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

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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 infrstructure, 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 sprawling. 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.

Keywords: Externalities, Urban Growth, Optimality, Policies, Taxation.
JEL classification Numbers: H23, R11, D60, R28, H2

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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). The problem examined in this paper is that for growing urban areas, growth creates benefits for an entire urban area, but the costs of that growth are often borne primarily by residents of the neighborhoods where the growth 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 zoning. The Tiebout model and many of its extensions examine neighborhood outcomes where individual preferences over public goods are heterogenous and individuals can move costlessly among neighborhoods. Households will sort into homogenous neighborhoods and there is some analysis of conditions under which neighborhoods would be likely to block potential new residents having to do with optimal public goods provision (Tiebout, 1959, Fischel, 1987). However, actions on the part of residents in existing neighborhoods to try to block new development or, at a minimum, reduce the density of any new development within their own borders is so prevalent, cutting across income levels and neighborhood locations (urban and suburban) within cities, that it begs more analysis. Opposition to new development in existing areas has elements of a NIMBY problem: 'not in my backyard,' because there is both a public good to the city as a whole and a 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)). The focus here is a new development in exiting urban areas and the effect on 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 development range from concerns over increased traffic, 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.

Local residents are often successful at blocking new development because land use is determined at the local level (Downs, 2005). Particularly as regions become developed, single family residents can become major players in local land-use decisions, along with urban planners, and developers (Fischel, 1978). Regions may develop comprehensive plans for the density and location of new development, but increasingly the aspect of those plans that puts development into existing urban areas is being undermined by the resistance of local residents (Downs, 2005, and Johnston, et al. 1991).

We develop a model of a growing urban area and examine the effects on urban density and size of local decisions to block new development. We assume that new residents want to move into the city, and we focus on the decision of local communities to admit new residents, and on where those new residents will be located – in existing neighborhoods or in the periphery of the city. The decision-makers are assumed to be existing local neighborhoods that have some ability to decide how many new residents to admit. 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, Glaeser, 2007). We abstract from individual location choices, and focus instead on the choices faced by local neighborhoods about whether to accept new residents. Instead of a general equilibrium model of the urban area, that includes effects on land/housing prices and endogenous transportation costs (e.g. Glaeser, 2005; Mills, 1972 , Brueckner, 2001, Knaap et al, 2001, Epple and Seig, 1999), our model includes existing neighborhoods in an urban area and a peripheral region that can be developed to address the trade-offs faced by each neighborhood. Knaap et al (2001) and Knaap and Hopkins (1999) examine models with efficient investment in urban infrastructure. Unlike ours, these models do not capture external effects nor account for the existence of congestion costs.

Our focus is on growing urban areas where population increases facilitate the positive effects of growth. Growing urban areas have been shown to have positive economic benefits for city residents in a number of ways. Economic historians have documented the strong positive correlation between growth and geographic agglomeration of economic activities (Hohenberg and Lees, 1985, Quah, 2002). An increase in agglomeration can have a positive effect on growth, due to such factors as lower costs resulting from technological spillovers and greater opportunities for innovation (Keller, 2002, Jaffe, Trajtenberg and Henderson, 2007; Fujita and Thisse, 2003; Fujita et al. 2001; Ciccone, 2002). Baldwin and Martin (2004) and Martin and Ottaviano (2001) present a model lingking growth and agglomeration of economic activities and discuss conditions under 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. Early research found that there are an array of urbanization economies in growing cities that provide amenities to local residents (Moomaw, 1981). In this paper, we concern ourselves only with growing cities, and assume growth provides benefits to all residents, whether it is in the form of higher wages, more employment opportunities, or a higher level of amenities.

There are a range of possible models of city growth that could be considered. We pick several cases that capture plausible outcomes for a growing urban area. 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. We then 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 examine how changes in certain parameters can impact 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; Evans-Cowley and Lawhon, 2003; Nelson et al., 1991). We find that there is an optimal subsidy that could induce existing neighborhoods to take in the welfare maximizing number of new residents. But in most cases, an impact fee on new residents is not sufficient to achieve the optimum - a subsidy is required to induce existing neighborhoods to admit more residents. The results have implications for cities that may be struggling to reduce urban sprawl and achieve more compact development.

2 City I: Fixed Boundary, 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,[1] 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. Neighborhoods are defined by the size of the jurisicdiction which has control over development within its boundaries. There is strong evidence that local neighborhood associations and groups have a great deal of control over land

[1] This 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.

use decisions in the USA, although this ability to control new development may differ substantially across jurisdictions. For the model, the neighborhood is how we identify the jurisdiction that has effective control over land use decisions.

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 or 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. 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:[2]

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

where

$$\frac{\partial c_i}{\partial k_i} > 0,\ \frac{\partial^2 c_i}{\partial k_i^2} > 0, \tag{2.0.2}$$

and $\partial c_i/\partial k_i \equiv c'(k_i,\ \bar{n})$.

2.1 City 1 Optimum

Assume the planning authority can costlessly determine the optimal number of new residents that maximize net benefit 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 ($\beta = bk$). 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

$$\underset{k_i}{Max}(\beta - C) = b\sum_{i}^{\bar{n}} k_i - \left(\sum_{i=1}^{\bar{n}} \left(c\left(k_i,\ \bar{n}\right) + \bar{c}k_i\right)\right). \tag{2.1.1}$$

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

[2] One reader has suggested that we could have used a median voter approach as an alternative way of framing the problem. If the average resident gets b/p (p is population of the city) in benefits from a new residents and the costs to the average voter are c/p, then the planner will admit the new resident if $b > c$. But since each neighborhood must bear the total costs of each new resident it will tend to block too much. We find that this median voter approach yields exactly the same results as the case presented in this paper.

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

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

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

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

2.2 Outcome with Neighborhood Choice

In most urban areas of the U.S., land use decisions are made at the local level. This includes decisions about zoning levels that set the minimum lot size or maximum allowable density in an area. Even when maximum density levels are set by zoning regulations for a parcel of land, local neighborhoods will often attempt to block new entrants completely, or to at least reduce density below proposed levels. Therefore, 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.

It is difficult to know how the existing residents might perceive their potential benefits; in fact they may have no understnding 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 $b/\bar{n}$. [3]

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.[4] The problem faced by each neighborhood is then to maximize neighborhood benefits net of cost, or:

$$\underset{k_i}{Max}\pi_i = \left(\frac{b}{\bar{n}}\right) k_i - c\left(k_i,\ \bar{n}\right) - \bar{c}k_i, \tag{2.2.1}$$

where,

$$\frac{\partial \pi_i}{\partial k_i} \equiv G(k_i; b, \bar{n}, \bar{c}) = (b/\bar{n}) - c'\left(k_i, \bar{n}\right) - \bar{c} = 0,\ i = 1, ..., \bar{n}. \tag{2.2.2}$$

[3] The marginal benefit of an additional resident could be decreasing in k_i instead of being constant, but this would not affect the result below.

[4] We will explore other policy options later in the paper.

Or

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

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

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

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

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

This is because in a city of a given physical size, as the number of neighborhoods goes up, the spatial size of each neighborhood decreases. Therefore, for a given number of new incoming residents, the effect of those residents will be greater the smaller the size of the neighborhoods they are entering.[5] 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 shown in Figure 1.[6]

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:

[5] We 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.

[6] To 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 as the number of neighborhoods increases. Assuming that $c''(k_i) > 0$ $(\partial^2 c(k_i, \bar{n})/\partial k_i^2 > 0)$, we obtain that:

$$\frac{\partial k_i}{\partial \bar{n}} = -\frac{\partial H(.)/\partial \bar{n}}{\partial H(.)/\partial k_i} = -\frac{c''_{\bar{n}}(k_i, \bar{n})}{c''_{k_i}(k_i, \bar{n})} < 0$$

Similarly, 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 is a decreasing function of $\bar{n}$.

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

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

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

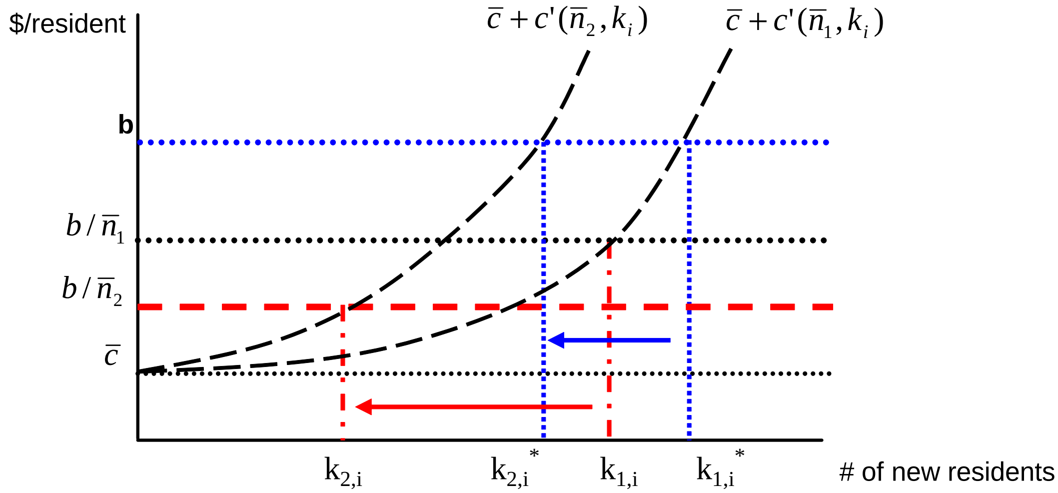

Figure 1: **Cost and benefit for neighborhood i of admitting new residents for city 1 as the number of neighborhoods changes**.

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 neighborhoord 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.[7] However, the outcome when 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 number of new residents allowed into existing neighborhoods is lower under neighborhood choice before infrastructure costs go up. The initial optimum number of new residents admitted under the planner's solution is $k^*_{3,i}$, while in the private choice case, the solution is $k_{3,i}$. When infrastructure costs increase from $\bar{c}_1$ to $\bar{c}_2$, the number admitted falls to $k^*_{4,i}$ for the optimal solution, and to $k_{4,i}$ for the neighborhood choice case. The reduction is greater under neighborhood choice conditions. Again, as infrastructure costs go up, the local choice outcome deviates relatively more from the optimal level.[8]

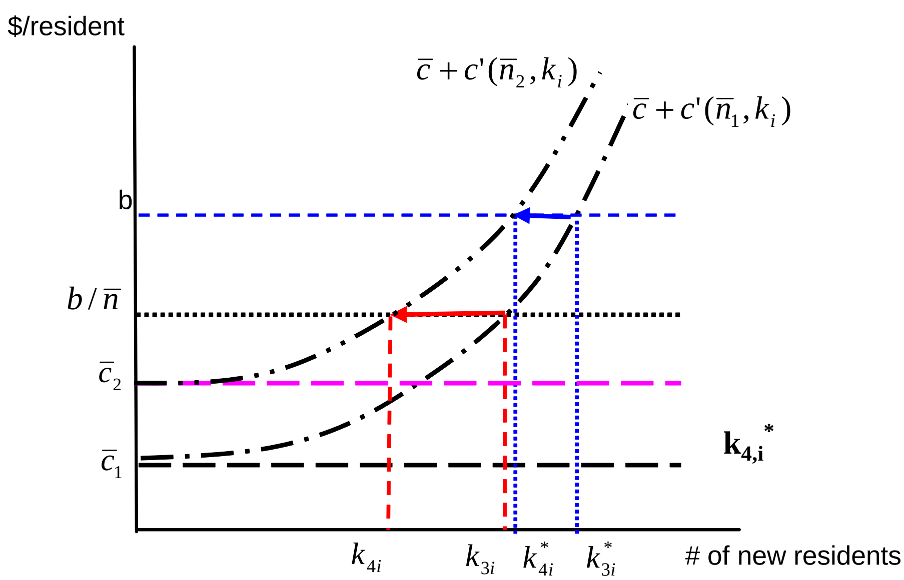

Figure 2: **Costs and benefits of admitting new residents for city 1 as the infrastructure cost increases**

We can summarize the results for city 1. Under the planner's solution, the city is more densely

[7] The partial change in the number of new residents with respect to the cost of infrastructure for both the planner case and the private market case are shown as:

$$\frac{\partial k_i}{\partial \bar{c}} = -\frac{\partial H(.)/\partial \bar{c}}{\partial H(.)/\partial k_i} = \frac{-1}{c''(k_i)} < 0, \text{ planner}$$
$$\frac{\partial k_i}{\partial \bar{c}} = -\frac{\partial G(.)/\partial \bar{c}}{\partial G(.)/\partial k_i} = \frac{-k_i}{c''(k_i)} < 0, \text{ private}$$

[8] This result depends on the functional form of the cost function. In our case, the marginal cost of additional resident is increasing.

developed with greater population than if control over growth is influenced by local neighboorhoods. 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; Boundary Variable

An alternative way to model a growing city is to assume there is an exogenous increase in population, and in-coming residents can locate either in the existing neighborhoods or at the periphery. In this case the growth rate in population is given, and we examine the differences between densities and physical city size in the optimal and local neighborhood choice 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 optimum to the outcome when the decision to admit new residents is under local control. 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, as in Model I above. First, we assume that the existing residents 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. Then, we assume that existing residents 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. We choose these two scenarios to show the range of possible outcomes.

3.1 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, $\bar{c}$, which is the same as the infrasctture costs of locating a new resident an the existing neighborhood. Also, new residents who locate in the periphery must pay transportation costs, $\bar{c}^T$.

The problem is to choose k_i^{e*} to be admitted in each existing neighborhood i, $i = 1, ..., n$, and k^{p*} to be admitted in the periphery to maximize net benefits to the city. Because the new population to be admitted is given, and the new residents will go somewhere, solving the maximization problem is equivalent to miniziming 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 minizimize the costs of admitting new residents into the existing neighborhood by choosing k_i^{e*} which minimizes the following equation:

$$\underset{k_i^e}{Min}\left(\sum_{i=1}^{\bar{n}}\left(c(k_i^e,\bar{n})+\bar{c}k_i^e\right)\right)+\left(\bar{c}+\bar{c}^T\right)\left(\bar{k}-\sum_{i=1}^{\bar{n}}k_i^e\right)$$

Given the fact that $\bar{k} = \sum_{i=1}^{\bar{n}} k_i^e + k^p$, the planner will choose the number of new residents, k_i^{e*}, in each existing neighborhood according to the following first order conditions:

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

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, $\left(\bar{c}+\bar{c}^T\right)$, 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 $b\bar{k} = b(\sum_{i=1}^{\bar{n}} k_i^{e*} + k^{p*})$.

3.2 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. We assume they will move into existing neighborhoods as long as they are allowed to because their costs are lower (no transportation costs). 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. We assume in this case that new residents who locate in the periphery must pay their own infrastructure costs. However, existing neighbhorhoods in this model pay all infrastructure costs. In the next section we explore the use of impact fees, which require new development to pay for all infrastructure costs.

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.

City $2B$: Existing neighborhoods think they will get some benefit from new residents. Assume b/n is the benefit per each new resident admitted.

Under City $2A$, because existing residents are aware that new residents are likely to be located somewhere in the city, and 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, or $k_i^e = 0,\ i = 1, ..., \bar{n}$, and $k^p = \bar{k}$. The city physical size will be larger with a lower density than was the case under the social planner.

It is possible, however, that existing residents may believe they will recieve some benefit, or they could just be uncertain about whether new residents will be allowed to locate somewhere. They could even believe they should take some share of new residents. To represent City $2B$ we make the assumption that existing residents perceive the benefits as their share of the total benefit $b/\bar{n}$, and ignore broader benefits to the city as a whole.

The solution for the existing neighborhoods for City $2B$ is[9]

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

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

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

Therefore, if $\frac{b}{\bar{n}} - \bar{c} < \bar{c}^T$, there will be more people admitted to the existing neighborhoods in the optimal case than in the private market case. Note that if the perceived benefits of a new resident, $\frac{b}{\bar{n}}$, is less than $\bar{c}$, the infrastructure costs, then no new residents would be admitted. If the perceived

[9] The maximization problem (neighborhood choice outcome) is as: $\mathrm{Max}(\frac{b}{n}k_i^e - c_i(k_i^e, \bar{n}) - \bar{c}k_i^e)$. The first order conditions with respect k_i^e are such that

$$Q(k_i^e, \bar{n}, \bar{c}) \equiv \frac{b}{\bar{n}} - c'(k_i^e, \bar{n}) - \bar{c} = 0,\ i = 1, ..., \bar{n}.$$

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. If the number of neighborhoods, $\bar{n}$, is relatively large or transportation costs, $\bar{c}^T$, are high, then this is likely to be true, and the city would be more compact in the optimal or planner case (See Figure 3. The number admitted to existing neighborhoods is higher in the planner's case).

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.

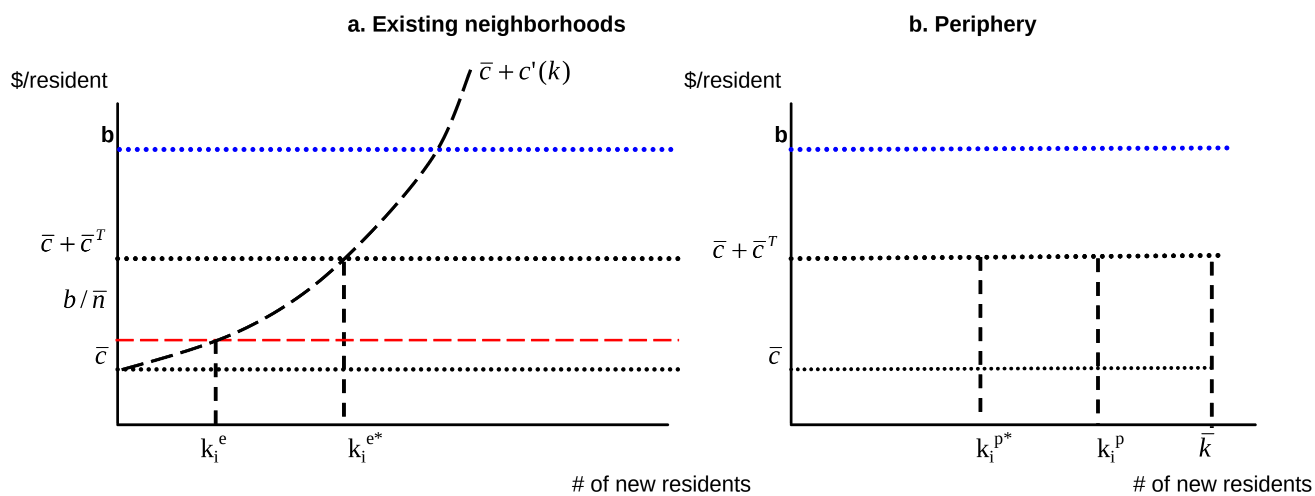

Figure 3. **Optimal and Market Outcomes in Existing Neighborhoods and the Periphery for city 2B**

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.[10] 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 private market cases described above, the number of new residents admitted into existing neighborhoods will be unchanged when transportation costs go up. In the case where

[10] From the social planner optimum, equation (3.1.1), recall that

$$V(k_i^{*e}, \bar{c}, \bar{c}^p, \bar{n}) \equiv c'(k_i^{*e}, \bar{n}) + \bar{c} - \left(\bar{c} + \bar{c}^T\right) = 0, \; i = 1, ..., \bar{n},$$

From this equation, we can obtain the partial derivatives of k_i^{*e} with respect $\bar{c}^T$ as follows:

$$\frac{\partial k_i^{*e}}{\partial \bar{c}^T} = -\frac{\partial V(.)/\partial \bar{c}^T}{\partial V(.)/\partial k_i^{*e}} = \frac{1}{c''_{kk}(k_i^{*e}, \bar{n})},$$

which is positive. If transportation costs increase, more new residents are admitted to each existing neighborhood, and fewer new residents will locate in the periphery.

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.

Therefore, the higher are the transportation costs from the periphery, the greater will be the difference between the social optimum and the market outcome. Higher transportation costs will tend to make the optimal city small and more dense and has no impact on the city when decisions are made by local residents.

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 neighhorhoods, ($\bar{n}$ is larger), then each neighborhood is smaller in size. Therefore, the congestion costs of admitting any given number of new residents will be greater (2.2.4). For the planner case, we find the partial derivative of k_i^{*e} with respect to $\bar{n}$ as follows:

$$\frac{\partial k_i^{*e}}{\partial \bar{n}} = -\frac{\partial V(.)/\partial \bar{n}}{\partial V(.)/\partial k_i^{*e}} = -\frac{\partial c'(k_i^e, \bar{n})/\partial \bar{n}}{\partial c'(k_i^{*e}, \bar{n})/\partial k_i^{*e}} = -\frac{c''_{k\bar{n}}(k_i^{*e}, \bar{n})}{c''_{kk}(k_i^{*e}, \bar{n})}$$

When there are a greater number of neighborhoods in the existing city, then the number of new residents admitted to each neighborhood will decrease. As in City 1 above, this is because costs of each admitted resident are higher in the existing neighborhoods, and the cost minimizing distribution of new residents will have fewer in the existing areas and more in the periphery.

With neighborhood choice we again examine the outcomes with City $2A$ and City $2B$ assumptions. Under $2A$, where existing residents block new residents completely, then 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 market outcome, but the optimal city is still more compact than that which would result from complete blocking.

With City $2B$, where existing residents see the benefit of new residents as $b/\bar{n}$, recall that the neighborhood choice equilibrium is given by $k_i^e : b/\bar{n} = c'(k_i^e, \bar{n}) + \bar{c}$. Taking the derivative of the above equation with respect to $\bar{n}$, we have

$$\frac{\partial k_i^e}{\partial \bar{n}} = -\frac{\partial Q(.)/\partial \bar{n}}{\partial Q(.)/\partial k_i^e} = -\frac{\left(b/\bar{n}^2 + c''_{k\bar{n}}(k_i^e, \bar{n})\right)}{c''_{kk}(k_i^e, \bar{n})}$$

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 under the optimal case above. Therefore, as $\bar{n}$ gets larger, the decline in the number of new residents admitted under neighborhood choice will be larger than under the optimal case, or the neighborhood choice 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 social 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.

In City $2A$ in which existing residents block new residents completely, there would also be no change if infrastructure costs go up. In City $2B$ where existing residents see their benefits as $b/\bar{n}$, however, there will be an effect of higher infrastructure costs. Rewriting equations 3.2.1,

$$Q(k_i^e, \bar{c}, \bar{n}) \equiv b/\bar{n} - c'(k_i^e, \bar{n}) - \bar{c} = 0, \ \forall i = 0, ..., \bar{n}$$

and taking the derivative of the above system with respect to $\bar{c}$, we have

$$\frac{\partial k_i^e}{\partial \bar{c}} = -\frac{\partial Q(.)/\partial \bar{c}}{\partial V(.)/\partial k_i^e} = -\frac{1}{c''_{kk}(k_i^e, \bar{n})}.$$

If infrasture 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 in which population growth is given and new residents can locate either in the existing neighborhoods or in the periphery. We find that when 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. 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, the same result will hold except if transportation costs are very large relative to the perceived net benefit of new residents to the neighborhood. 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. Higher transportation costs will have a similar effect, contributing to relatively lower density and greater sprawl.

Next, we turn to various policy options for improving the market outcomes in both the Model 1 city where the urban boundary is fixed, and in Model 2 where population is fixed and the boundary can vary.

4 Policies

4.1 The optimal subsidy

4.1.1 City 1: Population is endogenous and the city boundary is fixed

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.[11] 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,

$$\left(\frac{b}{\bar{n}}\right) k_i - \left(c\left(k_i,\ \bar{n}\right) - \tau k_i\right) - \bar{c}k_i.$$

The first order condition for an optimum with the subsidy is

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

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

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

We can show the magnitude of this subsidy in figure 4. The optimal number of new residents is k_i^*, and the market outcome is k_i. A per new resident subsidy of $(b - (b/\bar{n}))$ would induce the neighborhood to accept the optimal number of new residents. The city would have $\bar{n}(k_i^* - k_i)$ more residents than the private market case, and would have greater density in every neighborhood.

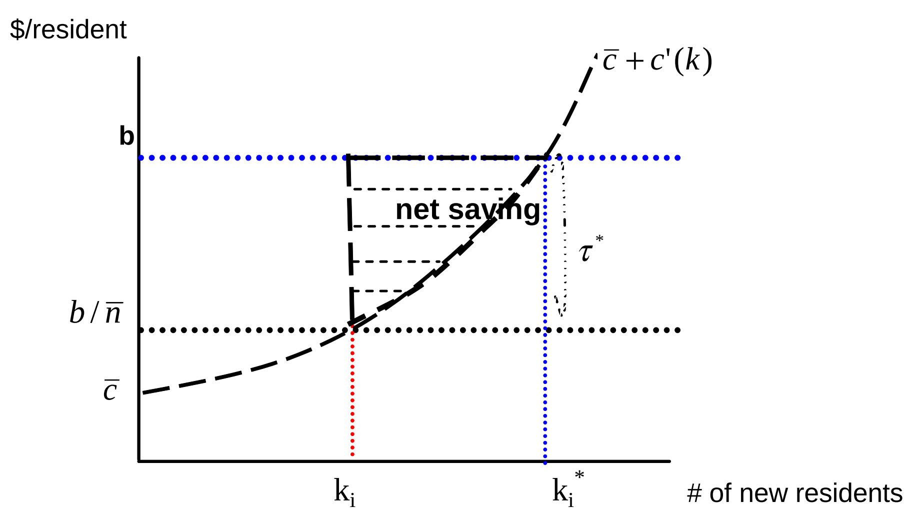

Figure 4. **Outcome with Neighborhood choice and optimal subsidy for city 1**

[11] Revenues 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.

There are several interesting implications of the optimal tax 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, then the larger the subsidy, τ, must be. If there are a large number of jurisdictions able to make their own decisions about development density, then the private market outcome is likely to be farther from the optimum, and any subsidy will have to be larger. However, even with large numbers of neighborhoods, it is possible to offer a subsidy to the neighorhoods that will make each better off.

City 2: Population growth is given, and the city boundary can vary

4.1.2 Optimal subsidy under Model 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. At the optimum there will be k_i^{e*} new residents admitted to each neighborhood, with $k^{p*} = \bar{k} - \sum k_i^{e*}$ located in the periphery. Therefore, the optimal subsidy for the existing neighborhoods that would induce them to admit the optimal number is $\tau^* = \bar{c}^T + \bar{c}$ for each new resident admitted. We show the optimal and market outcomes in Figure 5, and the optimal subsidy τ^*. With τ^*, the net savings to each existing neighborhood would be area A, or a total city-wide net $savings = \bar{n}A$. The benefits to the city are the same under either policy.

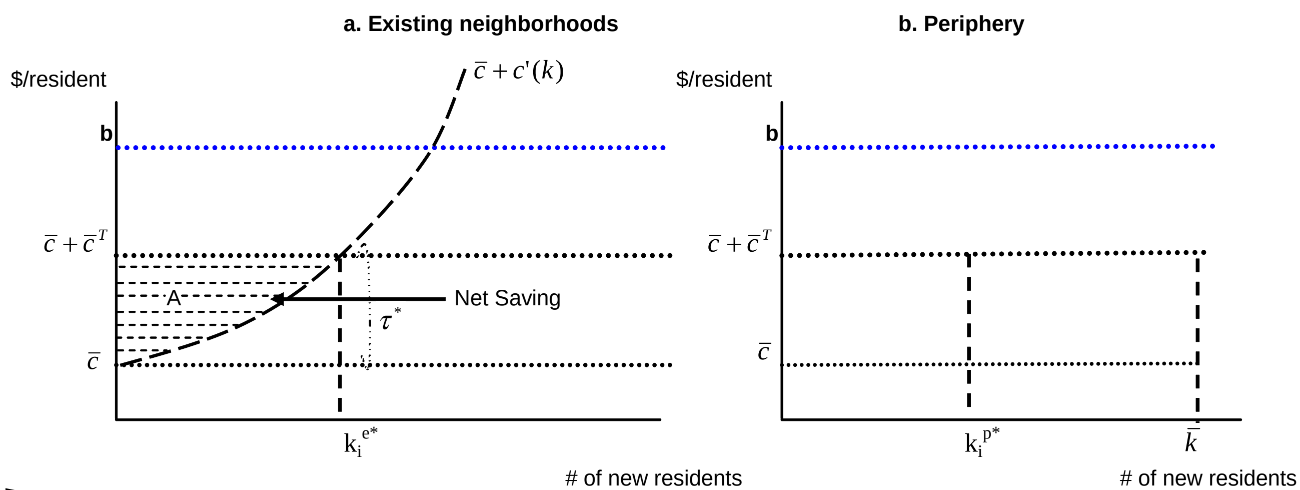

Figure 5. **Optimum Subsidy for City 2A.**

4.1.3 Optimal subsidy under Model $2B$.

In the planner case the optimal solution is characterized by the following first order condition from equation 3.1.4 above.

$$\begin{aligned} c'(k_i^{e*}, \bar{n}) + \bar{c} - \left(\bar{c} + \bar{c}^T\right) &= 0, \ i = 1, ..., \bar{n}, \quad \text{or} \\ c'(k_i^{e*}, \bar{n}) &= \bar{c}^T, \ i = 1, ..., \bar{n}. \end{aligned}$$

Under Model $2B$, we assume that existing residents are not sure about whether they would be entirely able to free ride, and in fact perceive neighborhood benefits for admitting each new resident as $b/\bar{n}$. The first order condition for an optimum with subsidy is then given by $\frac{b}{\bar{n}} = c'(k_i^e, \bar{n}) - \tau + \bar{c}$, and the optimal subsidy for existing neighborhoods 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 instead of in the existing neighborhoods, and $\bar{c} - \frac{b}{\bar{n}}$ is the additional cost a new resident imposes on residents of existing neighborhoods.

The neighborhoods must be compensated at least as much as the costs they bear per new resident, and enough to offset the higher costs if new residents must go to the periphery and pay transportation costs. We can show that τ^*will be a subsidy when $\bar{c}^T + \bar{c} > \frac{b}{\bar{n}}$, and a tax otherwise, as this can be seen in figure 5 below. If the perceived benefit is less than the opportunity cost, then the neighborhood should be subsidized by τ^* for each new resident. The net savings for the neighborhood is given below.

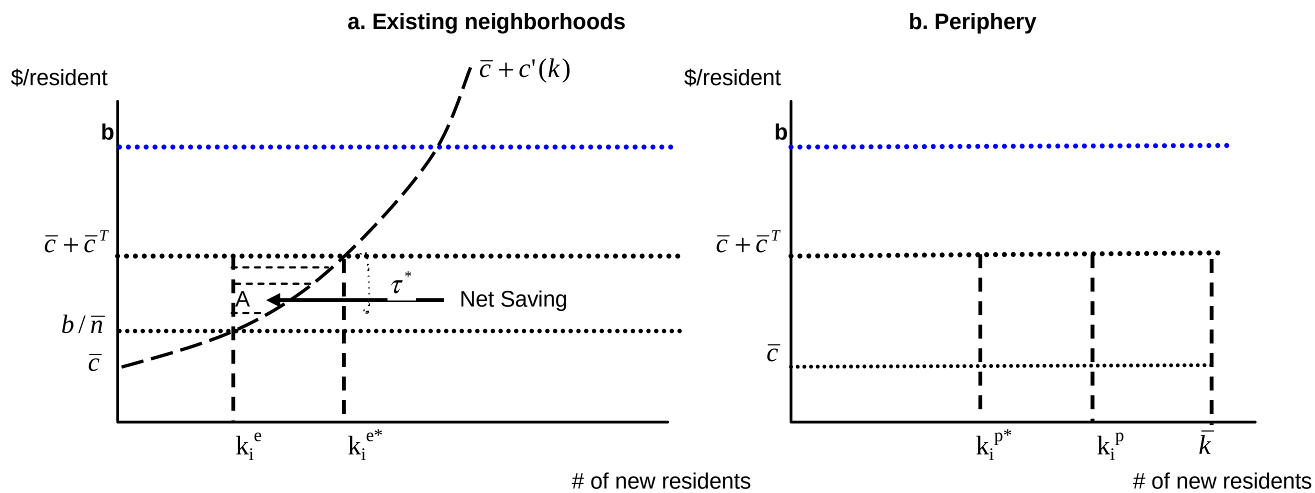

Figure 6. **Optimum subsidy for City 2B**

It is likely that perceived benefits will be low, and may appraoch 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.

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 refered to as an "impact fee". Local jursidictions 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.

4.2.1 Impact Fees in City 1.

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, $c\left(k_i,\ \bar{n}\right)$. 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 the perceived benefit, or:

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

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 the optimal subsidy derived above. Or, under what conditions is the optimal subsidy under the planner's solution (2.1.2) larger than a simple impact fee (new residents pay their own infrastructure costs (4.2.1))? The impact fee will be too small compared to the optimal subsidy if the following condition holds:

$$\bar{c} \leqslant b - \frac{b}{\bar{n}}. \tag{4.2.2}$$

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 optimum will have larger population size and 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.[12]

To summarize, for City 1, impact fees will 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

[12] The 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.

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.

4.2.2 Impact Fees City 2.

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. The optimal subsidy to offer existing residents to admit new households for both City 2A and 2B reduces to $\bar{c}^T + \bar{c}$ as derived above. If those 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. The city would be too spread out, and less dense than optimal under the impact fee.[13] In reality most impact fees charged for new development are not high enough to cover even the cost of infrastructure for that new development. These results suggest not only that 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 is equivalent to the higher costs of transportation that the new residents must pay if they locate in the periphery of the urban area.

5 Conclusion

This paper attempts to illustrate the effect of an externality in urban development using a simple model to depict city and neighborhood choice over how many new residents to admit to a growing city. The externality is that cities with growing populations often confer benefits to the entire region, but existing neighborhoods who must accommodate new entrants bear almost all of the costs. We attempt to show how the density of the urban area will be different when local areas have control over entry compared to an optimum outcome. Because of the 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 neighborhoods who can exert control over land use is greater, and when infrastructure and transportation costs are higher.

There are many market failures that contribute to urban sprawl, but this is one that may be important as communities consider ways to achieve greater density and reduce what they perceive as

[13] In this stylized model, the additional subsidy needed is equivalent to the higher costs of transportation that the new residents must pay if they locate in the periphery of the urban area.

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. This model takes a first step in considering effective policies for dealing with this issue. We have shown that there is a subsidy that 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.

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