_{k\bar{n}}(k_i^{*e}, \bar{n}) / c''_{kk}(k_i^{*e}, \bar{n})$. When there are a greater number of neighborhoods in the existing city, then the number of new residents admitted to each neighborhood will decrease.

For the neighborhood case we examine the outcomes associated with City 2A and City 2B. Under City 2A, where existing residents block new residents completely, the effect on city size of more neighborhoods makes no difference. A greater number of neighborhoods would actually make the optimal configuration of the city more similar to the neighborhood outcome, but the optimal city is still more compact than that which would result from complete blocking. Under City 2B, however, existing residents see the benefit of new residents as b/\bar{n} . Given that the neighborhood choice equilibrium is $k_i^e : b/\bar{n} = c'(k_i^e, \bar{n}) + \bar{c}$, and taking the derivative of the above equation with respect to \bar{n} , we find that $\partial k_i^e / \partial \bar{n} = -(b/\bar{n}^2 + c''_{k\bar{n}}(k_i^e, \bar{n})) / c''_{kk}(k_i^e, \bar{n})$. Comparing this result to the outcome for the social planner above, we find that though both are negative, the effect under neighborhood choice is larger in magnitude than the effect under the planner's case. Therefore, as \bar{n} gets larger, the decline in the number of new residents admitted under neighborhood choice will be larger than under the planner's case, or the neighborhood outcome is relatively more sprawling compared to the optimal configuration.

3.2.3 The effects of changes in the infrastructure costs

Finally, we compare the optimal and neighborhood choice outcomes for the city when infrastructure costs are higher. There would be no change on the city outcome for the planner from a change in infrastructure costs. This is because the population increase is given, and the infrastructure costs in our model are the same for new residents in the existing neighborhoods and in the periphery. For example, in City 2A in which existing residents block new residents completely, there would also be no change if infrastructure costs go up. In City 2B, however, there will be an effect of higher infrastructure costs. From equation 3.2.1, $Q(k_i^e, \bar{c}, \bar{n}) \equiv b/\bar{n} - c'(k_i^e, \bar{n}) - \bar{c} = 0$, $\forall i = 0, \dots, \bar{n}$, and taking its derivative with respect to \bar{c} , we find that $\partial k_i^e / \partial \bar{c} = -1/c''_{kk}(k_i^e, \bar{n})$. If infrastructure costs are higher, the number of residents admitted to the existing neighborhoods will be lower. Therefore, the difference between the optimal city size and city size under neighborhood choice will be even greater. The resulting city will be less dense and more spread out relative to the social planner's optimum.

We can summarize the results of the City 2 models. We find that when existing neighborhoods can limit entry, their perception of the benefits new residents bring may influence how spread out the city will be compared to the optimum case. When residents block completely, as in City 2A, the optimal outcome is always more dense and less spread out. Even when existing residents perceive some benefit from new residents, as in City 2B, the same result will hold. And, as in City 1, we find that the larger the number of neighborhoods and the higher the infrastructure costs, the more spread out the city will be relative to the optimum.

Next, we turn to various policy options for improving the neighborhood outcomes in both types of cities.

4 Policies

4.1 The optimal subsidy

We evaluate several policy instruments to deal with the externality created by decentralized neighborhood choices. Policies must provide incentives for existing residents to account for the full benefits to the entire city of admitting new residents. First, we evaluate a subsidy to existing residents, and then we examine a policy of impact fees on incoming residents.

4.1.1 City 1: Fixed boundary and population endogenous

We first examine optimal subsidies that would make the outcome of city population and density under neighborhood choice the same as the social optimum. The decision-maker or central authority will give a

subsidy, τ , to each of the \bar{n} neighborhoods for each new resident it admits.¹⁵ The maximization problem for each neighborhood is then to choose the number of new residents to admit, k_i , that maximizes the net benefit to the neighborhood, *i.e.*, $(\frac{b}{\bar{n}}) k_i - (c(k_i, \bar{n}) - \tau k_i) - \bar{c}k_i$. The first order condition for an optimum with the subsidy is, therefore, given by

$$\frac{b}{\bar{n}} + \tau - c'(k_i^*, \bar{n}) - \bar{c} = 0 \quad (4.1.1)$$

Using equation (2.1.2) and (4.1.1), we solve for the optimal level of compensation, τ^* , needed for the neighborhood outcome to coincide with the optimal one, namely:

$$\tau^* = b - \frac{b}{\bar{n}}.$$

We show the magnitude of this subsidy in Figure 4 as the difference between b and b/\bar{n} . The optimal number of new residents is k_i^* in each neighborhood, while in the neighborhood outcome the number of new residents is k_i . The per new resident subsidy of $(b - (b/\bar{n}))$ will induce the neighborhood to accept the optimal number of new residents. The net savings to the neighborhood is shown as the shaded area.

There are several interesting implications of the optimal subsidy in City 1. First, if there is only one neighborhood, then optimal decisions get made for the whole city, and there is no need for a subsidy. Second, the larger the number of neighborhoods, the larger the optimal subsidy, τ , must be. If there are a large number of jurisdictions able to make their own decisions about development density, then the neighborhood outcome is likely to be farther from the optimum, and any subsidy will have to be larger.

City 2: Fixed population growth and boundary variable

4.1.2 Optimal subsidy under City 2A

For City 2A, when existing residents know that there are new residents coming into the city somewhere, they may choose to block new development, and all of the new residents \bar{k} would have to locate in the periphery. However, at the optimum there will be k_i^{e*} new residents admitted to each neighborhood,

¹⁵Revenues to pay the subsidy could be raised by a city-wide tax on income accruing to all residents of the city as a result of urban growth.

with $k^{p*} = \bar{k} - \sum k_i^{e*}$ located in the periphery.

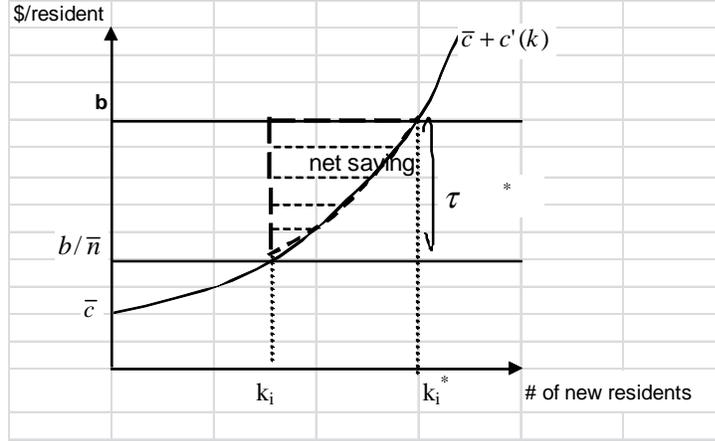


Figure 4. City 1: Neighborhood choice outcome & optimal subsidy

Therefore, the optimal subsidy for that would induce the existing neighborhoods to admit the optimal number is $\tau^* = \bar{c}^T + \bar{c}$ for each new resident admitted. We show the optimal and neighborhood outcomes in Figure 5, and the optimal subsidy τ^* . Under τ^* , the net savings to each existing neighborhood is given by area A_i , or a total city-wide net savings = $\sum_i^{\bar{n}} A_i$.

4.1.3 Optimal subsidy under City 2B

In the planner case the optimal solution is characterized by the first order condition given by equation (3.1.1), i.e., $c'(k_i^{e*}, \bar{n}) + \bar{c} - (\bar{c} + \bar{c}^T) = 0$, $i = 1, \dots, \bar{n}$, or $c'(k_i^{e*}, \bar{n}) = \bar{c}^T$, $i = 1, \dots, \bar{n}$. Under City 2B, we assume that existing residents perceive neighborhood benefits for admitting each new resident as b/\bar{n} . Using equations (3.1.1 & 3.2.1) the optimal subsidy that would induce each existing neighborhood to take in the optimal number of incoming residents is $\tau^* = (\bar{c} - \frac{b}{\bar{n}}) + \bar{c}^T$; where \bar{c}^T is the additional cost of admitting a new resident to the city at the periphery, and $\bar{c} - \frac{b}{\bar{n}}$ is the additional cost a new resident imposes on existing neighborhoods. Hence, this subsidy suggests that the neighborhoods must be compensated at least as much as the costs they bear per new resident, and enough to offset the higher costs associated with transportation if new residents must go to the periphery. However, it can be seen that that τ^* will be a subsidy when $\bar{c}^T + \bar{c} > \frac{b}{\bar{n}}$, and a tax otherwise (see Figure 5 below). If the perceived benefit is less than the opportunity costs of admitting a new resident, then the neighborhood should be subsidized up to τ^* for each new resident admitted into the neighborhood. The net savings

for the neighborhood is given in Figures 5 and 6 below as A_i for City 2A and City 2B, respectively.

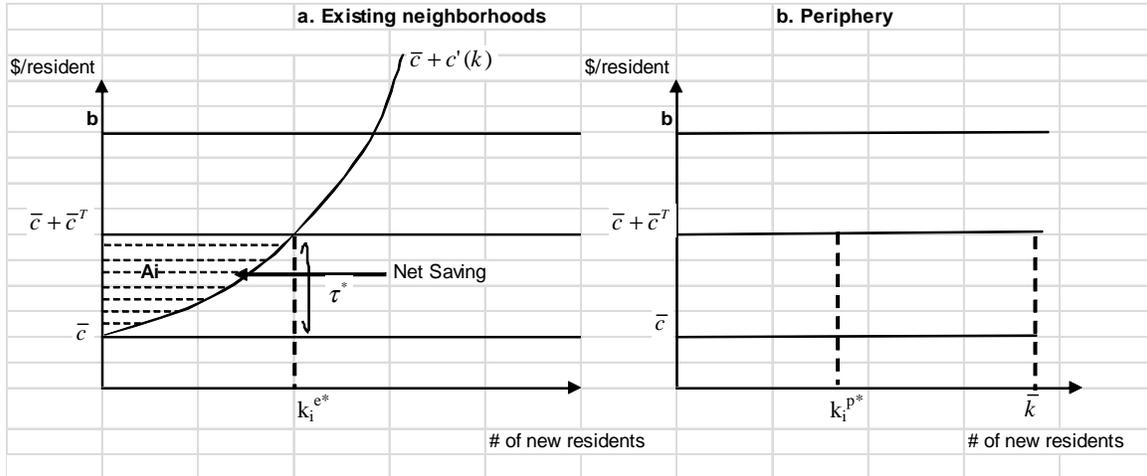


Figure 5. City 2A: Optimum subsidy

It is likely that perceived benefits will be low, and may approach zero if existing residents are aware that subsidies will be paid for incoming residents. In fact, with a subsidy, the outcome under City 2B is likely to approach that of City 2A. If local residents realize they will be compensated for admitting new residents, they would be unlikely to admit any without such compensation.¹⁶

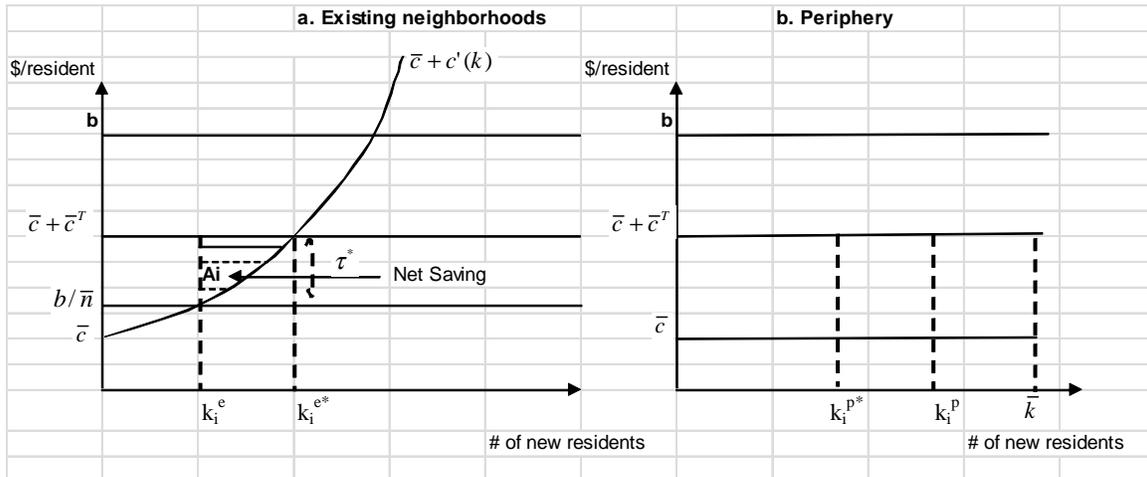


Figure 6. City 2B: Optimum subsidy

4.2 Impact Fees

An alternative to subsidies is the policy of requiring incoming residents to pay for their own cost of infrastructure, a tax often referred to as an “impact fee”. Local jurisdictions often impose these types of fees on developers of new housing. We examine how the policy of using impact fees compares to the optimal subsidy for both City 1 and City 2.

¹⁶An alternative to a subsidy would be a tax bill that would be a decreasing function of the number of people each neighborhood admits. For instance, if the tax bill levied on each existing neighborhood is $T = \gamma - \tau k_i$, then there would be an optimal tax rate reduction for each new resident admitted.

4.2.1 City 1: Impact fees

If new residents must pay for their own infrastructure costs, existing neighborhoods will perceive the costs of a new household as just the congestion costs they impose, $c(k_i, \bar{n})$. Each neighborhood would then admit new residents to maximize net benefits to the neighborhood. Assuming, as we did above for City 1, that existing neighborhoods perceive the benefits as $\frac{b}{\bar{n}}$, then they will admit new residents as long as the costs are less than or equal to the perceived benefit, or:

$$b/\bar{n} = c'(k_i, \bar{n}) \quad (4.2.1)$$

Alternatively, if the perceived benefit is zero, no new residents will be admitted.

It is important to ask whether the effects of impact fees are likely to be equivalent to those of the optimal subsidy referred to above. Or, put differently, under what conditions is the optimal subsidy which would induce the planner's solution (2.1.2) larger than a simple impact fee? The impact fee will be too small compared to the optimal subsidy if the following condition holds:

$$\bar{c} \leq b - \frac{b}{\bar{n}}. \quad (4.2.2)$$

If the number of neighborhoods, \bar{n} , is large, or if the benefit to the whole city, b , of admitting another resident is large relative to the infrastructure cost of that resident, \bar{c} , then this condition will hold and the city under the optimal outcome will have larger population size and will be more dense than under local control, even when new residents pay their own infrastructure costs. However, for all \bar{n} , if \bar{c} is greater than b (b is very small) then the condition in equation (4.2.2) is violated, and existing neighborhoods could actually admit more new residents than is optimal. For example, if infrastructure costs, \bar{c} , are greater than b , then the planner would not admit any new residents, but individual neighborhoods might if they perceived some benefit.¹⁷

To summarize, for City 1, impact fees would result in existing neighborhoods taking in more new residents, but it is unlikely that these fees will be high enough to induce them to take in the optimal number of new residents especially in growing cities where b is very large. Impact fees will, in most cases, be too small compared to what is needed for an optimal subsidy, and the city will be less dense and have lower population than is optimal. Existing neighborhoods will have to be subsidized more than the amount of the infrastructure costs to take in new residents, especially when the number of neighborhoods is large, and/or the benefits of admitting new residents are relatively large.¹⁸

¹⁷The condition in equation 4.2.2 could also be violated if the number of neighborhoods, \bar{n} , is small and b does not exceed \bar{c} by much.

¹⁸Given condition (4.2.2), the combined impact-fee-subsidy instrument would require that a subsidy of $t^* = (b - \bar{c} - \frac{b}{\bar{n}})$ be jointly used with impact fee for condition (4.2.2) to hold with equality, that is for the optimum to be achieved.

4.2.2 City 2: Impact fees

We find a similar outcome with impact fees in City 2. In City 2, because population growth is given, the issue is to determine how many households will locate in existing neighborhoods and how many will locate in the periphery. Assuming that existing neighborhood pay for the infrastructure costs, the optimal subsidy to offer existing residents to admit new residents reduces, respectively, to $\bar{c}^T + \bar{c}$ and $(\bar{c} - \frac{b}{n}) + \bar{c}^T$ for City 2A and 2B as derived above. However, if incoming households pay their own infrastructure costs as they would under an impact fee, this would not be enough of a subsidy compared to the optimum. In each case where impact fees are used the city will be too spread out, and less dense than the optimal case. In reality most impact fees charged for new development are not high enough to cover even the cost of infrastructure for that new development. Hence, these results suggest that not only full impact fees should be paid, but in addition a subsidy should be paid for each new resident existing areas take in. In this stylized model, the additional subsidy needed to achieve optimal density is equivalent to the higher costs of transportation that the new residents must pay minus the benefit, i.e., (\bar{c}^T) for city 2A and $(\bar{c}^T - b/n)$ for city 2B.

5 Conclusion

There are many market failures that contribute to urban sprawl, but the one we have addressed here is important as cities and metropolitan areas consider ways to achieve greater density and reduce what they may perceive as the negative consequence of urban sprawl. The problem of existing residents objecting to and attempting to block new development is always cited as one of the biggest, if not the biggest obstacle to higher density development in urban areas. We have shown that because of a particular externality, the city will be less dense and more sprawling than is optimal in almost all of the cases we examined. And, the problem is worse when the number of jurisdictions that can exert control over land use is greater, and when infrastructure and transportation costs are higher.

We have simplified the analysis of growth in the urban area by using an equilibrium model that illustrates the essential elements of the problem. There are interesting ways to extend this analysis. We have assumed that incoming residents are completely passive and want to come into the city, just as earlier studies of urban areas have modeled the choices of the incoming residents and assumed the existing residents as passive. An analysis that includes the behavior of both groups is important in future work. A general equilibrium model analysis would be a useful approach, and would allow for the exploration of feedbacks among important variables in the model. For example, if a land market is fully modeled, then the value of housing to existing residents will change with growth, and will

affect their willingness to admit new residents, and therefore the density and size of the city. Incoming resident would also be influenced by land and housing prices. The effects of agglomeration could be also modelled.

We have considered several policy instruments to deal with the externality created by decentralized neighborhood choices. We have shown that either a subsidy or a decreasing tax on existing residents to induce them to accept new residents will result in higher net welfare for all of the neighborhoods, and for the city as a whole. We also find that impact fees, which are fees to pay for infrastructure for new development are unlikely to be high enough to induce existing neighborhoods to accept efficient numbers of new residents. Subsidies over and above impact fees for adding new residents may result in improvements of overall welfare in growing cities. There are additional policies that could be explored in future work on this difficult issue. For example, it is possible that the provision of better information about the effects of new development could influence the willingness of neighborhoods to block new development. Alternatively, there might be conditions under which neighborhoods could be required to accept a certain amount of new development.

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